UNIVERSITY OF MINNESOTA.

EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE,

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BULLETIN No. 4.

AGRICULTURE.

COMPARATIVE VALUE OF COLD AND WARM WATER FOR STOCK, IN FOOD CONSUMED, AND IN THE PRODUCTION OF MILK, BUTTER AND BEEF.

ENTOMOLOGY.

FUNGI, WHICH KILL INSECTS,—ESPECIALLY AS AFFECTING CHINCH BUGS AND LOCUSTS.

VETERINARY.

"TUBERCULOSIS," OR CONSUMPTION IN DOMESTIC ANIMALS.

AGRICULTURAL

EXPERIMENT STATION

OF THE

UNIVERSITY OF MINNESOTA.

BOARD OF REGENTS.

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INTRODUCTORY.

In carrying out the objects of the organization of an "Agricultural Experiment Station," we cordially invite the co-operation of all persons interested in its success. Suggestions as to lines of experimental work, problems to be solved, inquiries relating to agriculture, horticulture, stock, and the dairy will be cheerfully received, and answered as far as possible; but no work will be undertaken unless of public value, and the results of which we are at liberty to use for the public good.

Specimens of grains and grasses ; seeds of fruit and forest trees ; vegetables, plants, and flowers that are true to name ; varieties of beneficial and injurious insects; samples of mineral waters and ores, and whatever may illustrate any department of agriculture will be gladly received, and due acknowledgments made in annual reports. Directions for collecting, packing and shipping such specimens will be furnished on applicatien, and all expenses paid.

Bulletins will be issued at least quarterly, giving the results of experimental work as fast as completed, together with such suggestions and information as may be thought valuable to the farmers of Minnesota.

The bulletins and reports of this Station are sent free to every citizen of Minnesota who applies for them. Copies are sent a soon as issued to every newspaper in the State, to every Grange, Farmers' Alliance, or other Agricultural Organization, whose addresses can be obtained. Bulletins and reports are also sent to the leading Agricultural papers of the country, and will be sent to *any* paper that may desire to exchange.

Letters relating to any special line of work should be directed to the officer in charge of that division, but all general correspondence relating to the work of the Station should be addressed to

EDWARD D. PORTER,
Director of Experiment Station.

St. Anthony Park, Ramsey County, Minnesota.

DIVISION OF AGRICULTURE.

EDWARD D. PORTER.

EXPERIMENTS IN STOCK FEEDING.

The following experiments were undertaken for the purpose of determining the comparative merits of cold and warm water for farm stock so far as relates to the amount of food consumed, to the production of milk, butter and beef, and the relative values of corn ensilage, timothy hay, wheat bran, corn meal, and oil meal, in various combinations, as food for dairy stock, and beefing animals.

Owing to the fact that the appropriations for the work of the station, were not available, until April last, these experiments were not commenced until the last months of the past winter, and were continued until the close of the feeding season, when the farm stock was turned out to pasture. In order to check the work already accomplished in this direction and to profit by the experience thus far gained, these experiments will be again commenced in November next, and continued through the entire winter. with such modifications as may be thought advisable.

In the experiments here reported the following facts were carefully observed and recorded:

(1) The date.
(2) Station number of the animal.
(3) The age of the animal.
(4) The breed of the animal.
(5) In the case of cows, the date of last calving.
(6) In the case of cows, the date at which the next calf was due.
(7) The weight of the animal, taken at 11 o'clock daily.
(8) The temperature of the external air, recorded morning, noon and night.
(9) The temperature of the air in the stables, recorded morning, noon und night.
(10) The temperature of the water drank by each animal, morning, noon and night.
(11) The weight of feed consumed by each animal, morning, noon and night.
(12) The weight of the water drank by each animal, morning, noon and night.

(13) The weight of milk given by each cow, morning and night.
(14) The precentage of cream, furnished by each cows milk, morning and night.
(15) The weight of the butter produced by each group of cows, at each churning from the beginning to the end of the experimental season.

The amount of time and labor involved in this class of experimental work may be inferred from the fact, that there were required each day two hundred and twenty separate weighings, besides the work of recording, tabulating and reducing the results. This work has been most satisfactorily accomplished by my assistant, Prof. Willet M. Hays, aided by his stable man, Mr. Charles Shultis, and the working force of the station; to all of whom our thanks are due for the faithful manner in which they have discharged the duties entrusted their care.

The publication of the daily records of this experimental work would expand this report beyond the limits of a bulletin article, and would not prove of general interest, these data will therefore be reserved for the annual report, and only the resulting averages and aggregates given here, showing the final conclusions.

EQUIPMENTS FOR FEEDING EXPERIMENTS.

STABLES, WORK-ROOM AND OFFICE.

The basement of the South wing of the main barn has been thoroughly fitted up and furnished for all the experiments in catttle feeding. The general arrangement of the stables, feed rooms, work room and office is shown upon the following ground plan. Room 2 is arranged with ten stalls, E, E; feed bins, D

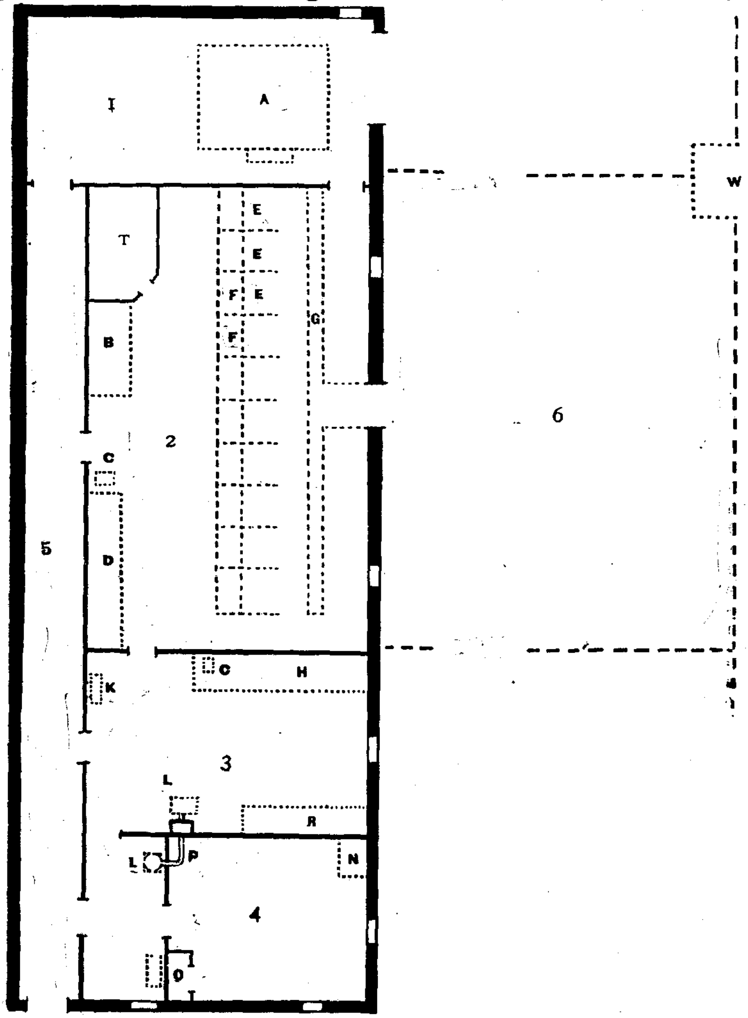
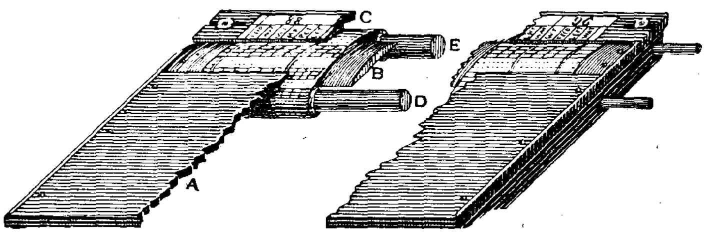


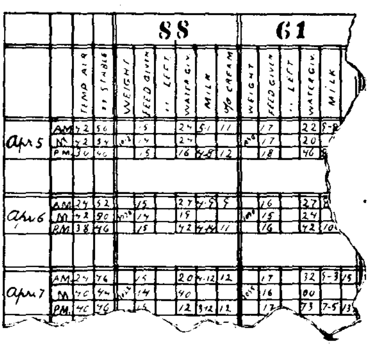
Fig. 1.—Ground Plan of Feeding Stable and adjacent Rooms.

and T; scales for weighing feed, C; mixing box, B, and all other necessary conveniences. It is ventilated by means of flues in the walls, also by windows. The stable opens into a small yard, 6, where the animals can exercise. In room 1 adjoining are platform scales, A, upon which the animals are weighed. Room 3 has a stove, L, with hot water attachments and cold water pipes; scales, C, for weighing milk, tables, H, R, and various other appliances. Room 4 serves as an office for the person in charge. An alley or hall, 5, extends along the west side of these rooms.

RECORDING DESK.

The necessity for some convenient method of tabulating the daily records of feed eaten, water drank, live weight, milk given and other facts, was the "mother of the invention" herewith described, which has proved to be admirably suited to the purpose. It is placed against the wall at K in room 3 in the above plan.





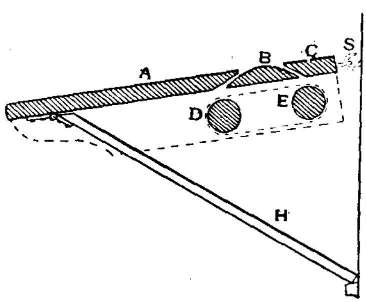


Fig. 2. Partial view in Perspective of Recording Desk.

Fig. 3. Section of Ruled Sheet. *Fig. 4. Cross Section of Desk.*

The upper engraving gives a partial view in perspective of the desk or shelf like arrangement when elevated and with paper in place. It is seventeen inches wide, forty-eight inches long (may be more or less), and is composed of three boards screwed to cross-pieces four inches in width, with two rollers two inches in diameter beneath. The board marked A, figs. 1 and 3, is the arm rest while writing. The sheet of paper, ruled as desired, passes up from the roller, D, over the middle board, B; thence down around the roller E, thus exposing a strip two inches wide the whole length of the desk. The sheet is ruled as shown in Figure 2. Each date is given a two-inch strip, reaching across the paper, and each animal a vertical space of the necessary width. The sheet is moved, to show any desired date above the middle board, by turning the rollers, which are made to roll together by a belt around them at one end, this keeping the paper drawn tightly over the slightly convex surface of the board, B. On the upper board, C, is pasted a duplicate of the headings on the sheet, thus obviating hunting down long columns of figures by having the headings always near the records being made. Fig. 3 gives the device in cross section, showing the rollers, D, E, the staff, H, which, hinged to A, serves as a support when the desk is raised for use. Screw hooks and eyes form hinges, S, which hold the desk to the wall. It can be taken off the hooks and into the office, where are other hooks, making it handy for copying records. At one end the axles of the rollers extend several inches through the cross pieces, enabling one to turn the rollers with the hand. The paper used for ten cattle is manilla forty-two inches wide and sixty-five inches long, giving two inches for each day. This space for each day's record is again divided into spaces for morning, noon and night. Several vertical columns under each animal's number give blank spaces for feed eaten, water drank, etc., while a blank space below these is left for irregular notes, as "off feed", etc. Each morning the rollers are turned, removing the records of the preceding day from sight, and showing only the ruled spaces for the new day. In copying these figures into permanent record books, it is quite an item to have only one day's records in sight and those near the headings. The handiness of making the records and the ease of keeping the sheets clean are not the least of its advantages. In the help to accuracy lies its greatest value. The person doing the feeding sees clearly each small blank, and appreciates the necessity of filling each one at the proper time with the correct figures.

Besides being of interest to those conducting feeding experiments this device could be adapted to creameries and cheese factories run on the whole milk plan, for their daily records of cream and milk received, also of skim-milk and butter-milk sold to or returned to patrons.

METHOD OF STRAINING AND CARRYING MILK.

The method of straining the milk used in the experimental, as well as in the regular dairy work on the farm, is so satisfactory to those desiring clean milk products that a description is here

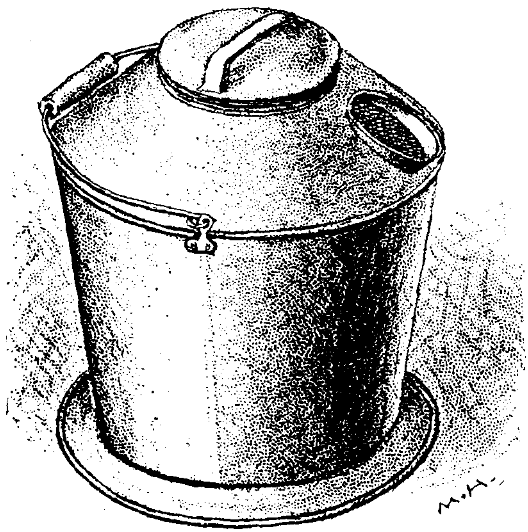


Fig. 5.—Perspective View of Carrying Pail.

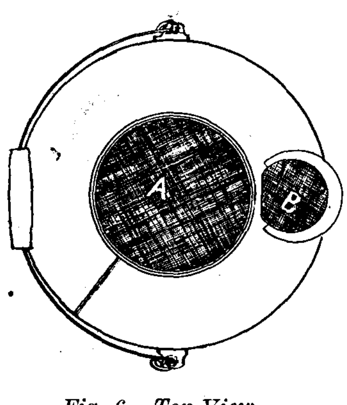


Fig. 6.—Top View.

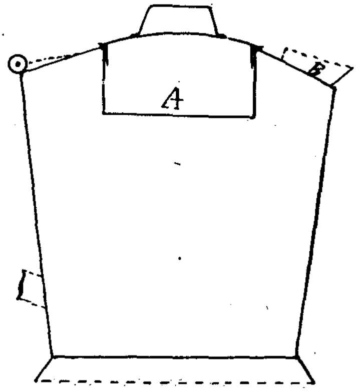


Fig. 7.—Cross Sectional View.

given. Common pails holding ten quarts are used to milk into and as each cow is finished the milk is weighed and poured into carrying pails placed on a bench behind the cows. The milk of each cow is so quickly weighed and recorded on a ruled sheet tacked on the wall or on a board, that no dairyman can afford to do without a pair of scales, and other necessary facilities for this work.

Figure 5 shows the general appearance of the carrying pail, figure 6 a top view, and figure 7 a cross sectional view. A cup or dish like arrangement with wire strainer bottom is fitted into the top as shown at A figures 6 and 7. The milk is poured through this, thus straining it as soon as drawn from the cow. The spout, B, is also covered with wire strainer cloth and strains the milk a second time when poured into the setting cans. A common strainer with wire bottom and rim for muslin is also used, thus straining the milk four times and with very little more work than straining but once when more or less hairs, dandruff and other dirt remains in the milk. Besides being a clean strainer this covered pail keeps dirt from entering the milk while being carried from the stables to the dairy room. A neck-yoke makes it easy for a man to carry two of these pails holding fifteen quarts each. The pails are cleaned by removing the cup-like strainer, A, at the top.

ENSILAGE VERSUS TIMOTHY HAY FOR DAIRX COWS.

March 9, 1888, six cows were selected from the dairy herd with a view to comparing ensilage with timothy hay as a feed, also to test the matter of warming water for dairy cows. It being the wrong time of the year to select from the herd cows all of one breed, fresh in milk and otherwise in similar conditions, three different kinds were chosen. Two of these, Nos. 42 and 16, were registered Holstein Friesians, Nos. 65 and 61 were grade Ayrshires and Nos. 88 and 76 were natives, probably having some Short-horn blood. They were pared off so as to have two groups of three each, alike as to weight, time since calving, daily milk yield, breeds, etc. In this way the individual and breed characteristics were more or less perfectly eliminated.

These cows had been fed on ensilage, chaffed hay and a medium allowance of bran during the several previous winter months, and their water had been kept warm by means of a steam pipe extending into the tank from the barn engine. They were accustomed to standing in stanchions, and in pleasant weather were allowed liberty in the barn-yard, where some ensilage or hay was given them during the day. The week of preliminary feeding was prolonged a few days by the stables not being completed as soon as was expected.

TABLE NO. 1.

TABULAR STATEMENT OF THE RECORDS OF THE SIX COWS.

	Station. Number.	Daily milk average, Mch 1 to 8.	Milk average, preliminary feeding, Mch 9to 21	Age.	Breed.	Dropped last calf.	Last time bred.	Weight, Mch. 5, '88
Warm Water Group	88	10 lbs.12oz	9lbs. 11oz	5	Native	July 26,'87	Oct. 18, '87	1005
	61	20 lbs.	18 lbs.13oz	12†	Ayrshire Grade	May, 1886	Not bred.	1125
	42	37 lbs.14oz	33 lbs. 2oz	5	Hols. F.	Jan. 30, '88	Mch.18,'88	1272
Totals		68 lbs.10oz	61 lbs.10oz	....	....	....	....	3402
Cold Water Group	16	18 lbs.14oz	18 lbs. 6oz	4	Hols. F.	July 28,'87	March, '88	1220
	65	24 lbs. 5oz	22 lbs.12oz	9	Ayrshire Grade	Nov. 22,'87	Jan. 14, '88	1072
	76	23 lbs. 6oz	23 lbs. 2oz	5	Native	Nov. 7, '87	Dec. 28, '87	975
Totals	..	66 lbs. 9oz	64 lbs. 4oz	....	....	....	....	3267

The ration selected for the first period was in the proportion of 14 pounds timothy hay, 7 pounds bran, 4 pounds corn-meal and 3 pounds old process oil-meal. This was calculated approximately to Wolf's daily standard for milk cows, live weight one thousand pounds, using analyses and tables of digestibility given in Armsby's Cattle Feeding.

TABLE NO. 2.

COMPOSITION OF FEEDING RATION.

	Dry Matter.	Digestible Protein.	Digestible Fat.	Digestible Nitrogen Free Extract.	Digestible Crude fiber.
14 lbs. Timothy Hay.........	12.11	.50	.11	4.04	2.35
7 lbs. Wheat Bran	6.09	.89	.20	3.00	.13
4 lbs. Corn-meal	3.56	.36	.15	2.64	.03
3 lbs. O. P. Oil-meal..........	2 72	.77	.32	.93	.07
Totals of the Station Ration.	24.48	2.52	.78	10.61	2.58
				13.19	
Wolf's Ration................	24 00	2.50	.40	12.50	

In going from the ensilage, hay and bran to this new ration, the change was made by gradually substituting the one for the other, and after a few days leaving the ensilage entirely. During the first part of this time there was a decrease in the production of milk, which we attributed mainly to the change from ensilage to dry hay, but partly to the fact that we did not give enough hay in addition to the grain while gradually getting the cows accustomed to the rich ration. At the end of this preliminary period they were nearly up to their original yields. The decrease was still noticeable in the warm water group while those changed to the cold water had gained.

After being placed in their new quarters the cows were fed this ration for seventeen days. The hay was chaffed in a feed cutter and moistened with its own weight of water, after which the bran, corn meal and oil meal previously mixed together were thoroughly stirred into the wet hay, making a uniform mass from which the several feeds were weighed out. The cows were fed thrice daily what they were quite sure to eat clean, and occasionally small amounts were weighed back so as to always have a clean manger for fresh feed. All the water they could drink was given one to two hours after each meal. The water given to Group No. 1, in all the experiments, was kept at a uniform temperature of 70 degress Farenheit, and that to Group No. 2 at a temperature of 32 degrees. Milking was done regularly at 5:30 o'clock A. M. and P. M. Records were kept of the amount of feed given each animal and that weighed back at each feed, the amount of water drank, and the live weight was taken just before the noon meal. A record of the temperature outside and within the stable was made at 7 A. M., 1 P. M. and 6 P. M. The amount of milk given by each animal was recorded and a test made of the quality of the cream at each milking. The temperature of the milk when it reached the cellar, temperature of setting water, time required and manner of souring the cream, temperature of churning and the method of working the butter were noted and were kept as uniform as possible. Churning was done at 62° to 64° and when the butter had formed granules the size of wheat grains, or smaller, the buttermilk was allowed to run off. The granular mass was then washed two or three times in ice cold water and the butter worked until "dry," and weighed before salting. This is not given as altogether a good way in practice as the salt was worked into the butter after it has been "massed and mussed," but this was necessary in the experiment so as to get the weight of the butter fats only.

TABLE NO. 3.

RESULTS OF PERIOD I. MARCH 22 TO APRIL 7.

STATION NUMBER.	Total water.	Pounds feed eaten.	Pounds milk given.	Per cent. cream.	WEIGHT. Beginning	WEIGHT. Ending.	Gain or loss in weight	Butter produced.	Lbs. milk to 1 lb. butter.	Lbs. feed to 1 lb. butter.	Lbs. feed to 1 lb. milk.	Butter to 100 lbs milk.
88	1,454	481	162	11	969	1,021	+52					
61	1,922	585	321	14	1,100	1,098	—2					
42	2,515	730	564	11	1,305	1,331	+26					
16	1,919	656	317	8	1,238	1,294	+56					
65	1,798	584	424	12	1,052	1,072	+20					
76	1,853	583	415	12½	960	1,002	+42					
								lbs.oz.	lbs.oz.	lbs.oz.	lbs.oz.	lbs.oz.
*Group.	5,891	1,796	1,047		3,374	3,450	+76	39.11	26. 7	45. 5	1:11½	3.12
†Group.	5,570	1,823	1,156		3,250	3,368	+118	42...	27. 8	43. 5	1. 9	3.10
Totals..	11,461	3,619	2,203		6,624	6,818	+194	81.11	26.14	44. 5	1.10	3.11

*Warm Water. †Cold Water.

These results were surprising in some respects. An increase in milk yield was expected, but instead there was a falling off in this respect, and an unusual gain in weight. This comparatively rich grain ration was made to produce beef rather than milk and butter—a very unprofitable thing for dairy cows to do when already in good condition. We had doubled or trebled the cost of feed over that upon which the cows had been previously wintered and the gains came only in the form of beef. Nearly two and one-half as many pounds gain in live weight were produced as the whole of the butter churned during this period. This could not be due to better care or warmer quarters, since they had nearly or quite as good during the time previous to their being selected for the experiment. During these seventeen days the six cows ate 1,811 pounds of hay, and an equal weight of grain or a total of 3,622 pounds of feed. The relatively small amounts of butter from one hundred pounds of milk was a surprise, as the churning was carefully done, but is explained more or less clearly by the small precentage of cream shown on the milk of the various animals, especially Nos. 88, 42 and 16.

TABLE NO 4.

RESULTS OF PERIOD II., APRIL 14 TO 30 INCLUSIVE.

Station Number.	Total Water.	Pounds Feed Eaten.	Pounds Milk Given.	Per Cent. Cream.	Weight. Beginning	Weight. Ending.	Gain or Loss in Weight.	Butter Produced.	Pounds Milk to One Pound of Butter.	Pounds Feed to One Pound Butter.	Pounds Feed to One Pound Milk	Butter to 100 lbs. Milk.
88	1,050	819	112¾	10½	1,037	1,019	—18					
61	1,259	940	350	12	1,102	1,054	—48					
42	1,864	1,330	442	11½	1,333	1,347	+14					
16	1,499	1,121	312¼	5	1,298	1,282	—16					
65	8,25*	691	228	11¾	1,054	1,047	—7					
76	1,290	1,042	364¼	13	889	1,008	+19					
								lbs.oz.	lbs.oz.		lbs. oz.	lbs.oz
Group†	4,173	3,089	905		3,472	3,420	—52	31–10	28–10	97½	3–7	3–8
Group‡	3,614	2,854	905		3,341	3,337	—4	32– 4	28– 1	88½	3-2	3-9
Totals...	7,787	5,943	1,810		6,813	6,757	—56	63–14	28-5	93	3–4½	3-8½

*Three days before the end of the second period, No. 65 was thrown out of the experiment, on account of sickness. Udder inflamed on left side, some fever, loss of appetite and very great dimunition of milk secretion. May have been caused by a hurt, or may have been constitutional troubles. Has not recovered normal flow of milk.

†Warm water.

‡Cold water.

In this period the 14 pounds of timothy hay in the ration was replaced by 35 pounds of Southern corn ensilage, the aim being to give with a good grain ration a sufficient bulk of ensilage. In other words, to give about as much ensilage as the cows would eat, and with it enough of the grain feed to make as good a ration as was given during the first period. Thirty-five pounds of this ensilage contained less than three-fourths as much *digestible* (calculated) dry matter as fourteen pounds of timothy hay. To have supplemented the grain with an equal amount of dry matter of ensilage would have required over seventy pounds mixed with fourteen pounds of the grain. The analysis of this ensilage, by Prof. Dodge, at the time of harvesting, see Bulletin No. 2, p. 2, compares with timothy hay analysis of Department of Agriculture, Washington, as follows:

TABLE NO. 5.

	Dry Matter.	Protein.	Fat.	Nitrogen Free Ex't.	Crud Fibr.
14 lbs. Timothy Hay.........	12.11	.87	.24	6.41	4.05
35 lbs. Ensilage............	5.81	.46	.05	3.78	1.31

Doubtless the above analyses showe a smaller proportion of dry matter in the green corn than would have been given by the ensilage as the latter was more or less dry when put into the silo. Only 1694 pounds of grain were eaten during this period instead of 1811 pounds during the first period and 4249 lbs. ensilage instead of 1811 pounds timothy hay. Counting out the time lost in sickness by No. 65, the amount of grain consumed is still smaller than that eaten during the first period, but is near enough for a fair comparison. During this period there was a loss in weight, as shown in the table above, also a decrease in both milk and butter. Practically stated, the hay did more good than two and one-half times its weight of this ensilage, or all the ensilage the cows would eat in place of the hay. Had the ensilage been made from a smaller variety of corn with more ears, doubtless the result would have been different.

TABLE NO. 6.

RESULTS OF PERIOD III, MAY 10 TO 17, INC.

Station Number.	Total water	Pounds Feed Eaten.	Pounds Milk Given.	Per Cent. Cream.	Weight. Beginning.	Weight. Ending.	Gain or Loss in Weight.	Butter Produced.	Pounds Milk to One pound Butter.	Pounds Feed to one pound butter.	Pounds Feed to one pound milk.	Butter to 100 pounds milk.
61	862	201	131½	12	1,005	1,018	+13					
42	1,202	350	216	12	1,330	1,366	+36					
16	1,056	349	150½	8	1,315	1,343	+28					
76	802	223	176	13	1,000	1,000	00					
								lbs.oz.	lbs.oz.		lbs.oz.	lbs.oz.
*Group..	2,064	551	347½		2,335	2,384	+49	11.11	29.11	47	1. 9	3. 6
†Group..	1,858	572	326½		2,315	2,343	+28	10. 8	31. 1	54	1.12	3. 1
Totals.	3,822	1,123	674		4,650	4,727	+77	22. 3	30. 2	50	1.10	3. 3

*Warm water. †Cold water.

Owing to sickness and other reasons Nos. 65 and 88 were not included in the third period, and still other causes led to stopping the experiment at about the middle of the third period. However, this period was only a duplicate of the first as the ration consisted of the same proportion of timothy hay, bran, corn meal and oil-cake-meal. The cows again made decided gains in flesh, No. 76 alone excepted. But the production of milk again fell off abnormally. The same tendency to produce fat rather than milk and butter that occurred when hay was fed the first time to cows accustomed to ensilage was again observed. While there was a decrease in milk and butter produced during the second period as compared with the first, this is also true of the third compared with the second. This puts the ensilage in a better light, as the decrease in milk was continuous throughout the experiment. Though this last period was more or less unsatisfactory because of removing two cows, the proportionate value of hay over two and one-half times its weight of this ensilage would have been overestimated had we stopped at the end of the second period. The one fact standing out prominently is, that the hay and grain ration produced an unusual and undesirable increase in live weight, while the ensilage and grain ration went more to milk, and even allowed a slight decrease in weight.

The kind and quality of the corn ensilage is a most important consideration. That used was made from the largest Southern variety, grown under conditions to make the largest possible growth, and by actual weight produced 35 tons per acre.

The average daily weight of the cows during the second period was 1128 pounds, and the average amount of ensilage eaten was 41½ pounds, together with 16½ pounds of grain. This ensilage was less than 20 per cent. dry matter, or in this respect the poorest quality of corn ensilage. Owing to the lateness of the season the ensilage had become slightly more sour than it was during the winter. This may have caused the cows to eat somewhat less than they should, though with such a good allowance of grain this is not probable. They did not eat enough of the ration to either maintain the flow of milk or to keep from falling off in weight. Had the ensilage been made from corn of average sized stalks, each with a good ear, the result would certainly have shown better for the silo.

A field has been grown in drills the present season to test this matter. One-half the field is large Southern corn, while the other is a good sized flint variety. These two kinds of corn have been made into ensilage ready for a comparative test of their feeding qualities the coming winter.

WARM VERSUS COLD WATER FOR DAIRY COWS.

In all the feeding experiments here reported the results of warming water for dairy and beefing stock were carefully noted, and although it was late in the season, it was thought that this time of the year would not only furnish a comparison between the earlier colder period during the last of March and first of April, and the warm weather later, but might also have a bearing on some theoretical questions of interest in connection with the subject, and might serve to compare with similar work to be done the next winter. The six cows above referred to were divided into groups of three each, the ffrst group receiving water warmed uniformly to 70° F., and the second group water cooled to 32° F., or ice cold. The only difference so far as we could control conditions was, that part had ice cold water and the others water with the "chill taken off." The milk of each group was set and churned separately. Results are shown in the tabular statements of periods I, II and III, in the above discussion of the ensilage vs. timothy hay experiment, tables 3, 4, 6.

TABLE NO. 7.

AVERAGE TEMPERATURE OUTSIDE AND WITHIN THE STABLE.

	Outside.	In the Stable.
Period I, March 22 to April 7	24½°	46½°
Period II, April 14 to 30	40	52½
Period III, May 10 to 17	42	52

These averages were made up of daily readings taken morning, noon and night. Though we had some below zero weather during the first period and a daily average outside of 7½ degrees below freezing, the temperature inside was not much below the average of the two subsequent periods. The cows were out in the yard nearly every afternoon during the first period, but were kept more confined during the remainder of the time on account of inclement weather. Much significance cannot be attached to the fact that the weather was colder in the first than latter periods, as the cows were comfortable nearly all the time and were not exposed to storms.

TABLE NO. 8.

HOW WARMING AFFECTED THE AMOUNT OF WATER DRANK.

		Total water given.	Daily average weight of group.	Daily average drank per 1000 pounds live weight including that used in moistening hay	Daily average drank per 1000 pounds live weight not including that given in feed.
Warm-water Group.	Period I. . .	5891	3387	104	89
	Period II. .	4173	3443	71	71
	Period III.	2064	2366	109	99
Cold water Group.	Period I. . .	5570	3311	99	90
	Period II. .	3614	3354	63	63
	Period III.	1858	2334	99	88

In the right hand columns of the above table the estimate is reduced to the average daily amount drank by a one thousand pound cow. The column furtherest to the right does not include the water used in moistening the hay during the first and third periods, while the column next to it does. Much less cold water was drank per one thousand pounds live weight, than of warm water in all the periods, one instance excepted, and less was drank when ensilage was fed than when hay was given even if that used in moistening the hay is not counted, see last column of the table. In the last period, when the average temperature outside was 42° and inside 52°, one-tenth more warm than cold water was taken.

TABLE NO. 9.

RESULTS IN PAIL AND CHURN.

	Period.	Feed eaten.	Milk given.	Butter produced.	Pounds Milk to 1 pound Butter.	Pounds Milk to 100 Pounds Feed.	Butter to 100 Pounds Feed.
Warm-water Group.	I.	1,796	1,047	39 lbs. 11½ oz.	26	58	2 lbs. 3 oz.
	II.	3,089	905	31 lbs. 10 oz.	28	29	1 lb.
	III.	551	348	11 lbs. 11 oz.	29	63	2 lbs. 2 oz.
Cold-water Group.	I.	1,823	1,156	42 lbs.	27	63	2 lbs. 4 oz.
	II.	2,854	905	32 lbs. 4 oz.	28	32	1 lb. 1 oz.
	III.	572	327	10 lbs. 8 oz.	31	57	1 lb. 13 oz.
W'm-wt'r Group.	Totals	5,436	2,300	83 lbs.	28	42	1 lb. 8 oz.
Cold-wt'r Group.	Totals	5,249	2,388	84 lbs. 12 oz.	28	45	1 lb. 10 oz.

The relatively large amounts of milk required per pound of butter can be attributed only to the fact that the cows gave milk very poor in butter fats, as the milk was carefully set and the cream was raised, soured and churned in the best manner.

As will be noticed from the above table, there is no marked advantage for either the warm or cold water group. During the first and second periods, slightly more milk and butter were produced from one hundred pounds of feed by group 2 on cold water, while during the third period the advantage was in favor of the warm water. Taking the total quantities of feed, milk and butter, the advantage appears on the side of the cold water. Doubtless, these differences are not striking enough to allow the assumption that cold water was really better for these cows than warm, but the testimony leans that way, at least for this time of the year, and with the best of shelter and care.

GAINS AND LOSSES IN LIVE WEIGHT.

The two Holsteins gave comparatively small amounts of milk of very poor quality and converted most of the rich feed into profitless beef. They both increased in weight for the whole time and for each period excepting No. 16 during the second period. The two natives also gained during the total time and during each period excepting No. 88 for the second period. Of the Ayrshire grades, No. 61 decreased in weight except during the last period. No. 65 gained during the first period and then fell off rapidly.

Taking the whole time, the second group or the one given cold water gained while the other no more than held its original weight. During the first period group 2 made the larger gains and fell off least in the second period, but gained somewhat less in the last period. The cold water group gained most in flesh under these conditions, viz.: comfortably warm nearly all the time. The following table shows the weights and gains or losses by periods, also for the entire time, for each animal and for the two groups. The last column, entire time, includes the two weeks of preliminary feeding before the second and third periods and on this account is not the sum of the previously given gains and losses.

TABLE NO. 10.

THE EFFECT OF WARM AND COLD WATER ON THE WEIGHTS OF ANIMALS.

Station Number.	Period I.			Period II.			Period III.			Entire Time.		
	Weight at			Weight at			Weight at			Weight at		
	Beginning.	Ending.	Gain or Loss.	Beginning.	Ending.	Gain or Loss.	Beginning.	Ending.	Gain or Loss.	Beginning.	Ending.	Gain or Loss.
* 88	969	1021	+52	1037	1019	—18	......	......	......	969	1019	+34
* 61	1100	1098	— 2	1102	1054	—48	1005	1018	+13	1052	1000	—52
* 42	1305	1331	+26	1333	1347	+14	1330	1366	+36	1305	1366	+61
† 16	1238	1294	+56	1298	1282	—16	1315	1343	+28	1238	1343	+105
† 65	1052	1072	+20	1054	1047	— 7	......	......	......	1052	1047	— 5
† 76	960	1002	+42	989	1008	+19	1000	1000	00	960	1000	+40
*Group	......	......	+76	......	......	—52	......	......	+49	......	......	+43
†Group	......	......	+118	......	......	— 4	......	......	+28	......	......	+140

*Warm Water. †Cold Water.

CORN MEAL AND WHEAT BRAN COMPARED.

March 31, 1888, four grade brown Swiss steers, two years old, were placed in the experiment feeding stables with the six cows above mentioned. They were partially fatted steers, selected from the Minnesota Transfer Stockyards, where they had been sold for beef. Other than being rather large boned, they were a fairly smooth lot of half-fatted steers. Presumably they had been sold as soon as marketable on account of shortage in feed. We congratulated ourselves that just the right stock had been secured, and that with these, both the experiments with hot vs. cold water and with different feeds would be entirely satisfactory. The sequel proved that too much had been based upon outside appearances, and that previous feeding, or other causes, had put them in such shape that they would not make profitable gains with the best of management and feed. True, large gains were not felt to be absolutely necessary to make comparison between two feeds, or between warm and cold water, though the experiment would have been better had the animals been in a condition to show profit. They were fed and watered three times a day, and were given a few hours' exercise during the day in fine weather. Though they were fed lightly during the early part of the first preliminary feeding which continued over thirteen days, they did not take hold of the mixed ration of ensilage, corn meal, and bran, fed in the first period. They would get "off feed," scour, become lame, drink very irregularly, and show a general indisposition to fatten. They were fed during two periods of eighteen days each, with a week or so of preliminary feeding between. During the first period, April 13 to 30, they were given a ration composed of 20 pounds of ensilage to 6 pounds of bran and 6 pounds of corn meal. The ensilage was from the same silo as that fed the six cows. The grain was thoroughly mixed with the ensilage before feeding. The feed consumed, water drank, and gains or losses are shown in the following:

TABLE NO. 11.

FIRST PERIOD APRIL 13 TO 30.

	Weight.		Gain or Loss.	Feed Eaten.	Water Drank.
	Beginning	Ending.			
* 38	1027	1024	--3	650½	1011
* 53	1186	1193	+7	686	1152
† 70	1152	1191	+39	602	887
† 96	1045	1037	--8	601	746
Group *.....	2213	2217	+4	1336½	2163
Group †.....	2197	2228	+31	1203	1633
	4410	4445	+35	2539½	3796

*Warm water.
†Cold water.

Though more or less dainty about their feed, the steers ate rather regularly during this period, but not enough at any time to make good gains. They were more irregular in drinking than the cows. The gain was only about one-half pound per day each, though 1525 pounds ensilage, 457 pounds corn-meal, and 457 pounds bran were fed.

Another experiment of longer duration was contemplated, but when the steers did so poorly the ration was changed to ensilage and all corn meal, instead of part bran, or 20 pounds of ensilage to each 12 pounds of corn meal.

TABLE NO. 12.
SECOND PERIOD, MAY 10 TO 27.

	Weight. Beginning.	Weight. Ending.	Gain or loss.	Feed eaten.	Water drank.
* 38	1,029	1,009	—20	630	674
* 53	1,213	1,215	+2	754	733
† 70	1,193	1,215	+22	633	632
† 96	1,047	1,039	—8	588	572
Group *	2,242	2,224	—18	1,384	1,407
Group †	2,240	2,254	+14	1,221	1,204
Totals.	4,482	4,478	—4	2,605	2,611

*Warm water.
†Cold water.

They were still more irregular in their eating during this time than during the first period, and were especially irregular in their drinking. The four cattle ate 1628 pounds ensilage and 977 pounds corn meal and did not quite hold their own in weight. During the last period the ensilage began to sour by being so long exposed to the temperature of springtime. The steers seemed to stand confinement worse the longer they were kept in the stable. These things may, partially, account for the slightly poorer performance of the cattle during the second period. Part bran with corn meal and ensilage produced better results than all corn meal and ensilage, though further and more satisfactory trials are necessary before laying this down as a principle. In sections north of the "corn belt" and near the great bran markets, such a method of feeding seems very desirable. The smaller dent varieties of corn that will ripen here and the flint kinds, furnish the relatively small proportion of corn meal, the flour mills furnish the bran, and ensilage can be as successfully grown here as in the best corn section. Ensilage made from green corn is poor in "muscle formers" which are not supplied in sufficient quantities by adding all corn meal. Bran supplies these more costly elements comparatively cheap. One of the largest economical elements in such a system of feeding is, that it returns, in the manure, the nitrogen contained in bran, to the same region from whence came the wheat, instead of allowing it to leave the wheat raising districts to be fed further south and east, enriching farms there, and impoverishing the wheat lands of the one element most desirable to retain.

WARM VERSUS COLD WATER FOR BEEF.

The steers above mentioned were divided into two groups, when placed in the stable, with numbers and weights as follows:

1, Warm Water Group,	No. 38	1,008 pounds.
	No. 53	1,200 pounds.
2, Cold Water Group,	No. 70	1,165 pounds.
	No. 96	1,060 pounds.

The above tables of the two groups, tables 11 and 12, show the amounts of water drank, together with the consumption of feed, etc. Group 1 received water warmed to 70° and group 2 ice cold water. The consumption of water by group 1 was 32 per cent. greater than by group 2, in the first period, and 17 per cent. greater in the second. Though due mainly to the gains of one steer, group 2 did better on cold water than group 1 on warm water. Taking the whole time. group 1 lost 14 pounds and group 2 gained 45 pounds, or a difference of 59 pounds in favor of cold water, nearly one pound a day for each steer.

GENERAL CONCLUSIONS.

(1) Besides getting our experiment feeding stables in running order and giving a little experience in conducting tests of this kind, for work to be taken up in the near future, the experiments here recorded have value, both of themselves, and to compare with results to be obtained hereafter.

(2) The fact that ensilage made from the largest, "most watery" kind of Southern dent corn, grown 35 tons to the acre, can be compared with fine timothy hay, nearly in the proportion of 2½ to 1 for milk cows, is most important. While we do not necessarily claim that more digestible food is taken out of the silo than is put into it, the results of these experiments would suggest that ensilage has the quality of making the grain feeds with which they are given, more digestible. The cows seemed to relish the *ensilage* with grain far better than the moistened *hay* with grain. If the succulency of the ensilage increases the *palatability* of the grains, it is reasonable to suppose that it may increase their *digestibility* also, since these two qualities of foods are so intimately associated.

(3) The fact that these cows decreased in milk yield when changed from the ensilage, bran and a little hay fed the dairy herd during the winter, to the rich grain and hay ration given during the first period, very much strengthened our faith in the silo. This faith was made still stronger by the practical work of the experimental feeding as well as by the results. One prominent fact is that the timothy hay favored the production of fat on these cows, during both periods one and two, while ensilage favored the production of milk and butter.

(4) Part bran, instead of all corn as a grain feed to supplement corn ensilage, proved the better for fattening steers. If confirmed upon further trial, this is a most important fact brought before those who produce beef, especially in the great wheat regions of the Northwest, where cattle and more diversified farming, to prevent lessened fertility, are much needed.

(5) With a warm stable and little exposure to cold during the late winter and early spring, milk cows did somewhat better on ice-cold water than those for which the water was warmed to 70 deg. F. Doubtless water at 50 deg. would have given better results than either of these extremes under the conditions of the experiment. The point made is, that any benefit arising from warming water in cold weather (and we believe there is a benefit) must come from the combined ill effect of cold applied externally and internally at the same time, as the latter alone gave no bad results. Cold water in common practice, doubtless adds much in ill effects to the externally applied cold, recently strained through barbed wire fences, or even the silent, unadulterated below zero weather of our northern winters. Cold water may be the last straw which breaks the back of profit.

(6) Warming water for these beef cattle during the spring weather proved quite harmful, even when compared with results from ice-cold water. This still further illustrates the point, that warming water in any but very cold weather does not pay, and may even do harm.

(7) The general interest which has been manifested by farmers in the subject of warming water for their stock, and the absence of well authenticated facts upon the subject, mark this as an important line of investigation, and our experiments will be continued during the ensuing winter, and the results reported.

DIVISION OF ENTOMOLOGY.

OTTO LUGGER.

FUNGI WHICH KILL INSECTS.

It is now a well known fact, that quite a large number of diseases attacking plants, animals and man are produced by very lowly organized plants. These vegetable parasites nearly all belong to the cryptogamous or flowerless plants, and are most usually called microscopic fungi. Fungi infesting plants were well known since time immemorial, but no one supposed them to be the cause of a disease; they were considered simply as the products of peculiar abnormal conditions of the parts of a plant upon which they were found growing. Only quite recently the investigations of Tulasne, de Bary, Kuehn and other students of microscopic organisms proved beyond any doubt, that all such vegetable parasites were produced—like every other plant—from seeds or spores, and that their growth in or upon other plants produced a diseased condition of its host, and eventually its death. The most indubitable proofs for such a statement consisted in artificially infecting a healthy plant with germs of the parasites taken from a diseased one, and by thus producing in due time the same disease. Furthermore, the actions of many of these vegetable parasites have been followed step by step with the microscope: the germination of the spore upon the infested plant, its entrance into that plant, the formation and growth of mycelium and later of the spores were all closely observed, and thus the course of the disease was made quite plain.

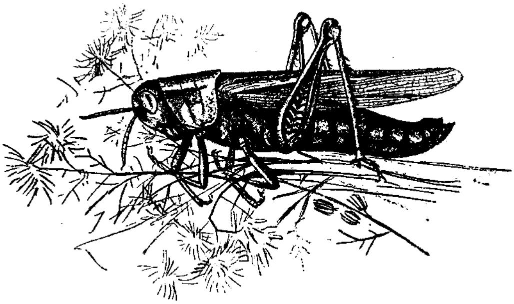
It would take up too much space to even mention the numerous parasitic fungi which produce disease in plants. They belong to several families of cryptogamous plants, and consequently are quite different in their respective actions. Prof. F. Lamson Scribner, in the Reports of the Department of Agriculture in Washington, has during the last three years described and illustrated a number of them, but chiefly those affecting grape vines. His excellent papers should be read by those interested in such matters, as being both instructive and of economic importance. As familiar instances of fungi producing disease I mention: blights, rusts, mildews, smuts, etc.

A disease in plants or animals produced by fungi usually takes the following course: the spores penetrating to the interior of their host, and there rapidly growing and multiplying, soon cause disintegration of the attacked healthy organs, and eventually either a slow or a sudden death. It is not by any means always easy to prove, that the presence of fungi is the cause or the effect of a disease, but in quite a large number of cases—aside from the diseases in plants produced by them—we know positively that they are the cause, and not the effect.

As an illustration of the fact that invisibly small plants are able to occasion either immense losses or great good, I simply mention the various and better known contagious diseases which kill our domesticated animals. It is not alone well known, but can also be demonstrated, that the Rinderpest, Texas Fever, Pleuro-pneumonia, Charbon, Black Quarter, Tuberculosis, Hog Cholera, Fowl Cholera and numerous other diseases are each caused by a different species of bacterium. Broadly speaking nearly—if not all—contagious diseases are due to the rapid multiplication of such small plants in the one or the other organ or organs of the affected animal. Nor is man himself exempt from their inroads, as Cholera, Yellow Fever, Scarlet Fever, Small Pox, and a host of other diseases too plainly prove.

The same assertion can be made in regard of insects killed by contagious diseases, and such diseases are by no means as isolated and rare as most people seem to think. If we examine carefully dead leaves and moss, principally in wet places or after a rainy season in summer or autumn, we will surely find large numbers of insects killed by various species of fungi. In turning over an old piece of decaying board quite frequently numerous dead ants can be seen fastened to it, and all plainly show the cause of their death by being surrounded with mycelium threads, or by having a horn-like process growing through the soft integument between their heads and thorax. During the past summer diseases of similar characters were quite common, and material for study could be obtained without much trouble. Certain plant-lice, frequently found upon clover, could be seen in vast numbers upon the leaves of that plant, dead, and surrounded and imbedded by spores. In fact I found it rather difficult to mature certain caterpillars in confinement, and had to shift the position of my breeding boxes quite frequently to insure success. Various caterpillars, chiefly those of our gaudy diurnal butterflies, all died from the effects of a disease produced by a fungus, and patches of their food-plants were draped with their black and putrid bodies. Chinch Bugs suffered greatly by one of these diseases, as will be mentioned later. Even the common Two-striped Locust (*Caloptenus bivittatus*), usually a rather tough insect and proof against the usual ailments of insects, was killed in numbers by a vegetable disease. Fig. 1 gives an illustration of this locust, showing the frantic efforts of the dying insect to keep its hold upon a plant. The specimen here

Fig. 1.



Caloptenus bivittatus, killed by a fungus. Original.

figured showed no outward indications of any disease, and as no spores were visible, it had the appearance of having been killed by a parasitic insect, by a Tachina fly. But closer investigation showed no evident trace of such being the case; on the contrary, the whole inside of the dead locust was filled with a white, powdery material, composed of mycelial threads, and strongly smelling like some of our common toad-stools.

It is not my intention to minutely describe the numerous species of fungi that kill insects, but simply to mention and illustrate a few of the more important ones, to give the reader an idea of these lowly organized plants. Some of the illustrations were borrowed from the "Lehrbuch der Mitteleuropæischen Forstinsekten-kunde" by Drs. Judeich and Nitsche. Some of these fungi occasion great losses to the silk-growers and bee-raisers; others are of great value in assisting us to combat our injurious insects. Future investigations and careful experiments may still give us the means to produce such diseases at will, and at a time when their assistance is most needed. I refer to the artificial culture of the fungi which produce disease. If this should ever become possible—and there is but little doubt that it will—practical entomology will have a new and most important assistant in fighting noxious insects, even in places, where their presence is only suspected.

The fungi which kill insects belong principally to the orders *Schizomycetes*, *Ascomycetes* and *Entomophthoreæ*.

SCHIZOMYCETES OR BACTERIA.

These fungi are exceedingly small organs, each consisting of a single cell. They multiply by self-division. The cells are of various shapes, some are globular, others oval, elliptical or cylindrical; they occur either singly, in pairs, or united in thread-like or chain-like masses. Some are without any motion, others move by means of whip-like organs, more or less rapidly, but even these latter enter stages in which no motion is visible. In this case they are imbedded in a jelly-like material.

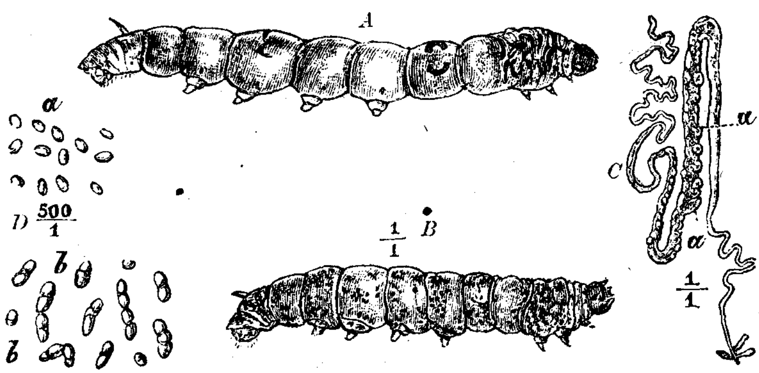
Large numbers of insects are killed by the various species of fungi composing this order, but only two of them have been studied more thoroughly.

The *flaccidity* (flacherie, maladie des morts, blancs, schlaffsucht) is produced by *Micrococcus bombycis* Cohn. This disease is in some years so prevailing in some countries that it prevents a successful silk-culture. An excellent article prepared by Prof. C. V. Riley on this and other diseases attacking the silkworms can be found in Bulletin No. 9 of the U. S. Agricultural Department, which forms a "Manual of Instructions in Silk-Culture." This disease was quite common this summer, attacking the caterpillars of our most common and beautiful butterflies. *Pyrameis atalanta*, *Pyrameis cardui*, *Vanessa antiopa* and *Vanessa grapta* were killed in vast numbers, both near the Experiment Station and in Otter Tail county. A few spores, introduced into a caterpillar either with food contaminated by a diseased one, or from the outside, multiply with great rapidity, and soon disintegrate the blood and tissues, thus causing decay and death. As this disease is very contagious the caterpillars of above insects, which are to some extent gregarious, as their food-plants: nettles, hops etc. are quite local and usually grow in patches, soon all die in any given locality. Newcomers, produced from healthy eggs laid by butterflies attracted from a distance to these inviting stores of food, also soon become diseased, probably from spores left upon the leaves by the former victims.

The "*Faulbrood*" of our honey-bee is also produced by a similar plant, the *Bacillus melitophthorus* or *alvei*. This disease is well known in many regions, and frequently threatens to put for the time a stop to any further attempts in raising bees.

The *Pebrine*, another disease of the silkworm, is also produced by low organisms, but at present their position in a botanical sense is not quite certain. Balbiani even considers the parasites producing Pebrine as animals belonging to a group called *Sporozoa*. In fact it is by no means quite certain that all the fungi mentioned thus far really belong to different species and genera; some naturalists claim them to be simply members of one and the same cyclus of growth. Fig. 2 illustrates the Pebrine of the silkworm.

Fig. 2.

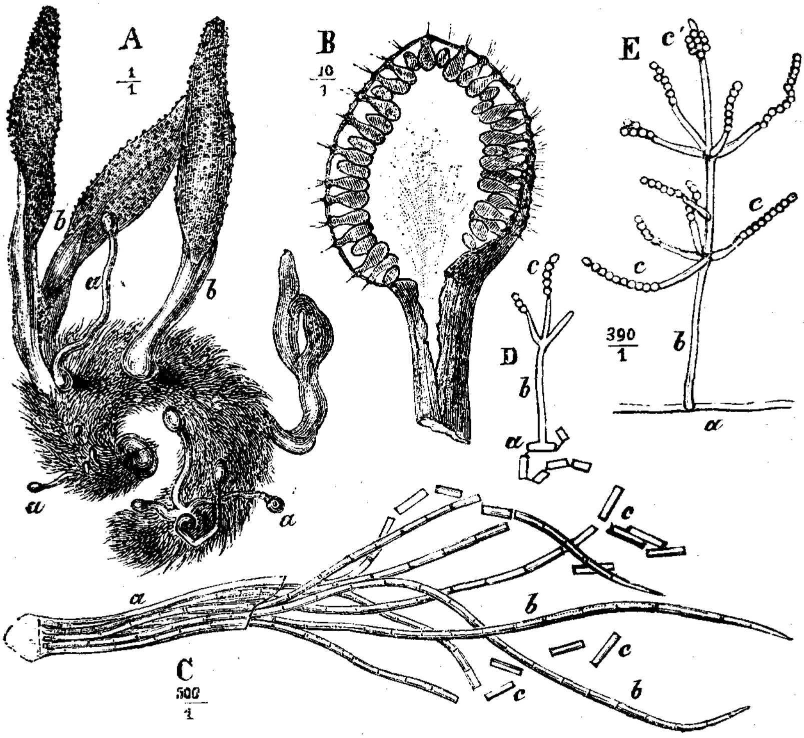


Silkworms affected by Pebrine —"*A*, Healthy silkworm. *B*. Diseased silkworm. *C*, Spinning glands of a diseased silkworm, with knotty swellings. *a D*, *Micrococcus ovatus* Lebert, the fungus causing disease; *a*, single cells. *b*, cells in the act of self-division. After Lebert.

ASCOMYCETES OR "CATERPILLAR FUNGI."

These fungi are distinguished by an elongated spadix-shaped fruit-bearer (Fig. 3, A) in which Asci or spores are formed in peculiar little bottle-like cavities (Fig. 3, B). But besides the spores formed upon such fruit-bearers others can be formed directly upon the surface of the mycelium, or by special hyphæ. All these methods of reproduction are illustrated in Fig 3.

Fig. 3.

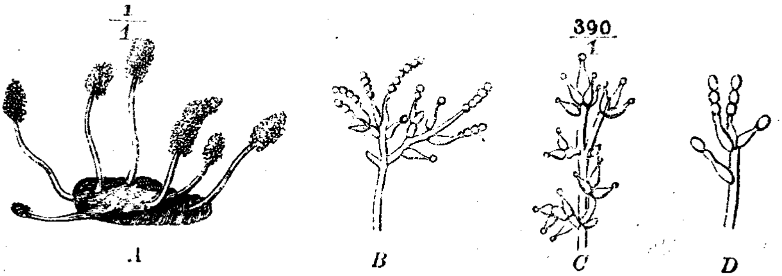


A, *Cordyceps militaris* Fries, upon a caterpillar of *Bombyx rubi*; *a*, undeveloped, *b*, developed spadix-shaped fruit-bearer withprojecting papillæ-like openings of the perithecia. *B*, Longitudinal section through the spadix-shaped fruit-bearer of *Cordyceps entomorhiza* Fries., to show the arrangement of the bottle-like perithecia. *C*, Exploded ascus of the same fungus with the eight long ascospores, which divide again in smaller spores. *D*, Gonidia-bearer *b*, developed from small spores *a*, and producing globular gonidia *c*. *E*, More mature gonidia-bearer *b*, of the same fungus, growing from a mycelical thread *a*, and carrying globular gonidia *c*. *A*, *B* and *C* after Tulasne; *D* and *E* after de Bary.

The best studied species in this order of fungi is *Cordyceps militaris* Fries. (*Torrubia militaris,* in honor of a Spanish monk who first discovered such peculiar parisitic growths upon some wasps in the West Indies.) A good description by Prof. C. V. Riley, with illustrations, can be found in the "American Entomologist," Vol. III. The larvæ of our May-beetles, well known by the popular name of White Grubs, are quite often attacked by this fungus, and when found always attract the attention of the curious. The inflorescence generally presents the appearance of a pair of elongate horns, one issuing from each side of the head. These two horns—sometimes there are four—are usually of different lengths, and grow to the length of three to five inches. Other larvæ are also affected in a similar manner, for instance, those of our Stag-beetles, of the Seventeen-years Cicada, and others.

A peculiar form, but belonging to the cyclus of growth of the *Cordyceps*, is found upon various caterpillars and pupæ; it is *Isaria farinosa* Fries. It is illustrated in Fig. 4. This fungus

Fig. 4.



Isaria Hill. *A*, pupa with the stomata of *I. farinosa*. *B*, end of fruit-hyphæ bearing globular gonidia. *C*, the same with less active fructification. *D*, the same with oval gonidia of *I. strigosa* Fries. After de Bary.

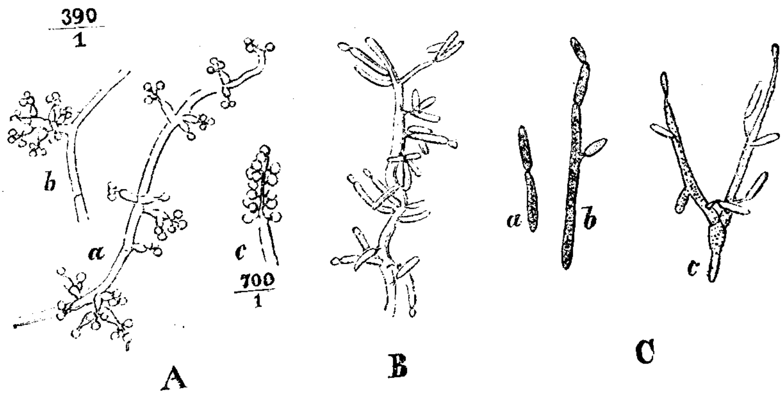
is quite common, and as seen in the figure, is distinguished by its peculiar and numerous stromata or fruit-bearers.

Botrytis Bassiana Balsamo is another fungus that belongs to this order. It produced at one time the well known disease of the silkworm, usually called the *Muscardine* (Fig. 5), but is now but rarely met with, appearing only in very wet, warm seasons. As soon as one of the spores of this fungus lodges upon the skin of a caterpillar, it commences to germinate, and penetrates through the skin, and once inside, ramifies in all directions. The point of entrance is usually indicated by a discolored spot. The affected caterpillars usually die in the course of twelve to fourteen days, looking soft and shrunken. Soon after, however, the corpse commences to swell up again, owing to the increasing pressure of the growing mycelium from within, until the extended skin is ruptured; in dry weather the caterpillar shrinks up into a mummy.

not only met in worms

It is only "the spores" [I think so] that attack plants or animals, and then only when the spore falls, or lights upon the proper [illegible]

Fig. 5.



Botrytis Bassiana Balsamo. *A*, *a*, *b* and *c* fruit-hyphæ bearing gonidia, with more of less numerous spores. *B*, hyphæ-tubes from the skin of a caterpillar producing gonidia. *C*, cylindrical gonidia and the beginnings of hyphæ in the blood of a caterpillar forming secundary gonidia. After de Bary.

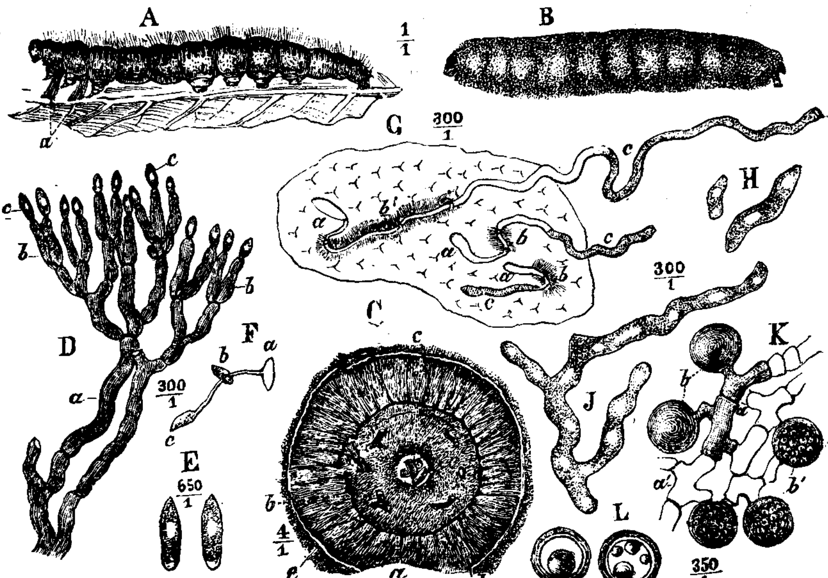
ENTOMOPHTHOREÆ, *or* INSECT KILLING FUNGI.

These fungi, which produce epidemic diseases only among insects, belong to the group of *Phycomycetes*, whose systematic position is not quite certain. It is a small family, only parasitic upon insects, and contains only the two genera *Entomophthora* and *Empusa*, which are mainly distinguished by the former having branching mycelial threads (Fig. 6 J.), while in the latter they are formed by one-celled threads (Fig. 8 F).

The most thoroughly studied species in Europe is *Entomophthora radicans* Bref., which produces quite frequently an epidemic disease upon the larvæ of the cabbage butterfly. It occurs in this country as well, and is illustrated in Fig. 6. The usually lively caterpillars of this noxious butterfly soon show the effects of an infection; they become quiet, slow in all their motions, die suddenly, and are soon entirely enshrouded by a greenish-white fungus, the infloresence of which lasts but a few hours, leaving nothing of the caterpillar as a brown shrunken skin, surrounded by large masses of white spores. This fungus does not increase in the body of its host by self-division (like yeast plants), but forms a many-jointed mycelium, which eventually fills the whole interior of the affected caterpillar. According to quite recent investigations this fungus forms also resting spores, which are said to be produced by the copulation of two mycelial branches.

Another species is *Entomophthora aulicæ* Reichard. (Fig. 7), which in Europe has been quite often of great service in

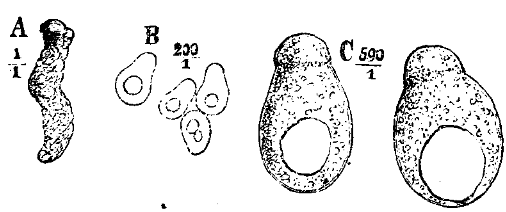
Fig. 6.



Entomophthora radicans Bref. *A*, caterpillar of *Pieris brassicæ* killed by it; *a*, the hyphæ growing out from it. *B*, the same at a later stage, and entirely enveloped by the fungus. *C*, cross-section through *B*; *a*, cuticula of caterpillar; *b*, tracheæ; *c*, remains of food —all the soft parts of the caterpillar are replaced by mycelium threads, which have, at *d*, penetrated through the skin, and formed spores, at *e*. *D*, *a*, fruit-hyphæ; *b*, basidia; *c*, spores. *E*, single spores. *F*, a single spore *a*, producing a mycelium thread with secondary spores *b* and *c*. *G*, a piece of the skin, with germinating spores *a*, penetrating the skin at *b*, and growing in the interior at *c*. *J*, branched mycelial thread. *K*, mycelial threads bearing resting spores; *a*, filled with protoplasm; *a'*, emptied; *b*, developing, and *b'*, mature resting spores, *L*, mature resting spores with a thick envelope and fat-drops within. After Brefeld.

checking the devastating armies of certain caterpillars. It is illustrated in Fig. 7.

Fig 7.



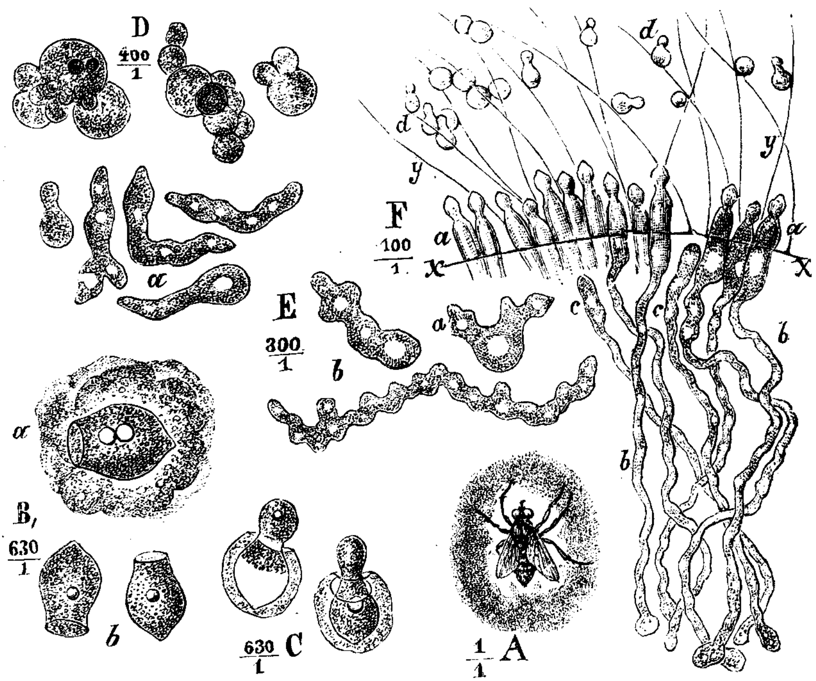
Entomophthora Aulicæ Reichard. *A*, caterpillar with fruit-hyphæ breaking through skin; *B* and *C* gonidia. After Nitsche.

One of the most frequently observed diseases produced by fungi is the "*Fly Cholera*," produced by *Empusa* muscæ*, Cohn. This disease can here be observed every year, from the middle of September to the beginning of winter, but in more southern regions it is found throughout the year. The first stages of it are indicated by the restlessness of the attacked flies; they soon, however, become weak and slow in their motions. Having securely fastened themselves with their broad tongues to the object upon which they happened to be when attacked by the last stages of the disease, a succession of spasmotic tremors pass through their wings and legs, and the tormentor and destroyer of our slumber is no more. The abdomen of the victim of this disease, previously already swollen, becomes more and more distended, and a fatty, whitish substance pushes through the softer membranes between the rings or segments. Soon after a whitish halo of spores is formed around the dead body, readily seen if the fly happens to have fastened to the glass of window or mirror. These spores gradually cover the whole insect with a white dust, and they appear in ever increasing numbers as the body of the victim dries up, until at last its whole interior is empty and only a shell remains. In the earlier stages of the disease, and before it can be recognized by any outward signs, its presence can be detected by the milky condition of the blood, produced by very numerous, roundish and floating cells of fungi. These cells (Fig. 8) grow into elongated, contorted and cylindrical bodies always composed of a single cell, which—after the death of the victim—push their cone-shaped heads through the thin skin between the chitinous abdominal rings, and produce outside the fatty, white dust already mentioned. At all the exposed ends of these elongated cells appear in due time globular spores, which gradually assume the form of bells; they are, by constriction, at last separated and thrown forcibly into space, forming the halo surrounding the dead insect. Each of the ejected spores is surrounded by a small mass of protoplasm torn away from the cell; this latter collapses after having ejected a spore, and a new one is gradually formed in its place, also to be ejected in due time. This throwing off of spores is continued for a long time. If such an ejected spore lodges upon a healthy fly, it is held in place by the sticky pro-

*Empusa, according to a greek superstition, was a weird spectre of constantly changing shape.

toplasm, and if it should have been glued upon a soft part of the insect, for instance upon the underside of its abdomen, it will commence at once to grow and penetrates through the skin of its new victim. Once inside the spore rapidly increases by self-division in the manner of yeast-cells, and soon afterwards produces again sickness and death. If, however, the ejected spore is lodged upon some unsuitable substance, it is able, on account of the drops of protoplasm surrounding it, to produce upon its end a secondary spore, which is again forcibly thrown into space.

Fig. 8.



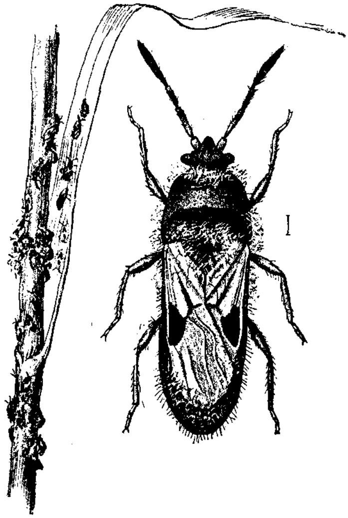
Empusa muscæ, Cohn. *A*, a dead fly killed and surrounded by a halo of spores. *B*, spores; *a*, surrounded by protoplasm; *b*, without the same. *C*, germinating spores forming secondary spores. *D*, empusa cells forming tubes. *F*, partly diagrammatic representation of the fructification; *x*, the skin of the fly; *y*, hairs of the fly; at *a* the ends of the hyphæ breaking through the skin and bearing spores; *b*, the hyphæ-tubes still in the body; *c*, tubes not yet reaching the skin; *d*, spores thrown off and adhering to hairs, some already forming secondary spores. After Brefeld.

Such secondary spores are very apt to come in contact with the underside of flies running over them. Diseased flies, dying in wet places, produce no bell-shaped spores, but simply globular, colorless, and thick-skinned ones, rich in fat, which are the resting or dormant spores. Such resting or dormant spores are not easily destroyed by unfavorable conditions, and can bridge over from one season to another, and some resting-spores have been known to be dormant for three and more years before they started a new cyclus of growth. Such spores, at least those of the *Empusa*, are produced without copulation ; there are, however, some species of Entomophthora, whose resting-spores are produced by copulation.

THE CHINCH-BUG AND ITS DISEASE.

During the last three years Chinch-bugs have occasioned immense damages to the various cereals in this State, but chiefly so in the more southern counties. They have been steadily on the increase, and were rapidly spreading in a northerly and westerly direction. This increase was entirely due to the very favorable atmospheric conditions prevailing throughout the summers of 1885, 1886 and 1887, which were very dry and warm, and just suitable to these bugs, which are essentially dry and warm summer insects. Owing to a wet, cold, and very backward spring in 1888 they were not in a very healthy condition when warm weather commenced, and large numbers were killed in their wintering quarters. Here at the Experiment Station all the Chinch-bugs hibernating in the fields, where they had been exceedingly numerous and injurious in 1887, were found upon close examination to be dead. Their bodies could be found in all suitable wintering quarters, and frequently hundreds were huddled together. But upon the slopes of the hills, covered with oaks, bounding and protecting the beautiful station on the north, the conditions were quite different, and in favor of the Chinch-bugs. The copious rains of the spring could not lodge there for any length of time, and the sun would soon dry the drenched bugs on these sunny hillsides. Consequently large numbers wintered there in safety, and formed a center of distribution for our experimental plots. A 40-acre field of oats, in very close proximity to these hills, formed the nearest point of attack for the hungry bugs, and as soon as warm weather commenced they migrated to this land of plenty. They invaded, however, only the outer edge of this field, and lodged upon the still quite small plants, which soon paled under this infliction. Prof. Porter and myself had just concluded to give our enemy a warm reception, even upon a field not belonging to the station, as a sudden change in the weather kindly assisted us, and removed the threatening danger, by means of three very cold and wet days. After this no bugs could be found in this field, and all danger was thought to be over. Real warm weather now became the rule, and the slumbering vegetation, as by magic, became a blooming reality; so became the Chinch-bugs! The gentle southern wind was loaded with them, and they landed in immense numbers, everywhere, to begin their destructive work in our fields. The warm weather continued, and the first generation of Chinch-bugs became quite numerous and destructive, and the second brood threatened a repetition of last year's disasters. Oats, rye, wheat, and some grass were utterly destroyed by them, and the young and promising corn formed now a standing invitation to the hungry hordes. To prevent their inroads, all the infested fields and experimental plots were surrounded by a low board fence, six inches high, and snugly fitting to the ground so as to prevent the insects from crossing under this fence. The upper edge of the boards were painted from time to time with tar, which prevented the bugs from crossing. The insects were at this time of all sizes and ages; adults of the first brood, eggs, young hatched bugs, and pupæ of the second brood were all mixed together, and all were decidedly hungry, as their intense activity and the swarming armies of famishing bugs plainly indicated. To gather in this crop of bugs, round holes, about six inches in diameter, were drilled in the ground close to the fence, and as one hole became filled with insects, it was closed and another one was opened close by for the reception of more victims. So matters worked to our satisfaction, when an unexpected assistant came to help us, making the structure of more fences unnecessary. The above mentioned holes were quite deep, and consequently were always wet, a condition of things not at all suitable to starving Chinch-bugs, nd ey soon became unhealthy and weak, thus presenting the best conditions for any disease to claim them as its victims. And such a disease, produced by a fungus, was not slow in making its appearance, as could be seen by the numerous dead bugs. The margins of all the holes, but chiefly those more densely crowded with captives, soon became whitened with dead bugs enshrouded in white mycelial threads and dust-like spores, in fact in a few days the upper rims of these holes looked as if recently white-washed. Nor did the disease stop there! On the contrary it spread very rapidly to adjoining fields of timothy, Hungarian grass, millet, etc. Even the course followed by it from the holes could be readily recognized for some time by the more or less numerous white spots left in its wake. The fields invaded by the disease afforded, upon closer examination, a truly edifying spectacle to those not interested in the welfare of the Chinch-bugs. They looked quite panic-stricken, and moved about in a slow and dazed way, figuratively speaking, as if badly scared. And well they might be! The victims of the disease could be seen everywhere by the thousands; they had been slaughtered in all kinds of positions, but they were usually fastened to the blades and stems of the grass, or to the leaves of young clover. All showed plainly that their last and strong determination in life had been to hold on as long as possible; their legs were firmly planted upon the substance where the bug happened to be; others had only their beaks inserted, and were dangling by it free in the air. But all showed the characteristic white mycelium threads and spores of the disease. The illustration in Fig. 9 shows an enlarged Chinch-bug, with white threads issuing from its body, and numerous other specimens in natural size

Fig. 9.



Diseased Chinch-bugs; enlarged specimen to show fungi penetrating through skin and covering it; others in natural size killed by the disease. Original.

killed by the fungus. Although almost exclusively attacking Chinch-bugs, the disease was not slow in also slaughtering such small flies, as found the society of such malodorous companions to their taste. A story with a moral! Not having had access to Prof. S. A. Forbes articles on the disease of the Chinch-bug, I am unable to say whether *Micrococcus insectorum* Burrill has anything in common with the friendly fungus causing all this slaughter, but I hardly think so, as the disease observed here has no similarity to the flaccidity of caterpillars, but appears to belong to a true species of *Entomophthora*. Those interested in contagious diseases of insects should read his excellent paper published as Article IV. of the Bulletin of the Illinois State Natural History, Vol. II.

Most, if not all, the Chinch-bugs would have been killed at the Experiment Station, if the suitable conditions for this disease had lasted a few days longer. But the wet spell prevailing part of the time the disease was playing such havoc amongst the bugs soon passed and was followed by warm and very dry days, which soon stopped any further increase and spread of the disease. But by artificially producing such conditions the disease was kept at work for some time, but only on a very limited scale. Nor could it be spread, because in nature such artificial conditions could neither be produced nor maintained on any extensive scale.

As many parts of the southern portion of this State were overrun with Chinch-bugs, I thought that a good opportunity and an inviting field was presented to purposely spread a disease —an act not usually considered a very kind one to engage in, and one not to be recommended to physicians. This was exceedingly simple, as all that was necessary was to gather a number of the diseased bugs, put them into tight-fitting tin boxes, and mail them to regions infested by Chinch-bugs. Arrived at their destination, the contents of the boxes could simply be thrown in any field known to be infested with such bugs. This was done with specimens of the diseased bugs collected at the Experiment Station, and eighteen different places in southern Minnesota were thus made centers of distribution for this disease. And as it seems with remarkable good results, as the disease has killed off the bugs to such an extent, that careful search in a majority of places failed to produce a single living specimen, whilst the traces of the disease was found everywhere. The disease spread so rapidly, that even corn growing near wheat fields crowded with Chinch-bugs were entirely protected, and no bugs had entered them in all the places visited by myself. But I am by no means satisfied, that the disease was really introduced in this manner. Is it not possible that the disease was there already, unknown to any one, and that I simply re-introduced its germs? The reason for this belief is based upon the fact, that too large an area was infested by the disease, too large to be readily accounted for by the short time in which the atmospheric conditions were—apparently—in its favor. But this may be as it is; one thing is certain, viz.: the disease has been there, and consequently the spores of the fungus producing it are there also, and remain there, to act whenever the conditions are favorable, and I firmly believe that our farmers need not entertain any fears of Chinch-bugs for the near future.

For lack of space the continuation of the article on the "Rocky Mountain Locust in Otter Tail County," as well as an article on the Army-worm, has been omitted. They will be published in the next bulletin.

"Tuberculosis, Tubercular Phthisis or Consumption in Animals."

M. J. TREACY, V. S.

Soon after my appointment, whilst making an inspection tour through the farm animals, my attention was directed to a shorthorn bull, about one year old, No. 36 on the farm records. This animal, although presenting no very definite symptoms of disease, nevertheless, did not show the "bloom of health" in his skin and coat, such as his comfortable surroundings, care and feed would warrant. A closer examination revealed the presence of a small hard, rather painful tumor, about the size of a peach, on the angle of the off side lower jaw. An inquiry revealed the fact, that the sire of this bull died from Tuberculosis, that intermittent lameness with swollen joints, had affected him occasionally. He was marked "suspect," and carefully observed From this time, until his destruction, on the 27th of August, the tumor on his jaw continued growing rapidly, until it extended from about the first molar tooth, to the base of the ear, becoming daily more painful and fluctuating. He emaciated rapidly, appetite poorer each day, the tumor implicating the parotid gland. Having consulted with Professor Porter, we decided to have him destroyed. The post-mortem examination revealed the usual symptoms of that dreadful disease so fatal to man, and the lower animals, viz: Tuberculosis.

The following facts speak volumes, as to the danger to human beings of eating the flesh or using the milk of cattle affected with consumption.

Dr. Kammerer, city physician of Vienna, reports on the dangers to the health and lives, through animals thus affected. He says "the milk of tuberculosed cows, acts with children, as the seeds of 'Phthisis' and that infection, through this channel is quite as fruitful source of diseases, as hereditary taint. He considers it doubtful, whether boiling or roasting ever so thoroughly, can eradicate successfully the germs of the infection from the flesh or milk of tuberculous animals."

Willeman, another scientist, says: "Tuberculosis is an infectious and specific disease, capable of transmission from man to animals or from one animal to another." Garlach, in Germany, and Cheauvean, in France, demonstrated the transmissibility of this malady by inoculating animals with the matter obtained from tuberculous cattle. Jessen says: "Calves fed on milk from tuberculous cows perish from the same disease." The danger of tuberculosis being inoculated to children with vaccine lymph, was demonstrated by Prof. Toussaint, of Toulouse, who inoculated two heifers with tuberculous virus on the 15th of October. 1881. These animals were destroyed on the 10th of February, 1882, and a postmortem examination revealed general tuberculosis. It has been experimentally and accurately conveyed over and over again from man to animals, and from animals to animals. Numerous cases are recorded of dogs, cats and chickens becoming consumptive from licking or picking up the expectorations of consumptive persons. Sexual intercourse, the use of spoons, glasses and other vessels from which consumptive persons have been feeding, must be considered modes of accidental contamination. Dr. Delamalleres states: "Quite recently I was called to attend a young woman, and was much surprised to find symptoms of Phthisis Pulmonalis. I sought minutely for the cause; after many and fruitless inquiries, I at last learned that she had partaken of eleven fowls which died at the house of another consumptive patient, during three months, and still more, she had cooked them very slightly, thinking she would derive more nourishment from the eating of slightly cooked flesh. These fowls had daily partaken of the expectoration of their consumptive owner; one of them had died that morning, and an examination revealed the cause of death to have been tuberculosis. The Microbe or Bacillas causing the disease in this case, being conveyed through the spittle of the first woman, through the fowl to the second party.

The aliment being half cooked could not have been deprived of the tuberculous virus, or microbes it contained, which once taken into the economy, is taken up by the circulation, and after choosing a favorable organ, implants itself there, producing those organic disorders, which are peculiar to it. It is an extremely insidious malady and destructive to the bovine and human race. National measures are required for its suppression in cattle, which are allowed to contaminate the flesh which supports us, and the milk which forms such a source of nourishment to the young. Our meat inspectors, appointed by some politician, are utterly ignorant of what constitutes good flesh. Our dairy inspectors would not be able to distinguish an animal affected with the disease; in the meantime, it continues to deal death out with liberal hands. The statistics show what dreadful havoc it annually commits amongst us. Prof Bang of Copenhagen says, "that the milk, cream and butter from tuberculous cows is infective, *even after subjection to a high temperature.*

Mr. Toussaint says, "a temperature of 125 F. was not sufficient to destroy the virus in meat, this temperature being in excess of that at which steak is usually cooked; even after being submitted to a temperature of 159 F, the virus was successfully inoculated. In view of these highly important experiments, the necessity of a better system of inspection of our meat and milk is evident. Dr. Bang states a case where a child six months old died of consumption, through being brought up on the milk of a consumptive cow. Many continental countries prohibit the use of the flesh and milk of animals so affected. Even so far back as the fourteenth century. The Jews attribute their great immunity from this and other diseases of animals to their strict observance of the old Mosaic laws, relative to the inspection of animals after death. A popular idea is, that a child brought up on the bottle, should have only one cows milk; there are grave objections to this, unless the cow is subjected to a very careful examination, for the milk of one cow, if tuberculous, will contain a far greater quantity of the tubercle bacilli, than if the milk were taken from the total yield of the dairy. It appears that Veterinarians (*who are duly qualified*) ought to form a section of our Boards of Healths, and that dairy animals should be regularly inspected and visited; a microscopic examination of their milk and also a minute inspection of animals before and after slaughter, should be instituted. So long as medical gentlemen undertake to investigate and control the diseases to which the lower animals are so subject, so long will that important branch of "Public Health Science", viz. the diseases of the lower animals, etc., remain as it now is, "*a farce, mockery, and delusion.*"

Tuberculosis or Scrofula is a constitutional disease, evincing itself as a deposition or infiltration of the various tissues, known as a tubercle, or in masses as scrofulous or tuberculous matter. By scrofula is meant the indwelling predisposition to exhibit, under favorable circumstances, the local changes spoken of as tuberculosis. Tubercle is the minute local product. Its very insidious nature has much to do with the comparative slowness with which general attention has been directed to it, but the strides it is making, and hold it is obtaining on our stock, renders the subject one of national importance. Looking at a small tubercle, representing the size of pinhead, perhaps, we are apt to despise its comparative insignificance, and ignore its deadly meaning, but when a carcass contains thousands and millions of those little masses, we are forced to recognize that we are dealing with an insidious, implacable and deadly foe; it is a disease of malnutrition and non-assimilation. The predisposing causes of tuberculosis in cattle are hereditary taint and inbreeding. Such influences as those which surround animals in city dairies, where it is plentifully found, as dark, filthy, damp stables, bad ventilation and want of exercise, food insufficient in quantity and defective in quality, fatigue, excitement of oversecretion of milk, in fact three principal predisposing causes, are prolonged and excessive lactation, damp atmosphere and hereditary tendency or taint. City dairies suffer most severely where cows are constantly confined in stables which are not ventilated or clean, deprived of exercise, and fed on that sort of food which most favors the secretion of milk, though it may not enhance its quality. Indeed it is a practical fact that deep milkers are most subject to tuberculosis and young animals are more predisposed to this affection (Flemming). Breeding in and in is a frequent cause, and in spite of the daily examples of this truth, breeders still cling to one strain.

Diseases of organs, originating in tuberculous infection, may be distingushed, by previous history, coincidence and other circumstances; thus the heifer will not become pregnant, but accept the bull on every occasion; laryng·al obstructions may ensue without apparent cause, or a joint may swell without apparent reason. The skin does not show the bloom of health, its hair is not reversed here and there by application of the tongue, its eyes are dull and the animal shows great lassitude, though it may be fat. When the history of the animal is not traceable, much difficulty is experienced, the disease may be in existence for long periods before being manifested. The first perceptible signs usually are dullness, lassitude, indifference, want of activity and energy, shrinking when pressed on the withers, back and loins, continued "rutting," (nymphomania,) aborting when they breed, milk watery and bluish tinted, dry, deep, feeble cough, especially when the animal comes out of a warm stable into cold atmosphere, intermittent lameness, enlargement of the parotid submaxillary, inguinal axillary or other glands. These symptoms may continue for variable periods, when such casual influences as cold, sudden chills, exertion, poor food or other incidental circumstances hastens the evident emaciation; sluggish movements, harsh dry skin, capricious appetite, weak digestion, milk blue colored and watery and deficient in butter and sugar; cough, difficult breathing, these symptoms become more and and more exaggerated, as the disease advances the cough becomes harassing, the head is held low, mouth open, tongue protruding, cold extremities, great emanciation, weakness, fœtid diarrhoea, whilst tapping the walls of the chest reveals extensive disease of the lungs and pleura.

Dr. Tappenier says, "The remarkable instances often seen, in which persons free from hereditary tendency to phthisis, because phthisical, after attendance on sufferers from that disease have suggested the idea of its contagious nature, by inhalation, with the breath of fine particles, of tuberculous sputa, atomized into the air by the patient coughing. The following experiment rendered this matter conclusive. A number of animals were made to breathe daily for several hours, in a chamber of air in which fine particles of phthisical sputum, were suspended; dogs were employed in these experiments, since those animals rarely suffer from tuberculosis; results were the eleven animals experimented upon, with one doubtful exception, after a period, varying from twenty to forty days, when killed, presented tubercular disease in the lungs and the organs.

The post morten appearance in well marked cases shows many organs and textures to be affected. In the lungs, coverings and linings of the walls of the chest and abdoman, etc., are found small nodules, varying from the size of a pins' point to that of a millett seed; these nodules are multiplied and extend deeper into the lung tissues as the disease advances, until they fill up and efface the air cells; these masses may increase to enormous proportions; each nodules is dense, hard and tenacious, grayish white at first but becoming opaque and yellow. These nodules undergo changes with age. The first being "calcification" or impregnation with certain earthy matters, giving them a hard stone-like feel, and when crushed resembling chalk, and usually found in bunches constituting the tubercular masses.

These masses often soften and break up, leaving large and badly defined cavities in the organ attacked. Nodules in various stages are formed in the lungs and their coverings, liver, spleen, intestinal walls, kidneys, brain, mesentery, various glands, in fact scarcely any organ of the body can be said to be exempt. Various experiments produced the following results. The respiratory organs were seriously affected, the lungs being studded superficiallyand deeply with grey,hard, semi-transparent nodules, varying from the size of a pin head. The submaxillary and other glands were similarly tuberculosed ; in one animal the mucous membrane of the larynx offered different phases of the disease, namely, granules and ulcers, closely set together in the peritoneum. These granulations were grouped in the terminal portion of the small bowel and commencement of the large one. The nodules were dense, resisting and hard, and the size of a millett seed. Ulcers were apparent, sometimes extending through the muscular coat. The glandular apparatus generally were so tuberculosed as to account for the great emaciation of the animal. The membranes of the mouth and pharynx become affected through contact with tuberculosed matter on which the animal fed. After the lympathic glands became involved, other organs became affected; first the lungs, liver, spleen and kidneys, at other times the joints. When the disease was of brief duration the nodules were grey, smooth and hard, but when it ran a longer course there were cheesy like masses the size of a pea, and there were largest when adhesion had taken place between the lungs and lining of the sides of the chest.

No practical results can be served by medicinal treatment of tuberculous animals. They are useless for breeding, dangerous for milking, and their flesh unfit for food.

PREVENTION.

All flesh and offal of tuberculous animals should be destroyed. Suspected animals should be isolated, until the disease is confirmed or otherwise. Destroy affected animals, contaminated food, litter, etc., by fire. Disinfect the stalls, etc., occupied by the animals, with boiling water first, then paint with whitewash containing half an ounce of corrosive sublimate to the gallon. Never breed from a suspected animal.