THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

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SUGAR BEETS.

Approved by the Station Council,
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

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Fort Collins, Colorado.

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FORT COLLINS, COLORADO.

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SUGAR BEETS.

AGRICULTURAL DEPARTMENT.

W. W. COOKE.

The present bulletin is written as an answer to the many letters that come to the Station asking for information about sugar beets. The fact that the number of these letters has largely increased during the past year shows that there is a renewed interest in the subject.

This Station has already sent out four publications on the subject of sugar beets, giving general instructions for their cultivation and detailing the results obtained in the experiments on their growth at the College Farm, on the sub-station at Rocky Ford, and at various places throughout the State. These publications have long been out of print and for this reason it is deemed advisable to repeat here some things that have been before published.

During the five years since the last bulletin on sugar beets was issued, the Station has continued its experiments at the College and many facts have accumulated concerning the adaptability of other parts of the State to sugar beet growing, so that we now have a pretty clear idea of the conditions of the problem for Colorado.

MARKET.

All manufacturers desire first of all to cultivate the home market in order to save transportation charges. He considers himself fortunate who can sell his entire product at the door of his factory. Such is the state of affairs that exists for the manufacturer of sugar in this State. Colorado pays out each year about $500,000 for sugar. This statement is based on the assumption of half a million inhabitants each consuming sixty pounds per year at a cost to the importer of five cents per pound. It would be a great help to the State if this money could be kept at home, as it would be if sugar was made here, since after the factory is once built nearly all expenses are for material and labor produced in the State. To produce the sugar consumed by the inhabitants of Colorado, would require five factories of large size employing two hundred men each, who with their families would represent about four thousand people. It would require the growing of sugar beets on fifteen thousand acres of land and add more than three hundred dollars to the income of each of two thousand farms.

PROFIT.

Are Colorado conditions such as to make the manufacture of beet sugar a profitable industry? The profit of the industry to the factory owner, depends ultimately on the price for which he can sell his product. This market price is at present so largely dependent on political legislation that the question at the head of this paragraph cannot be answered with any certainty.

What can be said is this; that sugar beets will grow as well in Colorado as any where in the world, both as regards their quantity per acre and richness in sugar. Moreover, land suitable for the growth of the beet exists in large bodies now under cultivation in several different parts of the State and this land is near to enormous deposits of coal and lime and but a few miles from the centers of population that will consume the finished product. It follows therefore that if prices are such as to make the business profitable anywhere, then it will pay in Colorado.

GROWTH.

The best possible climate for the growth of the sugar beet is that found in the section of Colorado east of the foothills of the Rocky Mountains and below 5,000 feet altitude. There are many valleys in western Colorado that have a similar climate, but the parks of the State are too cold for the sugar beet to be grown with profit.

The rainfall of Colorado is too small to grow the beet without irrigation, so that its growth will be restricted to the irrigated portions, especially to the valleys of the Arkansas, the Platte, and the Grand.

The soil best adapted to the growth of sugar beets is a rather firm sandy loam; such land as is used in northern Colorado for growing potatoes, and in the Arkansas Valley is planted to corn. A factory to be profitable must have at its command the beets from at least two thousand acres. There are several places in the Platte Valley where five times that amount is now yearly cropped in potatoes and equally large bodies of land are devoted to corn in the Arkansas Valley.

PLOWING.

A common cause of failure among beginners in sugar beet culture is a lack of thorough preparation of the soil. The sugar beet grows with the entire root below ground, and as this root should be at least twelve inches long, it follows that only the deepest of plowing will make a suitable condition for its growth. The land should be plowed in the fall and subsoiled to a depth of fifteen to eighteen inches. This is especially necessary in an irrigated district, for under irrigation, where the ground is plowed eight inches deep year after year, there is a layer of soil just below the furrow that becomes very compact and so hard that the roots of the sugar beet cannot penetrate it.

If the plowing is done in the fall, nothing more will be needed in the spring but a thorough harrowing just before planting. The harrowing should be continued until the ground is very fine and smooth. If the plowing is done in the spring, it should be delayed until just before planting, so that the weeds that have started will be killed and the beets have a chance to grow before the next crop of weeds appear.

PLANTING.

The planting is done in drills and may be by hand or machine according to the size of the field. The best results are obtained by hand planting, but this is too expensive for a large field. An ordinary garden drill does very good work, but on the large scale some machine drawn by horses will be employed. There are special horse drills made for the planting of sugar beet seed and these are the implements mostly used in the vicinity of factories. For the one who wants to experiment or grow a few acres for stock feed, an ordinary wheat drill makes a very good substitute. In the 8-hoe drill leave open the first, fourth and seventh hole and stop up the rest. This makes the rows of beets twenty-four inches apart, which is none too far for irrigation. Suppose the first hole on the right-hand end of the drill is left open, and seeding is begun at the right-hand end of the field. Then the first time across, the right-hand wheel of the seeder is run close to the edge of the field. In returning, the left-hand wheel follows the track it made in crossing. In starting across the second time, the right-hand wheel should go sixteen inches from the track it last made. In this way all the drills will be twenty-four inches apart.

The seed should be sown at the rate of about twenty pounds to the acre. This is far more seed than is needed if all grows, and a large part of it will be pulled up when the plants are thinned. But the most serious obstacle to a large crop is the lack of a full stand and the only way to get the ground well covered by plants is to start many more than are needed and thin out the surplus.

The seed should be covered about an inch and a half deep. If seeding happens to be done just after a hard rain, when the ground is thoroughly wet, half an inch deep is sufficient; but usually, in Colorado, the ground is rather dry at time of seeding and unless the seed is covered quite deep, there will not be sufficient moisture to insure germination. The getting a good stand is by far the hardest part of raising sugar beets.

There are a few favored spots in Colorado where irrigation water can be obtained very early in the spring. If then the plowing has not been done in the fall, it may be advisable to irrigate the ground thoroughly before plowing, and thus insure a good supply of moisture in the subsoil.

If, after the seed is sown, there comes on such a dry spell that the seed has to be "irrigated up," the chances of a profitable crop are slight. Even in such a case, there is some chance of success if a small furrow is made six inches from the seed drill and a small head of water allowed to run for quite a while until it has wet the seed by soaking sideways without running over the surface above the seed. This could only be done where the ground is well prepared and has a uniform slope.

Planting may be done any time from the last of March to the middle of June. If planting for a factory, it is advisable that both early and late planting be done, to extend the season for running the factory as long as possible. Where the beets are grown for stock food, the planting will be done at about the time of corn planting. Sugar beets sown the first of May will be ready for harvesting about the first of October.

CULTIVATING.

The first cultivation should take place as soon as possible, that is as soon as enough of the plants show so that the rows can be followed. Many forms of cultivators are on the market for this particular purpose. Any of the tools used for cultivating onions will do good work on sugar beets. The ordinary one-horse cultivators are often sold with special attachments for working on beets. Whatever implement is used it should merely scratch the surface of the ground, leaving it level and killing the small weeds, without throwing dirt onto the young beets. This cultivation needs to be repeated about once a week until the beets are large enough to shade the ground and conquer the weeds. The ground should be cultivated after each irrigation to throw the dirt back into the irrigating furrow and make a dirt mulch on top that will preserve the moisture. The cultivator should also be run after each rain that the crust formed may be broken up. Ordinarily, it will require about five cultivations to keep the crop in good shape.

IRRIGATION.

The uses of irrigation before plowing and to germinate the seed have already been mentioned. It is advisable to delay the first regular irrigation as long as possible. When it is necessary, it is always given in furrows, care being taken to keep the water off the surface and not let it touch the crowns of the plants. All beet crops in Colorado will require one irrigation, and may need two or three. The cultivator should be run as soon as possible after each irrigation.

The most of the sugar is made by the beet during the last few weeks before it is ripe. To make the highest per cent. of the best sugar it is necessary that at this time the plant should almost cease growing and devote its energies to storing up in the root, as sugar, the nourishment that has already been taken from the ground and elaborated in the leaves. If water is applied at this time by rainfall or by irritation, it induces the plant to keep on growing, making a large weight of crop, but one containing a low amount of sugar. Hence the last irrigation should be given about six weeks before the crop is matured. This will be from the first to the middle of August. In 1895, there was a heavy rain in September at the College Farm, which kept the beets in full growth until frost and gave a crop with much less than the usual amount of sugar. Such rains very seldom occur in Colorado and this fact coupled with the control that the farmer has over his water supply under irrigation makes the growth of a crop with the largest amount of sugar more reliable in this State than in those sections that depend on rainfall to grow the crop.

THINNING.

The thinning should be done when the plant has four leaves. The plants should be thinned so as to leave one plant in a place and the plants from eight to ten inches apart. If the crop is being raised for stock feed and the drills are two feet apart, a plant can be left every six inches. In general there is not much difference in the weight of the crop, at six, eight or ten inches apart, if the soil is rich and there are no missing plants; but the closer the roots are left the less likelihood there is of missing spots and the larger the crop on medium rich soil.

In beets for the manufacture of sugar it is not desired that they grow to a large size. They contain the largest amount of sugar when they weigh about two pounds apiece. They should average under this size rather than over. For stock feed there is less objection to the large beet. By thinning to twelve inches on rich ground it is easy to get beets that weigh five pounds and over, inferior for both sugar and stock food.

The thinning is usually done both by the hand and a hoe. With a narrow, sharp hoe the drill is struck crosswise and the beets cut into hills. The final thinning of these hills to one plant, must be done by hand.

FERTILIZING.

The sugar beet takes from the ground a large amount of plant food. It follows therefore that the land must be liberally manured to keep it fertile. Most of the cultivated land in Colorado, contains at the present time, plenty of fertility to grow several crops without manuring; but at most this is only a temporary condition and sooner or later the farmers of this State will have to follow the customs of their eastern brethren and put as much plant food on the land as the crop carries away.

For the next few years most beet raisers, will obtain fertility for their crops, by growing alfalfa and plowing under the sod. In this case the beet should never follow the alfalfa immediately, but a crop of grain should be grown first. This will rot the alfalfa roots and work the soil into better shape for the sugar beets.

Unless in the case of alkali fields,which will be mentioned later, it is not considered advisable to grow beets more than two years in succession on the same ground. Where the supply of suitable land is not limited, better results will be obtained by raising but one crop, following the next year with grain, or seeding back to alfalfa. Thus the rotation would be alfalfa three years, wheat one year, beets one year, oats one year with alfalfa seed, and alfalfa for the next three years.

When it becomes necessary to fertilize the ground with barnyard manure, the best crop to follow with is corn. The rotation would then be corn, beets, grain two years, manuring the second year after the grain, and then planting corn again the fifth year. If the stable manure is applied just before the beets, it produces a large crop, but the amount of sugar is small.

VARIETIES.

The varieties mostly used are the Kleinwanzleben and the Vilmorin. The beet sugar factories import this seed and sell it to their patrons at cost. An attempt is now being made in Utah to grow sugar beet seed on a commercial scale.

HARVESTING.

Harvesting for the factory is commenced as soon as the beets are ripe, which stage is known by the change in color of the leaves from green to yellow and at the same time the leaves droop to the ground and many of the outer leaves die and wither. Beets for stock food should be left in the ground as long as possible and gathered just before the ground freezes. In Colorado the harvest will extend from October 15th in the northern part to a month later in the southern and western portions.

Harvesting may be done by a beet puller made for the purpose, which looks much like a sulky plow, but in place of the plow are two strong iron prongs. When the machine is driven lengthwise of the row these prongs dig deep into the ground, one on each side of the beet and loosen it from its bed. It can then be lifted out by hand. A simpler method, and almost as good, is to plow a deep furrow by the side of the row of beets and as close to them as possible without cutting them. They may then be loosened by pushing sideways into the furrow and pulled by hand.

The most tedious and expensive part of the harvesting is the topping. Although machines have been invented for doing this, they have not been successful and the work is still done by hand. A strong heavy knife is used and with a single stroke the leaves are severed from the root. If for sugar, the "neck" of the beet is cut off with the leaves; that is, the part of the beet from which the leaves have grown.

For stock feed, where the beets are to be kept in a root-cellar for several months, this neck is left on the root, the leaves alone being cut off. Under this condition the beet wilts less and keeps better.

After topping, the beets are thrown into piles, covered over with the leaves and allowed to remain until they are taken to the factory or the root-cellar. If to the root-cellar, the storing should be delayed as long as possible. The danger of heating in the cellar during the fall, is fully as great as that of freezing in the field.

STORING.

The sugar factory will begin running as soon as the earliest beets are ripe. From then until freezing weather sets in, it will work on beets drawn directly from the field. But all factories desire to lengthen the working season as much as possible, to lessen the size of the factory required to work up a given quantity of beets, or with a given sized factory to increase its working capacity. Some precautions have to be taken to preserve the beets from freezing that are to be used the latter part of the season. Long, broad and shallow pits are dug close to the factory into which the beets are thrown, as brought from the field, and then covered with straw and a layer of dirt more or less thick according to the degree of cold to be withstood. It is customary for the factory to supply these pits close to its works, rather than for the farmer to pit the beets in his own field, because it is much more convenient to get at the beets during freezing weather when they are close at hand.

The stock feeder can use the system on his own land near his feeding barn, or he may build a regular root-cellar like those that are found all over Colorado for storing potatoes. The latter way in the course of years is by far the more satisfactory.

COST.

No statement of cost can be given that will not be subject to many changes in different localities. Leaving out of account rent or interest on the value of the land and also any charge for water tax etc., the items of raising an acre of beets will be approximately as follows:

Plowing and harrowing, man and team	10	hours
Seeding, man and team.............	2	"
Cultivating, man and horse.........	20	"
Hoeing, man........................	135	"
Thinning, man......................	65	"
Irrigating, man....................	10	"
Plowing, man and team..............	4	"
Pulling, man.......................	20	"
Topping, man.......................	80	"

Hauling will always be an item of cost, but varies from eight hours for man and team, to thirty hours according to distance to be hauled and facilities for hauling.

The time and expense for planting and cultivating the crop, will be about the same whether the yield is large or small. The expense of harvesting has been figured on the basis of twelve tons to the acre and will rise or fall according as the crop is greater or less.

Under the varying prices of labor, the ease with which the land can be worked, and the size of the crop, the cost of raising and marketing an acre of sugar beets has varied at different places in the United States from $30 to $45, and the cost per ton of beets from $2 to $4.

Beets are usually paid for according to their richness, the prices varying from $4 to $5 per ton and the returns per acre will average not far from $50. About eleven tons of sugar beets per acre at $4.50 per ton is a fair average crop, with a possibility of more than twenty tons at $5 per ton. As compared with $10 for the crop from the same land put into alfalfa, or $12 for the wheat it would raise, this return seems rather large, but of course there is a much larger amount of labor required to produce this return.

FEEDING VALUE.

Sugar beets have a high value for stock feed. They belong to the class of concentrated feeds in spite of the large amount of water they contain and are to be compared as a feed with grain rather than hay.

It is probable that the dry matter of beets has about the same value, pound for pound as the dry digestible matter in grain. On that basis, a pound of grain would have as much feeding value as four and one-half or five pounds of beets.

Sugar beets have been fed to stock at the College with very good results except where fed to steers. When the feeding is done out doors in cold weather, they seem to be too watery for profitable feeding to steers. They are excellent feed for milch cows and will take the place of grain for fattening lambs during the first half of the feeding period. It is advisable not to feed them during the last six weeks before marketing, giving grain at that time so that the flesh and fat may harden for shipment. Stock sheep and breeding ewes do well on beets all winter. They can even form profitably a portion of the food of breeding sows.

FEEDING VALUE OF LEAVES AND TOPS.

For every one hundred pounds of beets harvested there will be from fifty to sixty pounds of tops. These tops have a high feeding value. They are worth almost as much pound for pound as the beets themselves.

The tops are good feed for all classes of farm animals. They may be fed at once as soon as harvested or put in a silo and fed through the winter. The past two years, on the College Farm, there has been stock enough to eat them as fast as gathered. They have been fed to breeding sheep and to cows, being hauled from the field and fed in racks. Some beet growers wait until the crop is all harvested and then turn the stock into the field to eat up the tops and leaves. This saves some labor but is wasteful of fodder.

CHEMICAL DEPARTMENT.

WILLIAM P. HEADDEN.

The following pages contain the analytical results obtained in the laboratory of this Station up to the present time. The greater part of them have already appeared in Bulletins Nos. 7, 11, 14, and 21. The data concerning the condition of soil and cultivation, under which the beets were grown, are not given in satisfactory fullness in all cases, but in others it leaves little to be desired.

The record of analyses of all samples analyzed is interesting and profitable to the inexperienced beet grower, as showing the extent to which the sugar content of the beet is dependent upon the cultivation it receives as well as upon the character of the soil in which it is grown.

It is evident, from our records, that a great many persons have furnished the department samples but once, and that was the only attempt that they had made in sugar beet raising. A complete record of the work done in the laboratory would contain many samples of which this would be true and which would give a wholly erroneous impression of the facts as to the quality of beets grown in the various parts of the State under proper cultivation.

In 1888, the Station experimented with four varieties of beets: Excelsior, Lane's Imperial, Vilmorin, and Imperial Improved, with the following results:

Varieties.	Per cent. sugar.	Tons beets per acre.	Pounds sugar per acre.
Excelsior	9.47	29.04	5,517.60
Lane's Imperial	12.08	30.45	7,318.00
Vilmorin	11.39	25.09	5,695.48
Imperial Improved	8.83	24.15	4,250.40

The number of analyses seem to have been small, but the samples were representative of the four lots grown; and while the percentage of sugar varied considerably the results were considered satisfactory, indicating that beets of good quality can be grown in Colorado, and that the yield is large.

The study was continued the following year (1889) on a somewhat different line, i. e., to determine the effect of different soils upon the ash constituents and percentage of sugar in the beets; also to determine the feeding value of the tops and the relation of the weight of the tops to the sugar content of the beet. The second object of this experiment was defeated by an early frost which killed the tops.

A further object was to study the distribution of the sugar in transverse sections of the beets and the relation of the specific gravity of the juice to the sugar content.

In order to establish the first point, the relation of the ash and its constituents to the soil in which the beets grew, the ashes of two varieties of beets, one lot of each, grown upon rich and poor soil respectively, were subjected to analysis. Just what is meant by poor soil and rich soil is not definitely stated and so far as I can learn, the soils were not analyzed. In one paragraph the terms fertilized and unfertilized are used as explanatory of rich and poor, but the rest of the record seems to justify the inference that the term poor, is used in its ordinary signification, and rich to indicate a productive condition of the soil, but not a condition produced by the application of manure or other fertilizer immediately prior to the growing of this crop.

The following data show that the Silesian appropriated nearly one-fifth more mineral constituents and the Imperial over one-half more from the rich than from the poor soil. The Silesian, grown on poor soil, contained 1.08 per cent., but grown on rich soil, it showed 1.28 per cent. And the Imperial, grown under similar conditions, contained 0.801 per cent., and 1.234 per cent., respectively.

There is a difference both in the amount of ash contained in the beets and in its composition, according to the quality of the soil on which the beets are grown. The percentages of phosphoric acid and lime are higher in the case of beets grown on poor soils, but the percentage of potash is higher in those grown on rich soils.

The experiment was not conclusive in regard to the effect of the two soils upon the percentage of sugar. The

Silesian grown on poor soil contained 9.66 per cent. sugar; the same variety grown on rich soil contained 10.47 per cent., while the Imperial, grown on poor soil, contained 10.44 per cent., and grown on rich soil, contained only 9.07 per cent. The difference in either case is too small, especially as it is based on so small a number of analyses, to be conclusive.

The amount of sugar in successive transverse sections of these varieties was also made, the sections being taken one inch thick, beginning to number at the top. The result of this examination was that the first section contained less sugar than any other section, except in one instance, and always from two to over four per cent. less than the maximum in any one section which was found in the tip of the beet. The increased amount of sugar was, with one exception, quite marked in the second section of the beet; in the succeeding sections it was much less and quite regular. In the case of the Silesian grown on rich soil the difference in the quantity of sugar in the first and second sections amounted to 1.21 per cent.; in the second and third to 0.7 per cent.; in the third and fourth 0.29 per cent.; in the fourth and fifth 0.29 per cent.; in the fifth and sixth 0.04 per cent.; and in the sixth and seventh 0.25 per cent. The loss on dressing was between two and three per cent., and was about the same whether the beets were grown in rich or poor soil.

The feeding value of the beets, as influenced by the soil, was also studied. The study of the tops was prevented by an early frost, but the analyses of the roots, as given in Bulletin No. 11, are as follows:

	Water.	Crude ash.	Fat.	Crude protein.	Crude fiber.	Nitrogen free extract.
Silesian, poor soil	87.17	1.08	0.24	0.93	0.83	9.75
Silesian, rich soil	86.31	1.28	0.27	1.77	0.68	9.69
Imperial, poor soil	87.88	0.80	0.14	0.81	0.59	9.78
Imperial, rich soil	89.80	1.23	0.18	1.44	0.44	6.91
Vilmorin	88.69	1.13	0.18	1.16	0.62	8.22
*Average analysis of sugar beets	86.50	0.90	0.10	1.80	0.90	9.80

*As given by Jenkins and Winton, Exp. Sta. Bul. 11.

The same is true of the results recorded in this series of analyses as of the sugar determinations, i. e., they have a general value as they show the beets to have been about equal to the average sugar beet, so far as their feeding value was concerned, but the results are not positive enough nor based on a sufficiently extended series of experiments to show conclusively that the value of the roots for feeding purposes was materially affected by the nature of the different soils. It may be stated in this connection, that it is known that the beet is very sensitive to the influence of fertilizers and the cultivation it receives, particularly in regard to the purity of the juice or ratio of the sugar to the total solids.

Large beets are frequently received, being sent under the mistaken idea that the larger the beet the higher the percentage of sugar, which is not the case. The following table, reproduced from Bulletin No. 14, illustrates this, though the weight of the largest beet is much less than that of many samples sent us for analysis. The samples were selected with reference to their size as shown by the following table:

	Size.	Weight.	Loss on dressing.	Per cent. sugar.
Bulteau Desprez	Large.	1,245	170	12.83
" "	Medium.	285	20	14.10
" "	Small.	43	3	15.97
Kleinwanzleben	Large.	1,015	135	14.12
" "	Medium.	240	20	14.18
" "	Small.	42	2	17.11
Dippe's Vilmorin	Large.	860	70	14.37
" "	Medium.	280	35	14.84
" "	Small.	42	2	16.66
Bulteau Desprez, No. 2	Large.	980	110	14.26
" " "	Medium.	375	30	15.68
" " "	Small.	89	5	16.09
Simon Le Grande	Large.	1,150	150	12.17
" "	Medium.	150	10	12.88
" "	Small.	43	3	13.52
Florimond	Large.	1,310	170	12.99
"	Medium.	175	10	15.54
"	Small.	30	3	17.05

The size of the beet can be controlled by letting it stand closer in the row and its quality further improved by careful attention to cultivation and fertilizing.

Samples of the following varieties were sent to the Department of Agriculture, at Washington, for analysis and Dr. Wiley reports the results to Prof. Crandall, October 2, 1890, as follows:

	Per cent sugar.
Kleinwanzleben	10.11
Simon Le Grande	11.15
Florimond	15.39
Bulteau Desprez No. 1	15.20
Bulteau Desprez No. 2	14.75
Vilmorin	12.92

Samples were also sent to Grand Island, Neb., and their chemist reports, under date of Nov. 12, 1890, the following:

	Per cent. sugar.
Excelsior sugar	7.40
Improved Imperial	8.20
Bulteau Desprez	14.40
Dippe's Vilmorin	14.70
Kleinwanzleben	13.50
Florimond	13.20
Simon Le Grande	13.50

Taking the average of the analyses of the varieties made in this laboratory, we have:

	Per cent. sugar.
Bulteau Desprez No. 2	15.03
Bulteau Desprez No. 1	15.88
Kleinwanzleben	15.64
Dippe's Vilmorin	15.75
Florimond	16.30

The preceding samples were grown in a highly cultivated soil under the supervision of the Horticultural Department. The total solids do not seem to have been determined. Analyses were made of the following samples from various parts of the State; and also others which, being unaccompanied by any history, are omitted:

Name.	Where and by whom grown.	Per cent. Sugar.
Colorado Imperial	A. R. Black, Lamar, Colo,	8.02
California Sugar	" " "	13.03
Colored Vilmorin Desprez	" " "	11.26
Imported Florimond	" " "	8.45
Kleinwanzleben	" " "	11.04
Vilmorin	Stimson, Neb.	10.38
Simon LeGrande's White Imperial	San Luis Valley Stat'n, Monte Vista, Colo.	15.59
Bulteau Desprez	" " "	11.82
Vilmorin	" " "	14.14
Vilmorin Desprez	" " "	12.25
Kleinwanzleben	" " "	13.35
Red Top	Arkansas Valley Stat'n, Rocky Ford, Colo	11.84
Simon LeGrande	" " "	13.28
Dippe's Vilmorin	" " "	14.09
Florimond Desprez	" " "	14.72
Bulteau Desprez	" " "	12.89
Kleinwanzleben	" " "	13.66
Improved Imperial	College Garden, Fort Collins, Colo.	8.70
Imperial	" " "	9.75
Excelsior	" " "	6.95
Kleinwanzleben	" " "	12.57
Bulteau Desprez	" " "	13.37
Florimond Desprez	" " "	12.90
Dippe's Vilmorin	" " "	14.20
Bulteau Desprez	" " "	14.18
Simon LeGrande	" " "	11.38
Kleinwanzleben	" " "	11.11
Bulteau Desprez	" " "	10.97
Florimond	" " "	9.82
Dippe's Vilmorin	" " "	12.74
Bulteau Desprez	" " "	11.12
Simon LeGrande	" " "	9.26
Imperial	Chas. Green, Del Norte, Colo.	14.08
Imperial	A. S. Halsted, Del Norte, Colo.	14.76
Lane's Imperial	Chas. Schielman, La Junta, Colo.	11.80
Lane's Imperial		15.68
Imperial		15.00
Vilmorin	Denver, Colo.	18.00
Bulteau Desprez	" "	15.00

Name.	Where and by whom grown.	Per cent. Sugar.
Vilmorin	Denver, Colo.	16.00
Vilmorin	" "	16.00
Bulteau, No. 2	" "	16.00
Vilmorin, No. 8	" "	15.00
Improved Imperial	College Farm, Fort Collins, Colo.	8.80
French Variety	" " "	10.20
Vilmorin No. 1	Arkansas Valley Station, Rocky Ford.	6.00
Vilmorin, No. 2	" " "	9.20
Vilmorin, No. 3	" " "	10.75
Vilmorin, No. 4	" " "	8.50
Lane's Improved Imperial	College Farm, Fort Collins, Colo.	8.95
Vilmorin Improved	" " "	9.68
Dippe's Vilmorin	Arkansas Valley Station, Rocky Ford.	15.17
Dippe's Vilmorin	" " "	15.35
Dippe's Vilmorin	" " "	15.37
Dippe's Vilmorin	" " "	11.48
Vilmorin Improved	College Farm, Fort Collins, Colo.	8.00
Vilmorin Improved	" " "	11.15
Vilmorin Improved	" " "	13.69
Lane's Imperial	" " "	8.95
Improved Imperial	" " "	8.83
*Name not given	" " "	10.21
Name not given	Divide Experiment Sta. Monument, Colo.	9.35
Kleinwanzleben	" " "	7.95
Kleinwanzleben	" " "	9.67
Dippe's Vilmorin	Arkansas Valley Station, Rocky Ford.	15.17
Dippe's Vilmorin	" " "	15.35
Dippe's Vilmorin	" " "	15.35
Dippe's Vilmorin	" " "	11.48

*This set of farm samples is accompanied by a note to the effect that they did not have water enough, but there is no further explanation.

The Department of Horticulture sent to the laboratory four samples, grown at different distances in the rows, to test the effect upon the percentage of sugar in the beets. The results are as follows:

Variety.	Inches apart in row.	Per cent. sugar.
Vilmorin Improved	3	13.60
Vilmorin Improved	3	13.50
Vilmorin Improved	6	9.00
Vilmorin Improved	6	11.00

The result is clearly in favor of a thick stand. Neither the distance between the rows nor the weights of the beets are given.

Seed beets, to the number of 110 of the Vilmorin varieties, were analyzed; the results may be summarized as follows: The percentage of sugar ranged from 7 to 17, and it is noted that the beets were in bad condition. Seven of the 110 beets contained less than 10 per cent. of sugar and sixteen of them contained upwards of 14 per cent.

The following samples are accompanied by a statement of the number of irrigations with which they were grown. The rainfall at Fort Collins, from May to October, inclusive, was 8.8 inches; at Rocky Ford, 8.26 inches, and at the San Luis Valley station, 4.58 inches.

Name.	Where grown.	Times irrigated	Per cent. sugar.	Coefficient of purity.
Vilmorin, No. 1	Arkansas Valley Station.	..	6.00	....
Vilmorin, No. 2	" " "	1	9.00	....
Vilmorin, No. 3	" " "	..	10.75	....
Vilmorin, No. 4	" " "	..	8.50	....
Vilmorin,	College Farm.	.	14.75	81
Vilmorin	"	.	15.25	82
Vilmorin Improved	"	..	13.69	....
Vilmorin Improved	"	..	11.15	....
Kleinwanzleben	Divide Station.	..	13.00	....
Kleinwanzleben	"	..	13.70	....
Vilmorin Improved	San Luis Valley.	..	13.50	....
Vilmorin	Arkansas Valley Station.	..	21.00	....
No name given	" " "	..	14.00	....
Dippe's Vilmorin	" " "	1	15.17	....
Dippe's Vilmorin	" " "	2	15.35	....
Dippe's Vilmorin	" " "	3	15.37	....
Dippe's Vilmorin	" " "	4	11.48	....

Name.	Where grown.	Times irrigated.	Per cent. sugar.	Coefficient of purity.
Vilmorin Improved................	San Luis Valley Station.	3	13.50	....
Vilmorin No. 4..	College Farm.	3	14.00	....
Vilmorin No. 5.....................	"	3	14.00	....
Vilmorin	"	..	16.50	....
Kleinwanzleben.....................	Bellvue, Colo.	seepage	8.00	....
Vilmorin Improved................	"	seepage	9.00	....
Kleinwanzleben.....................	Arkansas Valley Station.	5	12.30	92.8
Vilmorin Brabant...................	" " "	5	8.80	80.0
Lane's Imperial.....................	" " "	5	8.00	80.0
Dippe's Improved..................	" " "	5	8.00	72.0
Dippe's Improved rich sugar.......	" " "	5	7.70	55.0
Vilmorin..........................	" " "	5	12.70	90.0
Vilmorin............................	" " "	5	13.43	67.0
Kleinwanzleben	" " "	5	8.80	63.0
Kleinwanzleben.	" " "	1	10.00	55.5
Dippe's Improved rich sugar.......	" " "	1	10.00	71.4
Vilmorin Brabant Imperial.........	" " "	1	10.10	71.4
Vilmorin	" " "	1	11.50	71.8
Vilmorin No. 7	" " "	1	10.50	55.2
Lane's Imperial....................	" " "	1	10.70	56.3
Dippe's Improved White Imperial.	" " "	1	5.70	38.0
Vilmorin...........................	College Farm.	2	12.70	84.6
Red Skinned........................	"	2	15.00	88.2
Silesian	"	2	13.30	88.6
Lane's Improved.............	"	2	11.70	83.5
Neise Improved...	"	2	16.50	91.6
Vilmorin White....................	"	2	15.30	90.0
Vilmorin Improved................	"	2	13.50	84.3
Dippe's Kleinwanzleben............	Fort Collins.	2	11.10	70.0
Vilmorin	"	2	10.30	70.0
Bulteau Desprez..................	"	2	11.70	73.1
Vilmorin rich sugar	"	2	11.17	65.7
Kleinwanzleben.................. ..	La Junta.	8	10.80	72.0
Vilmorin Improved................	La Porte.	seepage	11.00	57.5
Kleinwanzleben...................	"	seepage	12.50	83.3
Vilmorin..............................	Timnath.	2	10.50	87.5
Kleinwanzleben..	Brighton.	2	15.54	91.4
Vilmorin............................	Loveland.	4	11.00	73.3
Kleinwanzleben	"	4	12.75	79.7

Name.	Where grown.	Times irrigated.	Per cent. sugar.	Coefficient of purity.
Vilmorin Imperial..................	San Luis Valley.	..	13.55	85.3
Vilmorin Imperial..	" " "	..	14.08	87.1
Vilmorin..........................	College Farm.	..	15.40	79.0
Vilmorin..........................	"	..	14.78	79.7
Vilmorin....	"	..	16.63	80.0
Silesian	"	..	14.42	83.9
Red Skinned........................	"	..	15.16	81.4
Vilmorin Imperial..................	"	..	16.13	84.5
Lane's Imperial....................	"	..	16.50	86.9
Vilmorin White.....................	"	..	18.59	89.0
Neise Imperial.....................	"	..	19.37	90.6
Vilmorin Imperial..................	"	..	16.52	86.1
Vilmorin...........................	"	..	18.90	84.3

The last thirteen analyses were made at the Department of Agriculture, Washington, D.C.

The record is not complete enough to justify more than the general statement that an excess of water is as detrimental to the yield of sugar as a lack of water. The record, so far as it goes, shows that those beets which received two and three irrigations contain the highest average percentage of sugar, while those which received one and five, stand quite close to each other, and are much lower than those which received two and three irrigations. There are some pronounced exceptions to this, particularly in some instances in which the plants received five irrigations. Out of eight samples, furnished by the Arkansas Valley Station, each plat having received five irrigations, five of them showed less than 9 per cent. of sugar, and none of them reached 14 per cent. of sugar; whereas, the samples from this Station, grown with fewer irrigations, show from 12 to 21 per cent. With one irrigation only, the percentage of sugar varies between 6 and 11 per cent., with one exception, which reaches 15.17 per cent.

The average percentage of sugar in beets grown on the College Farm, and analyzed in this laboratory, is 12.8 per cent.; but in 1893, we had heavy rains during the latter part of September and in October, immediately prior to harvesting the beets. The average percentage of sugar, as determined in seventeen samples, was 10.24 per cent., with a coefficient of purity ranging from 44.36 to 76.30. In one only did the coefficient of purity reach 81.13.

The alkalized portions of our land are wet and the beets grown on the College Farm in such soils have contained but little sugar. The Vilmorin made the best showing with 10.60 per cent. sugar. Whether this is due to the alkali or the water, matters not so far as the value of the beets is concerned.

The only attempt to raise sugar beets in the more elevated portions of the State, which has come to my knowledge, was made in the counties of Garfield, Eagle, and Pitkin, during the past season. The individual beets were mostly large, and no history of the soil in which they grew, or the cultivation which they received, was furnished with the samples. But it was the first experience which any of the growers had had in this line and they had apparently chosen the richest soil in which to make their experiment. Still 53 per cent. of the samples contained from 10 to 15 per cent. of sugar. The results of the experiment show that these counties can produce beets suitable for the manufacture of sugar, perhaps not to the same extent or at so fair a profit as our lower-lying districts, but still with great advantage to themselves.

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The

Birds of Colorado

BY

W. W. COOKE

APPROVED BY THE STATION COUNCIL

ALSTON ELLIS, President

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THE BIRDS OF COLORADO.

BY W. W. COOKE.

The following paper is designed to set forth our present knowledge of the distribution and migration of Colorado birds. There is also included a bibliography of the subject and an historical review of the progress of ornithological investigation in this State.

The total number of species and varieties of birds known to occur in Colorado is 360, of which 228 are known to breed. This is a larger number of species than has been taken in any state east of the Mississippi and is exceeded by only one state of the Union, that is by Nebraska with nearly four hundred species.

The reason for this great variety of bird life is found in the geographical position of the State and the physical characteristics of its surface.

From the Atlantic Ocean to western Iowa but slight changes occur in the avi-fauna. But with the decreased rainfall and the increase in altitude from there westward, a great number of new forms appear. The greatest change is at the eastern foothills of the Rocky Mountains, which is the natural dividing line between the eastern and middle provinces of the United States. But while many of the western forms extend as stragglers eastward into Kansas and Nebraska and especially into the Black Hills of South Dakota and northwestern Nebraska, a large number of eastern forms do not pass west of the semi-arid region of twenty inches of annual rainfall and are not found in Colorado. It is due to this fact that Nebraska exceeds Colorado in the number of species taken in the State. All of the eastern species reach Nebraska and nearly all the western forms extend into northwestern Nebraska. This is strikingly shown in the case of the Warblers. Nebraska has more than twenty Warblers that do not occur in Colorado, while Colorado has less than five that are not found in Nebraska.

The avi-fauna of Colorado is reinforced by species that belong more properly to the regions on all sides of it. The basis may be considered as the species that range over the whole of the United States and those that are most abundant in the middle west. As additions to these, there come to the State from the east such distinctively eastern species as the Bobolink, Phœbe, Blue Bird, and Baltimore Oriole; from the west the Dwarf Hermit Thrush, Grace's Warbler, Golden-crowned Sparrow, and the Black Swift; from the north Holbœll's Grebe, Arctic Tern, Harlequin Duck, and Barrow's Golden-eye; while something over twenty truly southern species have been taken as stragglers in southern Colorado.

Of accidental visitants we have our share. Three varieties of Surf Ducks have wandered to Colorado; a specimen of the English *Saxicola œnanthe* was taken near Boulder, a Bendire's Thrasher at Colorado Springs, an Olivaceous Flycatcher at Fort Lyon, a White-winged Dove in Jefferson County, a White Ibis at Denver, a Roseate Spoonbill at Silverton, and most wonderful of all, a Scarlet Ibis near Pueblo.

The broken character of the surface of Colorado offers inducements for birds of all kinds. The eastern third of the State is a vast plain, rising from an altitude of 3,500 feet at its eastern edge to nearly 6,000 feet where it joins the foothills of the Rockies. This whole region is treeless, except a narrow fringe along the streams. Innumerable throngs of birds sweep across it during migration, especially water fowl and waders, but its attractions are too few to induce many to remain through the summer.

The center of the State is occupied by the Continental Divide. Range on range attaining a height of over 14,000 feet offers favorable conditions for even boreal species. The great mountain parks lie in this section, and at an altitude of 8,000 feet mark the limit of height reached by the great bulk of the species.

The western third of Colorado presents a wilderness of rolling hills from 5,000 to 8,000 feet in altitude, covered with a few trees and a very scanty vegetation. Bird life is present in small numbers but great variety and partakes largely of western characteristics.

The temperature of Colorado is much below that of corresponding latitudes in the Mississippi Valley. On the plains the average for the year is not far from 52° F., with extremes more marked and changes more sudden than in moister climates. At 7,000 feet among the mountains the average temperature is five degrees lower, and at 9,000 feet only a little colder.

Timber line is about 11,500 feet in Colorado and with an average temperature of two degrees below freezing is yet the home of some birds for the entire year, while during the short summer many species find here congenial nesting sites.

The rainfall on the plains is about fourteen inches per year, increasing to twenty inches at 8,000 feet in northern Colorado, but in the southern scarcely reaching that amount until nearly to timber line. This scarcity of rain has a direct influence on the vegetation and through that on the distribution of the birds. With the exception of a few species of sparrows, almost all the bird life of the State is confined to the vicinity of water or high enough on the mountains to reach timber.

The records given in this bulletin are based first of all on the printed matter that has appeared dealing with the birds of Colorado. This mass of material has been supplemented by much manuscript matter, and by the personal observations of the author during a four years' residence in the State.

There is no State in the Union that offers a more difficult field for thorough work, and a recapitulation of our present knowledge only serves to bring out more clearly the many points on which further information is needed.

The only claim for completeness made by the present list is that it is complete so far as work done up to this time is concerned. Experience in this State as well as in others teaches that additions will be made for many years to come. These will not be confined to any one part of the State nor to any particular class of birds. In addition to accidental visitants, it may be confidently expected that several more eastern species will be found to follow up the Arkansas and the Platte Rivers, and a still greater number of western species up the valley of the Grand into western Colorado.

Though much ornithological work has been done in Colorado, many parts of the State have never yet been visited by an ornithologist. The region along the eastern base of the foothills at the juncture of mountain and plain has been quite thoroughly studied. Fully four-fifths of all the records of Colorado pertain to this narrow strip, thirty miles wide and one hundred and fifty miles in length. As this constitutes less than one-twentieth of the area of the State, it can be seen how little attention has been paid to much of Colorado. In this strip, Beckham, Nash and Lowe have worked at Pueblo; Aiken at Pueblo, Cañon City and Colorado Springs; Allen at Colorado Springs; Henshaw, Anthony and H. G. Smith at Denver; Trippe at Idaho Springs; Gale at Gold Hill; W. G. Smith and Osburn at Loveland; Breninger at Fort Collins, and Dille at Greeley. In most cases this work has been continuous through the year, and has resulted in a pretty thorough knowledge of the main features of the ornithology of this region. About a dozen other ornithologists have given us results of short visits to various places in this belt.

Eastward lie the great plains, stretching 150 miles from Pueblo to the Kansas line and crossing the whole breadth of Colorado. Here is an extent of country four times as large as the State of Massachusetts, and in this whole region but two ornithologists have ever worked. Capt. P. M. Thorne was at Fort Lyon, on the Arkansas, and Mr. H. G. Hoskins at Burlington and vicinity, in Kit Carson County. There are fourteen counties in eastern Colorado that have not a single printed bird record to their credit.

The great parks of Colorado have received but little more attention. Coues crossed North Park; Stevenson, Middle Park, and Allen, South Park, and took hurried glimpses at the bird life. San Luis Park has fared somewhat better, thanks to the labors of Henshaw and Aiken. Stone spent several months between South Park and San Luis Park, in the vicinity of Hancock. In southwestern Colorado, Drew in San Juan County, and Morrison in La Plata County, have given us valuable notes on the birds of the higher portions of the region. The whole of northwestern Colorado remains unexplored. What a field for the ornithologist! As large as the whole of New England outside of Maine, and containing the whole valley of the Grand River and its tributaries, it will reward the zealous seeker with many Pacific forms not now known to Colorado. No other part of the State will probably show so large a return as the region around Grand Junction. Other specially favorable localities for new developments are the lower waters of the tributaries of the San Juan River in southwestern Colorado, the region around Trinidad in south central Colorado, the Arkansas River near the Kansas line, and especially the Cimarron River of southeastern Colorado and the Platte River near Julesburg in northeastern Colorado.

For increased knowledge of distribution with regard to altitude, and for range during the breeding season, so little is known compared with what remains to be discovered that any part of the mountain region of Colorado offers an inviting field to the ornithologist.

In addition to the mass of published data accessible to all, the present writer has received valuable assistance from many manuscript notes, and he wishes here to express his thanks to the correspondents who have put so much time, labor and care into their preparation. Much information on special points has been obtained in answer to direct inquiries and also the following lists have been received:

A. W. Anthony. List of 226 species known by him to have been taken in Colorado.

W. H. Bergtold. Notes on 20 species seen by him in Routt County and near Denver.

G. F. Breninger. List of 257 species known by him to have been taken in Larimer County.

R. A. Campbell. List of 40 species noted near Boulder.

E. B. Darnell. Notes on 68 species found in Routt County.

H. G. Hoskins. Notes on 58 species seen near Burlington, and dates of migration for four years.

Mortimer Jesurn, M. D. List, with annotations, of 161 species taken on the Platte River 150 miles north of Cheyenne.

W. P. Lowe. List of 188 species found at Pueblo and in the Wet Mountains, distinguishing the breeders.

Chas. F. Morrison. List of 332 species known to occur in Colorado, of which 152 are marked as breeding in the State.

Wm. Osburn. Annotated list of 254 species identified by himself and Wm. G. Smith in the vicinity of Loveland.

Capt. P. M. Thorne. Annotated list of 160 species shot by him during five years residence at Fort Lyon. Especially valuable, because nearly all the specimens have been identified by Mr. Brewster and are now in the Field Museum in Chicago.

One of the hardest things to determine in making out a state list, is what shall constitute a valid record and entitle the bird to a place in the list. The present writer has endeavored to take a middle course between including everything that seemed to have a fair claim for admission and excluding everything to whose record attached any suspicion. With all species at all doubtful the full record has been given, so that future students may judge for themselves whether the species is entitled to entry. This course has been taken owing to the small amount of work that has as yet been done on Colorado ornithology. Some readers will undoubtedly believe that the records of some of the species here given need confirmation and should have been omitted. On the other hand the author can say that he has in his possession the records of *forty-two* species that have been ascribed to Colorado. Many of these, in fact the larger part of them, he believes to occur in the State, yet they have been excluded from this list, pending further information.

CLASSIFICATION OF COLORADO BIRDS.

1. Residents; species found in the State at all times of the year regardless of the season.

Merganser americanus.
Lophodytes cucullatus.
Anas boschas.
Dafila acuta.
Clangula islandica.
Histrionicus histrionicus.
Colinus virginianus.
Callipepla californica.
Callipepla gambeli.
Dendragapus obscurus.
Bonasa umbellus umbelloides.
Lagopus leucurus.
Pediocætes phasianellus campestris.
Centrocercus urophasianus.
Meleagris gallopavo.
Meleagris gallopavo mexicana.
Circus hudsonius.
Accipiter velox.
Accipiter cooperi.
Accipiter atricapillus.
Buteo borealis kriderii.
Buteo borealis calurus.
Buteo swainsoni.
Archibuteo ferrugineus.
Aquila chrysaëtos.
Haliæetus leucocephalus.
Falco mexicanus.
Falco peregrinus anatum.
Falco sparverius.
Strix pratincola.
Asio wilsonianus.
Asio accipitrinus.
Syrnium occidentale.
Nyctala acadica.
Megascops asio.
Megascops asio maxwelliæ.
Megascops asio aikeni.
Megascops flammeola.
Bubo virginianus subarcticus.
Speotyto cunicularia hypogæa.
Glaucidium gnoma.
Conurus carolinensis (formerly)
Geococcyx californianus.
Ceryle alcyon.
Dryobates villosus hyloscopus.
Dryobates pubescens homorus.
Dryobates scalaris bairdi.
Picoides americanus dorsalis.
Ceophlœus pileatus.
Melanerpes torquatus.
Colaptes cafer.
Otocoris alpestris arenicola.
Pica pica hudsonica.
Cyanocitta stelleri macrolopha.
Aphelocoma woodhousei.
Perisoreus canadensis capitalis.
Corvus corax sinuatus.
Corvus cryptoleucus.
Corvus americanus.
Nucifraga columbiana.
Cyanocephalus cyanocephalus.
Pinicola enucleator.
Carpodacus cassini.
Carpodacus mexicanus frontalis.
Loxia curvirostra stricklandi.
Leucosticte australis.
Spinus tristis.
Spinus pinus.

Passer domesticus.
Calcarius ornatus.
Rhynchophanes mccownii.
Junco caniceps.
Pipilo fuscus mesoleucus.
Ampelis cedrorum.
Cinclus mexicanus.
Catherpes mexicanus conspersus.
Troglodytes hiemalis.
Certhia familiaris montana.
Sitta carolinensis.
Sitta calolinensis aculeata.
Sitta canadensis.
Sitta pygmæa.
Parus inornatus griseus.
Parus atricapillus septentrionalis.
Parus gambeli.
Psaltriparus plumbeus.
Myadestes townsendii.

2. Winter visitants; species that have been taken commonly in the State during the winter, but are not included in the foregoing list.

Urinator imber.
Merganser serrator.
Aythya americana.
Aythya vallisneria.
Aythya affinis.
Charitonetta albeola.
Chen hyperborea.
Archibuteo lagopus sancti-johannis.
Otocoris alpestris leucolæma.
Coccothraustes vespertinus montanus.
Acanthis linaria.
Plectrophenax nivalis.
Leucosticte tephrocotis.
Leucosticte tephrocotis littoralis.
Calcarius lapponicus.
Zonotrichia leucophrys intermedia.
Spizella monticola ochracea.
Junco aikeni.
Junco hyemalis connectens.
Junco mearnsi.
Junco annectens.
Pipilo maculatus arcticus.
Ampelis garrulus.
Lanius borealis.

3. Species that breed in the State and regularly winter further south, but a few occur irregularly in southern Colorado in winter and in mild winters may occur throughout the State.

Podilymbus podiceps.
Larus delawarensis.
Anas carolinensis.
Branta canadensis.
Grus mexicana.
Gallinago delicata.
Falco columbarius.
Agelaius phœniceus.
Sturnella magna neglecta.
Scolecophagus cyanocephalus.
Zonotrichia leucophrys.
Melospiza fasciata montana.
Cistothorus palustris paludicola.
Merula migratoria.
Merula migratoria propinqua.
Sialia mexicana bairdi.
Sialia arctica.

4. Species that have been taken in Colorado in winter, either as rare or accidental visitors.

Stercorarius parasiticus.
Rissa tridactyla.
Larus argentatus smithsonianus.
Larus atricilla.
Xema sabinii.
Aythya marila nearctica.
Harelda hyemalis.
Oidemia americana.
Oidemia deglandi.
Oidemia perspicillata.
Branta canadensis hutchinsii.
Accipiter atricapillus striatulus.
Buteo borealis harlani.
Nyctea nyctea.
Colaptes auratus.
Scolecophagus carolinus.
Loxia leucoptera.
Leucosticte atrata.
Zonotrichia coronata.
Junco hyemalis.
Melospiza fasciata.
Cardinalis cardinalis.

5. Summer residents; species that have been known to breed in the state.

A. Species that breed on the plains and in the mountains or mountain parks.

Colymbus nigricollis californicus.
Larus delawarensis.
Hydrochelidon nigra surinamensis.
Anas boschas.
Anas strepera.
Anas americana.
Anas carolinensis.
Anas discors.
Anas cyanoptera.
Spatula clypeata.
Aix sponsa.
Erismatura jamaicensis.
Botaurus lentiginosus.
Ardea herodias.
Grus mexicana.
Porzana carolina.
Fulica americana.
Recurvirostra americana.
Himantopus mexicanus.
Totanus solitarius.
Symphemia semipalmata inornata.
Actitis macularia.
Ægialitis vocifera.
Ægialitis montana.
Centrocercus urophasianus.
Meleagris gallopavo mexicana.
Zenaidura macroura.
Cathartes aura.
Circus hudsonius.
Accipiter velox.
Accipiter cooperi.
Buteo borealis calurus.
Buteo swainsoni.
Archibuteo ferrugineus.
Falco mexicanus.
Falco peregrinus anatum.
Falco columbarius.
Falco richardsonii.
Falco sparverius.
Asio wilsonianus.
Asio accipitrinus.
Bubo virginianus subarcticus.
Speotyto cunicularia hypogæa.
Coccyzus americanus occidentalis.
Ceryle alcyon.
Dryobates villosus hyloscopus.
Dryobates pubescens h orus.
Ceophlœus pileatus.

Melanerpes erythrocephalus.
Colaptes cafer.
Phalænoptilus nuttalli.
Chordeiles virginianus henryi.
Tyrannus tyrannus.
Tyrannus verticalis.
Tyrannus vociferans.
Myiarchus cinerascens.
Sayornis saya.
Empidonax difficilis.
Empidonax traillii.
Otocoris alpestris arenicola.
Pica pica hudsonica.
Corvus cryptoleucus.
Corvus americanus.
Molothrus ater.
Xanthocephalus xanthocephalus.
Agelaius phœniceus.
Sturnella magna neglecta.
Icterus bullocki.
Scolecophagus cyanocephalus.
Carpodacus mexicanus frontalis.
Spinus tristis.
Spinus psaltria.
Spinus psaltria arizonæ.
Chondestes grammacus strigatus.
Poocætes gramineus confinis.
Spizella socialis arizonæ.
Spizella pallida.
Spizella breweri.
Melospiza fasciata montana.
Pipilo maculatus megalonyx.
Oreospiza chlorura.
Pipilo fuscus mesoleucus.
Zamelodia melanocephala.
Passerina amœna.
Progne subis.
Petrochelidon lunifrons.
Chelidon erythrogastra.
Clivicola riparia.
Stelgidopteryx serripennis.
Ampelis cedrorum.
Lanius ludovicianus excubitorides.
Vireo gilvus.
Dendroica æstiva.
Icteria virens longicauda.
Setophaga ruticilla.
Oroscoptes montanus.
Galeoscoptes carolinensis.
Troglodytes ædon aztecus.
Cistothorus palustris paludicola.
Merula migratoria propinqua.
Sialia arctica.

B. Species that breed on the plains, but only to the foothills of the mountains.

Podilymbus podiceps.
Sterna forsteri.
Pelecanus erythrorhynchos.
Dafila acuta.
Nycticorax nycticorax nævius.
Rallus virginianus.
Steganopus tricolor.
Bartramia longicauda.
Numenius longirostris.
Colinus virginianus.
Pediocætes phasianellus campestris.
Callipepla californica.
Meleagris gallopavo.
Buteo borealis kriderii.
Strix pratincola.
Megascops asio.
Conurus carolinensis. (formerly)
Icterus galbula.
Quiscalus quiscula æneus.
Passer domesticus.
Calcarius ornatus.
Rhynchophanes mccownii.
Spizella socialis.

Ammodramus savannarum perpallidus.
Spiza americana.
Calamospiza melanocorys.
Vireo olivaceus.
Dendroica striata.
Geothlypis trichas occidentalis.
Mimus polyglottos.
Harporhynchus rufus.
Sitta carolinensis.
Merula migratoria.
Sialia sialis.

C. Species that breed in the mountains or mountain parks and not on the plains.

Merganser americanus.
Lophodytes cucullatus.
Clangula islandica.
Histrionicus histrionicus.
Branta canadensis.
Gallinago delicata.
Dendragapus obscurus.
Bonasa umbellus umbelloides.
Lagopus leucurus.
Accipiter atricapillus.
Pandion haliætus carolinensis.
Nyctala acadica.
Megascops flammeola.
Glaucidium gnoma.
Picoides americanus dorsalis.
Aëronautes melanoleucus.
Contopus borealis.
Empidonax wrightii.
Cyanocitta stelleri macrolopha.
Perisoreus canadensis capitalis.
Nucifraga columbiana.
Cyanocephalus cyanocephalus.
Pinicola enucleator.
Carpodacus cassini.
Loxia curvirostra stricklandi.
Leucosticte australis.
Zonotrichia leucophrys.
Junco caniceps.
Melospiza lincolnii.
Passerella iliaca schistacea.
Piranga ludoviciana.
Helminthophila virginiæ.
Helminthophila celata.
Helminthophila celata lutescens.
Dendroica auduboni.
Dendroica townsendi.
Geothlypis macgillivrayi.
Sylvania pusilla.
Anthus pensilvanicus.
Cinclus mexicanus.
Troglodytes hiemalis.
Certhia familiaris montana.
Sitta canadensis.
Sitta pygmæa.
Parus gambeli.
Regulus satrapa.
Regulus calendula.
Myadestes townsendii.
Turdus fuscescens salicicola.
Turdus ustulatus swainsonii.
Turdus aonalaschkæ auduboni.
Sialia mexicana bairdi.

D. Species that breed principally in the mountains, and but sparingly on the plains.

Aquila chrysaëtos.
Haliæetus leucocephalus.
Megascops asio maxwelliæ.
Megascops asio aikeni.
Sphyrapicus varius nuchalis.
Sphyrapicus thyroideus.
Melanerpes torquatus.
Selasphorus platycercus.

Contopus richardsonii.
Aphelocoma woodhousei.
Corvus corax sinuatus.
Spinus pinus.
Ammodramus sandwichensis alaudinus.
Tachycineta bicolor.
Tachycineta thalassina.
Vireo solitarius plumbeus.
Salpinctes obsoletus.
Catherpes mexicanus conspersus.
Sitta carolinensis aculeata.
Parus atricapillus septentrionalis.

E. Species that breed regularly only in southern Colorado.

Callipepla gambeli.
Columba fasciata.
Syrnium occidentale.
Geococcyx californianus.
Dryobates scalaris bairdi.
Cypseloides niger borealis.
Trochilus alexandri.
Selasphorus rufus.
Amphispiza bilineata.
Amphispiza belli nevadensis.
Pipilo aberti.
Guiraca cærulea eurhyncha.
Compsothlypis americana.
Dendroica æstiva sonorana.
Dendroica graciæ.
Dendroica nigrescens.
Thryothorus bewickii leucogaster.
Parus inornatus griseus.
Psaltriparus plumbeus.
Polioptila cærulea.

6. Species taken in the State during the summer, but not known to breed.

Ajaja ajaja.
Plegadis guarauna.
Ardea candidissima.
Philohela minor.
Callipepla squamata.
Melopelia leucoptera.
Coccyzus erythrophthalmus.
Melanerpes carolinus.
Phalænoptilus nuttalli nitidus.
Dolichonyx oryzivorus.
Icterus spurius.
Junco phæonotus dorsalis.
Passerina cyanea.
Mniotilta varia.
Seiurus aurocapillus.

7. Migrants; species that have been taken in the State during the spring or fall, but are not known to breed or winter in Colorado.

Æchmophorus occidentalis.
Colymbus holbœllii.
Colymbus auritus.
Larus occidentalis.
Larus californicus.
Larus franklinii.
Larus philadelphia.
Sterna paradisæa.
Phalacrocorax dilophus.
Anas obscura.

Aythya collaris.
Clangula clangula americana.
Chen hyperborea nivalis.
Anser albifrons gambeli.
Olor columbianus.
Olor buccinator.
Guara rubra.
Grus americana.
Grus canadensis.
Gallinula galeata.
Phalaropus lobatus.
Macrorhampus scolopaceus.
Micropalama himantopus.
Tringa maculata.
Tringa fuscicollis.
Tringa bairdii.
Tringa minutilla.
Tringa alpina pacifica.
Ereunetes pusillus.
Ereunetes occidentalis.
Calidris arenaria.
Limosa fedoa.
Totanus melanoleucus.
Totanus flavipes.
Numenius hudsonicus.
Squatarola squatarola.
Charadrius dominicus.
Ægialitis semipalmata.
Arenaria interpres.
Myiarchus lawrencei olivascens.
Sayornis phœbe.
Empidonax minimus.
Carpodacus purpureus.
Ammodramus bairdii.
Zonotrichia querula.
Zonotrichia albicollis.
Piranga rubra cooperi.
Helminthophila peregrina.
Dendroica cærulescens.
Dendroica coronata.
Dendroica maculosa.
Dendroica rara.
Seiurus noveboracensis notabilis.
Sylvania pusilla pileolata.
Harporhynchus bendirei.
Turdus aonalaschkæ.
Turdus aonalaschkæ pallasii.
Saxicola œnanthe.

8. Stragglers or doubtful species, including those of which but one instance is known.

Æchmophorus occidentalis.
Colymbus holbœllii.
Colymbus auritus.
Rissa tridactyla.
Larus occidentalis.
Larus californicus.
Larus atricilla.
Anas obscura.
Chen hyperborea nivalis.
Branta bernicla.
Ajaja ajaja.
Guara alba.
Guara rubra.
Tantalus loculator.
Ardetta exilis.
Ardea rufescens.
Nycticorax violaceus.
Gallinula galeata.
Callipepla squamata.
Melopelia leucoptera.
Elanoides forficatus.
Ictinia mississippiensis.
Accipiter atricapillus striatulus.
Buteo lineatus elegans.
Coccyzus erythrophthalmus.
Sphyrapicus varius.
Milvulus forficatus.
Myiarchus lawrencei olivascens.

Sayornis phœbe.
Icterus spurius.
Scolecophagus carolinus.
Carpodacus purpureus.
Zonotrichia querula.
Zonotrichia coronata.
Zonotrichia albicollis.
Melospiza fasciata.
Cardinalis cardinalis.
Piranga rubra cooperi.
Vireo solitarius cassinii.
Dendroica cærulescens.
Dendroica rara.
Seiurus aurocapillus.
Icteria virens.
Sylvania pusilla pileolata.
Harporhynchus bendirei.
Turdus aonalaschkæ pallasii.
Saxicola œnanthe.

9. Regular visitants from the east or southeast.

Colaptes auratus.
Tyrannus tyrannus.*
Quiscalus quiscula æneus.*
Spizella socialis.*
Spiza americana.*
Helminthophila celata.*
Compsothlypis americana.*
Dendroica coronata.
Galeoscoptes carolinensis.*
Harporhynchus rufus.*
Sitta carolinensis.*
Polioptila cærulea.*
Merula migratoria.*
Sialia sialis.*

*Breeding.

10. Rare or irregular visitants from the east or southeast.

Xema sabinii.
Anas obscura.
Branta bernicla.
Ajaja ajaja.
Philohela minor.
Elanoides forficatus.
Ictinia mississippiensis.
Coccyzus erythrophthalmus.
Sphyrapicus varius.
Melanerpes carolinus.
Phalænoptilus nuttalli nitidus.
Milvulus forficatus.
Sayornis phœbe.
Dolichonyx oryzivorus.
Icterus spurius.
Icterus galbula.
Scolecophagus carolinus.
Carpodacus purpureus.
Zonotrichia querula.
Zonotrichia albicollis.
Melospiza fasciata.
Cardinalis cardinalis.
Passerina cyanea.
Vireo olivaceus.
Mniotilta varia.
Helminthophila peregrina.
Dendroica cærulescens.
Dendroica maculosa.
Dendroica rara.
Dendroica striata.
Seiurus aurocapillus.
Icteria virens.
Saxicola œnanthe.

11. Regular visitants from the west or southwest.

Anas cyanoptra.
Grus canadensis.
Columba fasciata.
Glaucidium gnoma.
Geococcyx californianus.
Dryobates scalaris bairdi.

Cypseloides niger borealis.
Trochilus alexandri.
Selasphorus rufus.
Myiarchus cinerascens.
Amphispiza bilineata.
Amphispiza belli nevadensis.
Pipilo fuscus mesoleucus.
Guiraca cærulea eurhyncha.
Dendroica graciæ.
Dendroica nigrescens.
Dendroica townsendi.
Catherpes mexicanus conspersus.
Parus inornatus griseus.
Psaltriparus plumbeus.

NOTE. All of these species have been found breeding in Colorado except *Grus canadensis.*

12. Rare or irregular visitants from the west or southwest.

Plegadis guarauna.
Callipepla squamata.
Callipepla gambeli.*
Melopelia leucoptera.
Accipiter atricapillus striatulus.
Zonotrichia coronata.
Myiarchus lawrencei olivascens.
Junco phæonotus dorsalis.
Pipilo aberti.*
Piranga rubra cooperi.
Vireo solitarius cassinii.
Turdus aonalaschkæ.

*Breeding.

SUMMARY.

Total species in Colorado	~~360~~ 363
1. Residents	87
2. Regular winter visitants from the north	24
3. Regular breeders that sometimes occur in winter	17
4. Rare or accidental winter visitants	22
5. Summer residents	~~228~~ 230
A. Breeding on plains and in mountains	101
B. Breeding on plains, but not in mountains	~~34~~ 35
C. Breeding in mountains, but not on plains	53
D. Breeding principally in mountains, sparingly on plains	~~20~~ 21
E. Breeding regularly only in southern Colorado	20
6. Summer visitants, not known to breed	15
7. Migrants	58
8. Stragglers	~~48~~ 51
9. Regular visitants from east and southeast	14
10. Rare visitants from east and southeast	33
11. Regular visitants from west and southwest	20
12. Rare visitants from west and southwest	12

DATES OF MIGRATION.

The notes on migration given in the following table are designed to show the different time at which the same species of birds arrive at different places and altitudes in Colorado as compared with the time of their arrival in the same latitude farther east and at a lower altitude. St. Louis, Mo., is thirty miles farther north than Fort Lyon, Colo., and one hundred and twenty miles south of Loveland, Colo. Hence, according to latitude, the birds should arrive in St. Louis about the same time as at Fort Lyon. But it is found that in fact they reach St. Louis on the average about twelve days before they appear at Fort Lyon. The dates of arrival seem to indicate an average difference of six days between Fort Lyon and Loveland. The distance between these two places is one hundred and fifty miles, or an average movement for the birds of twenty-five miles per day. This agrees quite closely with the average of twenty-eight miles per day that was found to be the usual speed of migration in the Mississippi valley.

The birds arrive at Idaho Springs about twenty-five days later than at Loveland, the result of the nearly three thousand feet more of altitude at the former place.

The records that follow for St. Louis, Mo., were taken by Mr. O. Widmann during the spring of 1884, and published on pages 33-37 of "Bird Migration in Mississippi Valley." The records for Fort Lyon were made by Capt. P. M. Thorne, U. S. A., and those at Loveland by Mr. Wm. G. Smith. These records were made for the Division of Ornithology and Mammalogy of the Department of Agriculture at Washington, and the present writer is indebted to the chief of the division, Dr. C. Hart Merriam, for copies of these records. The notes from Idaho Springs are those taken by Mr. T. M. Trippe, and published by Dr. Coues in "Birds of the Northwest."

It is understood, of course, that when dates are given for western varieties that do not occur at St. Louis, it is meant that the western variety was noted in Colorado and its eastern representative at St. Louis. Thus, *merula migratoria propinqua* was seen at Fort Lyon, while *merula migratoria* was the bird seen at St. Louis.

All the dates given are those on which the first individuals of the species were seen.

DATES OF ARRIVAL.

	St. Louis, Mo., 1884.	Ft. Lyon, Colo., 1883–1886.	Loveland, Colo., 1887–1890.	Idaho Springs, Colo., 1873.
Dafila acuta	Jan. 30	Mch. 14–Apr. 1	Jan. 27–Feb. 10	
Aythya americana		Feb. 22–Mch. 1	Feb. 2–Mch. 6	
Anas carolinensis	Feb. 18	Feb. 20–Mch. 3	Feb. 21	
Anas strepera		Mch. 1	Mch. 1–12	
Sialia arctica		Mch. 16–17	Mch. 6–16	Mch. 10
Aythya vallisneria		Apr. 7	Feb. 10–Mch. 12	
Larus delawarensis		Mch. 23	Mch. 9–20	
Spatula clypeata			Mch. 10–20	
Aythya affinis		Mch. 27–Apr. 10	Mch. 8–19	
Anas americana			Mch. 10–13	
Merula migratoria propinqua	Jan. 30	Mch. 14–18	Feb. 25–Mch. 15	Mch. 15
Ægialitis vocifera	Mch. 11	Mch. 9–12	Mch. 10–16	
Charitonetta albeola		Mch. 27–Apr. 1	Mch. 20	
Chen hyperborea	Feb. 25	Apr. 7	Mch. 21	
Falco sparverius	Feb. 26	Apr. 4–20	Mch. 21–29	
Anas cyanoptera		Mch. 7	Mch. 25–Apr. 13	
Anas discors		Mch. 1	Mch. 25–Apr. 13	
Fulica americana		Mch. 31	Mch. 10–25	
Totanus melanoleucus		Mch. 28–Apr. 10	Mch. 26–Apr. 6	
Falco peregrinus anatum			Mch. 29	
Tringa bairdii			Mch. 29–Apr. 9	
Sialia mexicana bairdi			Apr. 1	
Sayornis saya		Mch. 1–Apr. 15	Mch. 31–Apr. 15	
Oroscoptes montanus			Apr. 4–15	May 10
Pipilo maculatus megalonyx	Feb. 20	Apr. 16	Apr. 4–19	May 15
Zonotrichia leucophrys	Feb. 20		Apr. 4	
Erismatura jamaicensis	Feb. 26	Mch. 27–Apr. 10	Mch. 27–Apr. 5	
Ægialitis montana		Mch. 26	Mch. 27–Apr. 18	
Speotyto cunicularia hypogæa			Mch. 28–Apr. 7	
Grus americana	Mch. 17		Apr. 8–16	
Pandion haliaëtus carolinensis			Apr. 8	
Rallus virginianus			Apr. 9	
Lanius ludovicianus excubitorides	Jan. 30		Apr. 9–14	
Zenaidura macroura	Mch. 22	Mch. 22–Apr. 17	Apr. 11–14	
Xanthocephalus xanthocephalus		Apr. 23	Apr. 11–12	
Recurvirostra americana		Mch. 28	Apr. 9–23	
Numenius longirostris			Apr. 10–15	
Anthus pensilvanicus			Apr. 14–15	May 10
Totanus flavipes		Mch. 30	Apr. 15	
Podilymbus podiceps			Apr. 15–28	
Poocætes gramineus confinis	Mch. 22	Apr. 13	Apr. 17	May 10
Cathartes aura	Feb. 26		Apr. 10–22	
Scolecophagus cyanocephalus		Apr. 22	Apr. 18–25	
Dendroica auduboni		Apr. 29–May 12	Apr. 19–24	May 15
Tringa minutilla		Apr. 28–May 7	Apr. 19–23	
Totanus solitarius	May 5		Apr. 20	
Ammodramus savannarum perpallidus	Apr. 30		Apr. 21	
Actitis macularia	Mch. 17	May 12–17	Apr. 21	May 10
Ammodramus sandwichensis alaudinus	Mch. 22		Apr. 21	
Ardea herodias		Apr. 10	Apr. 11–21	
Pelecanus erythrorhynchus			Apr. 23	
Chelidon erythrogaster		Apr. 17	Apr. 23	
Progne subis	Mch. 24		Apr. 21–24	
Petrochelidon lunifrons	Apr. 15	May 6–8	Apr. 24	

DATES OF ARRIVAL—Continued.

	St. Louis. Mo., 1884.	Ft. Lyon, Colo., 1883-1886.	Loveland, Colo., 1887-1890.	Idaho Springs, Colo., 1873.
Nycticorax nycticorax nævius	----------	--------------	Apr. 25	----------
Ægialitis meloda circumcincta	----------	--------------	Apr. 25-May 5	----------
Dendroica coronata	Apr. 13	Apr. 17	Apr. 24-25	Apr. 25
Turdus aonalaschkæ auduboni	----------	May 6-9	Apr. 25-May 7	May 25
Myadestes townsendii	----------	Apr. 22-23	Apr. 25	Resident
Spizella pallida	----------	Apr. 25	Apr. 25	----------
Tachycineta thalassina	----------	--------------	Apr. 26	----------
Stelgidopteryx serripennis	Apr. 15	--------------	Apr. 28	----------
Limosa fedoa	----------	--------------	Apr. 20-May 1	----------
Tringa alpina pacifica	----------	--------------	Apr. 29-May 9	----------
Macrorhampus scolopaceus	----------	May 2	Apr. 29	----------
Melospiza fasciata montana	Feb. 23	--------------	Apr. 29	----------
Steganopus tricolor	----------	--------------	Apr. 27-May 1	----------
Salpinctes obsoletus	----------	Apr. 20	Apr. 29-May 8	May 20
Cistothorus palustris paludicola	----------	--------------	Apr. 30	----------
Colymbus nigricollis californicus	----------	--------------	Apr. 26-30	----------
Spizella socialis arizonæ	Mch. 22	--------------	Apr. 30	----------
Phalaropus lobatus	----------	--------------	May 1-9	----------
Helminthophaga celata	May 10	May 9	May 2-5	----------
Melospiza lincolnii	Apr. 29	Apr. 30	May 5	May 10
Symphemia semipalmata inornata	----------	May 2	Apr. 27-May 5	----------
Clivicola riparia	Apr. 29	--------------	May 5	----------
Tachycineta bicolor	Mch. 24	--------------	May 5	----------
Sterna forsteri	----------	--------------	May 5	----------
Oreospiza chlorura	----------	Apr. 30-May 8	May 6	May 10
Larus franklinii	----------	--------------	May 6	----------
Ereuntes pusillus	----------	Apr. 25	May 6	----------
Dendroica æstiva	Apr. 19	Apr. 17-May 8	May 7-19	----------
Passerina amœna	----------	May 8-15	May 7-19	----------
Chondestes grammacus strigatus	Apr. 25	Apr. 27	May 7	----------
Tyrannus verticalis	----------	May 5-6	May 8-12	----------
Contopus richardsonii	----------	May 22	May 8	May 25
Tyrannus tyrannus	Apr. 18	May 6-10	May 7-9	----------
Turdus ustulatus swainsonii	Apr. 26	May 6	May 9-10	----------
Setophaga ruticilla	Apr. 17	May 14	May 9	May 20
Dendroica nigrescens	----------	--------------	May 9	----------
Icterus bullocki	----------	May 4-12	May 9-19	----------
Geothlypis trichas occidentalis	Apr. 18	May 13	May 9	----------
Ereuntes occidentalis	----------	--------------	May 9	----------
Calamospiza melanocorys	----------	May 10-15	May 9-12	----------
Troglodytes aëdon aztecus	Apr. 19	Apr. 21-May 10	May 10	May 15
Piranga ludoviciana	----------	--------------	May 10-17	June 20
Harporhynchus rufus	Mch. 22	May 4-10	May 10	----------
Geothlypis macgillivrayi	----------	May 2-3	May 10-19	May 25
Vireo solitarius plumbeus	Apr. 29	--------------	May 11	May 25
Galeoscoptes carolinensis	Apr. 25	May 8-14	May 11-12	May 20
Contopus borealis	----------	May 11	May 11	----------
Vireo gilvus	Apr. 19	--------------	May 12	----------
Vireo olivaceus	Apr. 26	May 29	May 12	----------
Dendroica striata	Apr. 29	May 8	May 12	----------
Empidonax minimus	Apr. 29	--------------	May 12	----------
Mimus polyglottos	Apr. 14	Apr. 17-May 2	May 13	----------
Sylvania pusilla	May 6	May 5	May 11-13	May 20
Aëronautes melanoleucus	----------	--------------	May 13	----------
Botaurus lentiginosus	----------	Apr. 26	May 13	----------
Zamelodia melanocephala	----------	May 19-20	May 13	May 20
Helminthophaga peregrina	Apr. 29	--------------	May 17	----------
Micropalama himantopus	----------	May 2-22	May 20	----------

BIBLIOGRAPHY OF COLORADO ORNITHOLOGY.

The following list of publications, concerning the birds of Colorado, is believed to be practically complete with the following exceptions: No record has been made of the reviews or notices that have appeared of these publications. Some twenty-three articles have been omitted as being but incidental references and having no valuable bearing on the subject matter in hand.

One important particular should be noted in regard to the following pages. While referring to the book or article by its title as a whole, the explanatory notes have reference to only that part of the work that deals with Colorado birds as such explicitly. All implied references have been neglected. Even such a broad and comprehensive statement as "found in the entire Rocky Mountain region" has not been deemed sufficient to warrant considering it a Colorado reference. No reference whatever is made to all that part of the publications that deals with other matters.

The names of the authors are arranged alphabetically and the articles under each author in chronological order.

AIKEN, C. E. and HOLDEN, C. H. JR. Notes on the Birds of Wyoming and Colorado Territories. By C. H. Holden, Jr. with additional memoranda by C. E. Aiken. *Proc. Bost. Soc. Nat. Hist. XV.* 1872, *pp. 193–210.*

The paper is edited by T. M. Brewer who states that Mr. Holden's notes are based on birds and eggs found "in the northern part of Colorado and southern part of Wyoming Territories." As no record is given of the precise localities wnere each species was obtained, Mr. Holden's notes cannot be quoted with any certainty as referring to Colorado.

The records of Mr. Aiken were taken near Fountain, El Paso County, between November 1, 1871 and May 1872, and formed an important contribution to the knowledge of Colorado birds. The paper treats of 142 species, fully annotated, of which 59 are for the first time accredited to Colorado.

AIKEN, C. E. A Glimpse at Colorado and its Birds. *Am. Nat. VII.* 1873, *p. 13.*

Field notes on 21 species of birds seen in October in El Paso County.

AIKEN, C. E. A New Species of Sparrow. *Am. Nat. VII.* 1873, *p. 236.*

Description of *Centronyx ochrocephalus* since ascertained to be a synonym of *A. bairdii.* Taken in El Paso County, Colorado.

AIKEN, C. E. The Nidification of the Blue Crow and of the Gray-headed Snowbird. *Am. Sportsman, V.* 1875, *p. 370.*

Contains the first published description of the nest and eggs of the Blue Crow (*Cyanocephalus cyanocephalus*) also the first description of the nest and eggs of the Gray-headed Snowbird (*Junco caniceps*).

AIKEN, C. E. Notes on the Ornithology [of Colorado] observed by Mr. C. E. Aiken, Assistant. *Ann. Rep't Chief of Engineers*, 1875, *part II. Appendix LL, p. 1070.*

A short sketch of the birds observed by him in a trip from Pueblo to Pagosa Springs and return by way of the San Luis Valley. These notes, in a much fuller form, are included in H. W. Henshaw's report on the Birds of the Geographical Explorations and Surveys west of the one hundredth meridian.

ALLEN, J. A. Notes of an Ornithological Reconnoissance of portions of Kansas, Colorado, Wyoming and Utah. *Bull. Mus. Comp. Zool. III.* 1872, *pp. 113-183.*

A notable paper for the student of the historical side of Colorado Ornithology, as it contains the first real "local list" ever published of Colorado birds. All that had been written previous to this time on the birds of Colorado treats of less than twenty-five species, while this paper mentions more than three times that number. It is not meant that no ornithologists previous to this time had visited Colorado, but that their observations had not at this time been published. Mr. Allen's paper contains in addition to notes on birds from other states, a list of birds observed in Colorado, July-August, 1871 (81 species); in South Park, Colorado, July, 1871 (54 species); on Mount Lincoln, Colorado, July, 1871 (36 species). Of these 84 species are for the first time accredited to Colorado.

ALLEN, J. A. and BREWSTER, WM. List of Birds Observed in the Vicinity of Colorado Springs, Colorado, during March, April and May, 1882. *B. N. O. C. VIII.* 1883, *pp. 151 and 189.*

Notes on the arrival, abundance and breeding of 134 species. Also technical notes by Mr. Brewster on the specific characters of 14 species. The first and only records for Colorado of Bendire's Thrasher and the Florida Gallinule are given here. Mr. Brewster here gives the original description of *Helminthophila celata lutescens*, but without including Colorado in its geographical range, where however it has been taken by subsequent observers.

ALLEN, J. A. On the Avi-Fauna of Pinal County, with Remarks on some Birds of Pima and Gila Counties, Arizona. By W. E. D. Scott, with annotations by J. A. Allen. *Auk, V.* 1888, *p. 160.*

States that *Troglodytes aëdon aztecus* is the form found in Colorado.

ALLEN, J. A. The North American Species of the Genus *Colaptes* considered with Special Reference to the Relationships of *C. auratus* and *C. cafer*. *Bull. Am. Mus. Nat. Hist. IV. No. 1*, 1892, *article II. p. 21.*

Considers that true *auratus*, true *cafer* and also the mixed forms are found in Colorado.

AMERICAN ORNITHOLOGISTS' UNION. The Code of Nomenclature and Check List of North American Birds, adopted by the American Ornithologists' Union, being the Report of the Committee of the Union on Classification and Nomenclature. New York: American Ornithologists' Union, 1886.

Contains specific Colorado references to 35 species.

AMERICAN ORNITHOLOGISTS' UNION. Check List of North American Birds, prepared by a Committee of the American Ornithologists' Union. Second and Revised Edition. New York: American Ornithologists' Union, 1895.

Contains specific Colorado references to 53 species.

ANTHONY, A. W. Winter Plumage of *Leucosticte australis*. *Auk*, *IV*. 1887, *p. 257*.

Description of the plumage of male, female and young, based on specimens taken at Gold Hill, Colorado.

ANTHONY, A. W. The Scaled Partridge (*Callipepla squamata*) in Colorado. *Auk*, *XII*. 1895, *p. 388*.

A freshly killed bird seen in a taxidermist shop during the winter of 1892-3; said to have been killed on the Platte River near Denver.

BAIRD, S. F., CASSIN, J. and LAWRENCE, G. N. Reports of Explorations and Surveys to ascertain the most practicable and economical route for a railroad from the Mississippi River to the Pacific Ocean. Made under the direction of the Secretary of War in 1853-6, according to Acts of Congress of March 3, 1853, May 31, 1854, and August 5, 1854. Vol. IX. Birds: by Spencer F. Baird, Assistant Secretary Smithsonian Institution, with the co-operation of John Cassin and George N. Lawrence.

Capt. Gunnison's party and that of Lieut. Warren brought back skins and records of about twenty species of birds that have nothing but an historical value in this connection. They are included in the above volume with the records of the other surveying parties.

BAIRD, S. F. Pacific Railroad Reports as above, Vol. X. Route near the 38th and 39th parallels explored by Captain J. W. Gunnison, and near the 41st parallel, explored by Lieutenant E. G. Beckwith. Zoological Report No. 2. Report of Birds Collected on the Survey. By S. F. Baird.

Contains much the same notes from Gunnison's party that had already been printed in Vol. IX. Unimportant records of 15 species.

BAIRD, S. F. Geological Survey of California. J. D. Whitney, State Geologist. Ornithology, Vol. 1. Land Birds. Edited by S. F. Baird from the manuscript and notes of J. G. Cooper. Published by authority of the legislature, 1870, pp. XI., 591.

The only reference to Colorado ornithology is the appearance here under the name of *Leucosticte campestris* of a specimen of *Leucosticte tephrocotis* sent from Denver to the Smithsonian, January, 1862, by Dr. C. Wernigk. This is the first record for this species from Colorado.

BAIRD, S. F., BREWER, T. M. and RIDGWAY, R. A History of North American Birds. Land Birds, Vol. I.–[III.]. Boston, Little, Brown and Company, 1874. 3 vols.

Contains specific Colorado references on 54 species, nothing of which is new material.

BATCHELDER, C. F. Description of the First Plumage of Clarke's Crow. *Auk, Vol. I.* 1884, *p. 16.*

Specimens obtained in Chaffee County, Colorado.

BATCHELDER, C. F. An Undescribed Subspecies of *Dryobates pubescens. Auk, VI.* 1889, *p. 253.*

Describes *D. p. oreœcus* (=*homorus*) with type from Loveland, Colorado.

BATTY, J. H. The U. S. Geological Survey. *Forest and Stream, I. August 28*, 1873, *p. 35.*

Brief notes of a trip from Denver to Buffalo Peaks. Mentions seven species of common birds and in addition says: "I have also taken the nest, eggs and young of the *Regulus calendula* (ruby-crowned wren), which have never been taken before."

BATTY, J. H. The White-tailed Ptarmigan—*Lagopus leucurus. Forest and Stream, I. January 29*, 1874, *p. 390.*

Seen in winter in the foothills of South Park, Colorado.

BECKHAM, C. W. The Black-headed Grosbeak (*Zamelodia melanocephala*). *O. and O. VIII.* 1883, *p. 63.*

Notes on the nest and eggs. A male seen incubating near Pueblo, Colorado.

BECKHAM, C. W. Notes on Some of the Birds of Pueblo, Colorado. *Auk, II.* 1885, *p. 139.*

Brief records of the movements of 91 species of birds. Contains the first record for Colorado of *Thryothorus bewickii leucogaster* and, with one exception, the only record to date.

BECKHAM, C. W. Additional Notes on the Birds of Pueblo County, Colorado. *Auk, IV.* 1887, *p. 120.*

Addition of 22 species to the 91 previously noted and further notes on 28 species in the original list. First records for Colorado of *Zonotrichia querula* and *Z. albicollis.* There has been a second specimen of the latter taken; the former remains the only record for the state.

BENDIRE, C. E. Notes on the Habits, Nests and Eggs of the Genus *Sphyrapicus* Baird. *Auk, V.* 1888, *p. 226.*

Contains extended notes by Mr. Dennis Gale on the habits of *S. v. nuchalis* in Colorado.

BENDIRE, C. E. Notes on the Habits, Nests and Eggs of the Genus *Glaucidium* Boie. *Auk, V.* 1888, *p. 366.*

States that the form found in Colorado is *G. gnoma.*

BENDIRE, C. E. A Peculiar Nest of *Cinclus mexicanus. Auk, VI.* 1889, *p. 75.*

Describes one taken by Mr. Dennis Gale at Gold Hill.

BENDIRE, C. E. *Picicorous columbianus* (Wils.), Clarke's Nutcracker. Its Nest and Eggs, etc. *Auk*, *VI.* 1889, *p. 226.*

Notes made by Mr. Dennis Gale at Gold Hill, Colorado, together with a reprint of Bendire's description of the first nest and eggs ever taken, specimens procured in Oregon, (*Bendire, O. & O. 1882 pp. 105-107 and 113-114*); and a reprint of Goss' description of the nest he found at Fort Garland, Colorado, (*Goss, B. N. O. C., VIII. 1883, p. 44*). Mr. Gale's specimens are the third known to science.

BENDIRE, C. E. Description of the Nest and Eggs of *Megascops asio maxwelliæ*, the Rocky Mountain Screech Owl. *Auk*, *VI.* 1889, *p. 298.*

The first nest known was taken by Mr. A. W. Anthony near Denver; also several nests taken by Mr. Dennis Gale near Gold Hill.

BENDIRE, C. E. *Megascops asio maxwelliæ.* *Auk*, *VII.* 1890, *p. 91.*

Results of the examination of three ejected pellets sent by Mr. Dennis Gale from Gold Hill.

BENDIRE, C. E. A Second Nest and Eggs of *Picicorvus columbianus* taken in Colorado. *Auk*, *VII.* 1890, *p. 92.*

Taken by Mr. Dennis Gale at Gold Hill.

BENDIRE, C. E. Smithsonian Institution. United States National Museum. Special Bulletin No. 1. Life Histories of North American Birds, with special reference to their Breeding Habits and Eggs, with twelve lithographic plates. By Charles Bendire, Captain U. S. Army (retired), Honorary Curator of the Department of Oölogy, etc. pp. VIII. 446. Washington: Government Printing Office, 1892.

Descriptions of the nests and eggs of many species of Quail, Grouse, Doves, Hawks and Owls, of which 26 are specifically mentioned as occurring in Colorado. Contains many interesting and valuable notes by Mr. Dennis Gale, of Gold Hill, Colorado, on the breeding habits of birds in the Rocky Mountains.

BENDIRE, C. E. Smithsonian Institution. United States National Museum. Special Bulletin [No. 3.] Life Histories of North American Birds from the Parrots to the Grackles, with special reference to their Breeding Habits and Eggs. By Charles Bendire, Captain and Brevet Major U. S. A. (retired). Honorary Curator of the Department of Oölogy, U. S. National Museum, Member of the American Ornithologists' Union. With seven lithographic plates. Washington: Government Printing Office, 1895. pp. I-IX. 1-518.

This is Part II. of the work quoted above as Special Bulletin No. 1. It has the same general plan and style and the notes come from the same sources.

Brackett, A. E. Jack Snipe in Colorado. *Forest and Stream IX.* 1877, *p. 397.*

Breninger, G. F. Lincoln's Sparrow and its Nesting. *O. & O. XII.* 1887, *p. 191.*

Nest with young taken July 5 at 12,000 feet.

Breninger, G. F. Nesting of the Western Yellow Warbler. *O. & O. XIII.* 1888, *p. 64.*

Short note on its breeding habits.

Breninger, G. F. Nesting of the Green-tailed Towhee. *O. & O. XIII.* 1888, *p. 90.*

Eggs taken late in June at 7,000 feet.

Brewer, T. M. Exhibition of a Pair of *Plectrophanes maccowni* from "California," *i. e.*, Colorado. *Proc. Bos. Soc. Nat. Hist. XV.* 1873, *p. 311.*

Brewer, T. M. Note on the Nesting and Eggs of *Logopus leucurus. Proc. Bost. Soc. Nat. Hist. XVI.* 1874, *p. 348.*

Taken by Mr. T. M. Trippe at Idaho Springs, Colorado, June 28, 1873, a thousand feet above timber-line.

Brewer, T. M. [Letter on the Nest and Eggs of *Dendrœca auduboni.*] *Ibis, 4th Series* 1877, *p. 394.*

Fully described specimens from Summit County, Colorado.

Brewer, T. M. Notes on *Junco caniceps* and the Closely Allied Forms. *B. N. O. C. III.* 1878, *p. 72.*

Nest and eggs taken by J. H. Batty. Egg also taken July 12, 1876, in South Park.

Brewer, T. M. The Rocky Mountain Golden-eye (*Bucephala islandica*). *B. N. O. C. IV.* 1879, *p. 148.*

First eggs in the United States probably taken by Edwin Carter in 1876

Brewer, T. M. The Rocky Mountain Whiskey Jack (*Perisoreus canadensis capitalis*). *B. N. O. C. IV.* 1879, *p. 239.*

Nest taken by Mr. Carter, April 2, 1879, at Breckenridge.

Brewster, Wm. On a Collection of Birds lately made by Mr. F. Stephens in Arizona. *B. N. O. C. VIII.* 1883, *p. 21.*

Refers to the occurrence of the Chapparel Cock in Colorado.

Brewster, Wm. and Allen, J. A. See Allen, J. A. and Brewster, Wm. *B. N. O. C. VIII.* 1883, *pp. 151 and 189.*

Brewster, Wm. Bendire's Thrasher (*Harporhynchus bendirei*) in Colorado. *B. N. O. C. VIII.* 1883, *p. 57.*

First and only capture in Colorado.

BREWSTER, WM. Recent Occurrence of the Flammulated Owl in Colorado. *B. N. O. C. VIII.* 1883, *p. 123.*

Note from Mr. C. E. Aiken recording a young bird in nestling plumage taken near Manitou, and one taken at Mosca Pass, at the same place where Dr. Walbridge shot one four years previous.

BREWSTER, WM. The Red Crossbill (*Loxia curvirostra stricklandi*) in Kansas. By L. L. Dyche. *Auk, III.* 1886, *p. 260.*

With a supplementary note by Mr. Brewster in which he states that Colorado specimens are much nearer *stricklandi* than *americana.*

BREWSTER, WM. Three New Forms of North American Birds. *Auk, IV.* 1887, *p. 145.*

Describes a new subspecies *Symphemia semipalmata inornata* with types from Larimer County, Colorado.

BREWSTER, WM. On Three Apparently New Subspecies of Mexican Birds. *Auk, V.* 1888, *p. 139.*

The Colorado *Dendroica æstiva* is considered as a fair intermediate between *sonorana* and *morcomi.*

BREWSTER, WM. Descriptions of Seven Supposed New North American Birds. *Auk, VIII.* 1891, *p. 139.*

Includes *Megascops asio aikeni* with type from El Paso County, Colorado.

BURNS, FRANK L. The American Crow, (*Corvus americanus*) with Special Reference to its Nest and Eggs. Bull. No. 5 The Wilson Ornithological Chapter of the Agassiz Association, pp. 1-41. Oberlin, Ohio, March 15, 1895. H. Kenaston's print, Oberlin, Ohio.

Contains notes from Colorado by Mr. F. M. Dille.

BYERS, W. N. Birds and Electric Light. *Forest and Stream, XVIII.* 1882, *366*

Destruction of large numbers of birds by flying against the framework of the electric light towers in Denver, Colorado.

CANTWELL, GEO. C. Doings of a Tenderfoot. *O. & O. XV.* 1890, *p. 104.*

Short notes on several species of common birds seen near Pike's Peak.

COALE, H. K. Ornithological Notes of a Flying Trip through Kansas, New Mexico, Arizona and Texas. *Auk, XI.* 1894, *p. 216.*

A few notes on five species of the winter birds of Fort Logan, near Denver, Colorado.

COCKERELL, T. D. A. The Second Report of the Colorado Biological Association. *Custer County Courant* [local newspaper], *December*, 1888.

Note from Chas. F. Morrison giving record of the capture of *Ajaja ajaja* at Silverton, Colorado.

COCKERELL, T. D. A. The Sixth Report of the Colorado Biological Association. *Custer County Courant*, *January* 16, 1889.

Note from H W. Nash of the recent capture of the Pygmy Owl near Pueblo.

COCKERELL, T. D. A. The Ninth Report of the Colorado Biological Association. "Our Spring Migrants," T. D. A. C[ockerell]. *Custer County Courant*, *February*, 1889.

Dates of arrival for 1888 of 11 species.

COCKERELL, T. D. A. The Thirteenth Report of the Colorado Biological Association. *Custer County Courant*, *March*, 1889.

Robins first seen near Short Creek, March 19, 1889.

[Oversheets of all these reports were issued, unpaged and mostly undated].

COOKE, W. W. Ten New Birds for Colorado. *Auk*, *XI.* 1894, *p. 182.*

Records of some 15 species, of which *Oidemia deglandi*, *Ardetta exilis*, *Calidris arenaria* and *Coccyzus erythrophthalmus*, proved to be new birds for the State.

COOKE, W. W. The Summer Range of Colorado Birds. *Auk*, *XII.* 1895, *p. 151.*

Gives recapitulation of the altitudes at which the birds breed in the State, but mentions only a few species by name.

COUES, E. Range of the *Geococcyx californianus*. *Am. Naturalist*, *VII.* 1873, *p. 751.*

Quotes a letter from Dr. A. Woodhull on the occurrence of this species on the Arkansas River near Fort Lyon, Colorado.

COUES, E. Department of the Interior. United States Geological Survey of the Territories. F. V. Hayden. U. S. Geologist in Charge. Miscellaneous Publications No. 3. Birds of the Northwest. A Hand-book of The Ornithology of the Region drained by the Missouri River and its Tributaries. By Elliott Coues, Captain and Assistant Surgeon U. S. Army. Washington: Government Printing Office, 1874. pp. XII. 791.

A large part of Colorado falling within the scope of this volume, there is here collected nearly all that had been written on Colorado birds up to this time. One hundred and forty-five species are attributed specifically to Colorado, in addition to many whose habitat includes Colorado by implication. But the most important part of the work with reference to Colorado, is the very full and valuable notes of Mr. T. M. Trippe on the birds in the vicinity of Idaho Springs. They form to-day the best record there is of the vertical movements of the birds in spring and fall migration.

COUES, E. On the Breeding Habits, Nest and Eggs of the White-tailed Ptarmigan (*L. leucurus*). *Bull. U. S. Geological Surv. Terr. 2d series*, *No. 5*, *January* 8, 1876, *pp. 263–266.*

Most of the material on which these notes are based came from Colorado.

COUES, E. The Destruction of Birds by Telegraph Wire. *Am. Naturalist*, *X.* 1876, *p. 734.*

A detailed account from observations in Colorado.

COUES, E. Range of the Lanier Falcon. *B. N. O. C. II.* 1877, *p. 26.*

Very numerous in open portions of Colorado.

COUES, E. Western Range of *Conurus carolinensis*. *B. N. O. C. II.* 1877, *p. 50.*

Letter from Mr. E. L. Berthoud of its occurrence from 1860 to 1862 at Golden, Denver, on the Little Thompson, and on the Arkansas River near old Fort Lyon.

COUES, E. Note on the Cinnamon Teal. *B. N. O. C. II.* 1877, *p. 51.*

This and several other species very abundant, breeding at a small lake in North Park, Colorado.

COUES, E. *Melopelia leucoptera* in Colorado. *B. N. O. C. II.* 1877, *p. 83.*

Note from Mr. E. L. Berthoud of seeing a dozen or more, July, 1869, at the head of Cub Creek, Jefferson County, Colorado.

COUES, E. Nest and Eggs of *Selasphorus platycercus*. *B. N. O. C. III.* 1878, *p. 95.*

Record of five nests found by Mr. E. A. Barber, July 26, 1875, in extreme southwestern Colorado.

COUES, E. Department of the Interior, United States Geological Survey of the Territories. F. V. Hayden, U. S. Geologist in charge. Miscellaneous Publications No. 11. Birds of the Colorado Valley. A Repository of Scientific and Popular Information Concerning North American Ornithology. By Elliott Coues. Part First. *Passeres* to *Laniidæ*. Bibliographical Appendix. Seventy Illustrations. pp. XVI. 807. Washington: Government Printing Office, 1878.

Contains a good deal of material on Colorado birds, but it is all quoted from Henshaw's Report on the Surveys West of the Hundredth Meridian. q. v.

COUES, E. Nest and Eggs of *Catherpes mexicanus conspersus*. *B. N. O. C. V.* 1880, *p. 181.*

Nest with five eggs taken by Mr. H. D. Minot at Manitou, June 8, 1880.

COUES, E. Nest and Eggs of *Myiadestes townsendii*. *B. N. O. C. VIII.* 1883, *p. 239.*

Description of nest and eggs found by Mr. Wm. G. Smith in Jefferson County, Colorado.

COUES, E. Nest and Eggs of *Parus montanus*. *B. N. O. C. VIII.* 1883, *p. 239.*

Description of both taken by Mr. Wm. G. Smith.

COUES, E. Key to North American Birds, Etc. Fourth Edition, 1890.

Gives specific Colorado references for 35 species.

DAVIE, OLIVER. Nests and Eggs of North American Birds. By Oliver Davie. The Fourth Edition. Introduction by J. Parker Norris. Illustrations by Theodore Jasper, A. M., M. D., and W. Otto Emerson. pp. XII. 451. Columbus, Hann & Adair, 1889.

Contains specific references to 77 species of birds as breeding in Colorado.

DEANE, RUTHVEN. Capture of a Third Specimen of the Flammulated Owl (*Scops flammeola*) in the United States and First Discovery of its Nest. *B. N. O. C. IV.* 1879, *p. 188.*

Taken by Mr. C. E. Aiken at Poncha Pass, Fremont County, June 15, 1875; also the nest with one egg. This is the first record of its breeding in Colorado.

DEANE, RUTHVEN. The Old Squaw (*Clangula hyemalis*) in Colorado. *Auk, XII.* 1895, *p. 292.*

A male and female, shot by Mr. John B. Sibley near Denver, November 13, 1892. This is the first record for Colorado.

DILLE, F. M. Nesting of *Archibuteo ferrugineus. Young Oölogist*, 1885, *pp. 44, 45.*

Nesting April 13, 1885, in Weld County.

DILLE, F. M. A Week's Trip after Hawk's Eggs in Colorado. *O. & O. XII.* 1887, *p. 97.*

Eggs or young of *B. b. kriderii*, *B. b. calurus*, *B. swainsoni*, *A. ferrugineus*, and *F. mexicanus*, taken May 20-25, 1886, in Weld County.

DILLE, F. M. Nesting of the Black-billed Magpie. *O. & O. XIII.* 1888, *p. 23.*

Eggs on the plains usually about the first of May; in the mountains by May 25.

DILLE, F. M. Home Life of the Mountain Bluebird. *Nidologist, II.* 1894-5, *p. 36.*

Notes on the nesting of the Rocky Mountain Bluebird and the House Finch.

DILLE, F. M. Colorado Birds. The Black-billed Magpie. *The Sunny South Oölogist, I. No. 1.*

DILLE, F. M. Egg Collecting in Colorado. *The Sunny South Oölogist, I. No. 2.*

DILLE, F. M. Colorado Birds. Lark Bunting and Mountain Plover. *The Sunny South Oölogist, I. No. 3.*

DREW, F. M. Field Notes on the Birds of San Juan County, Colorado. *B. N. O. C. VI.* 1881, *pp. 85 and 138.*

Notes of the occurrence, migration and breeding of 104 species that range to or above 10,000 feet. Contains the first Colorado records of *Histrionicus histrionicus*, *Ceophlœus pileatus*, *Cypseloides niger*, *Loxia leucoptera* and *Dendroica graciæ.*

DREW, F. M. Song of the White-bellied Swallow (*Iridoprocne bicolor*). *B. N. O. C. VI.* 1881, *p. 115.*

"A peculiar chirrupy warble, bearing resemblance to a sparrow's song in some respects and strikingly like a robin's in some of the half-whistles."

DREW, F. M. The Golden-crested Wren Breeding in the Colorado Valley. *B. N. O. C. VI.* 1881, *p. 244.*

A young bird just from the nest, taken in San Juan County, Colorado, on July 25, 1881, at 11,000 feet.

DREW, F. M. *Lopibes hyperboreus* at 9,500 feet. *B. N. O. C. VI.* 1881, *p. 249.*

Six killed by flying against the telegraph wires.

DREW, F. M. Notes on the Plumage of *Nephœcetes niger borealis.* *B. N. O. C. VII.* 1882, *p. 182.*

Believes that four years are necessary to acquire full plumage.

DREW, F. M. Notes on *Lagopus leucurus.* *Auk*, *1*, 1884, *p. 392.*

On the moulting of the toe-nails of specimens taken in southern Colorado.

DREW, F. M. On the Vertical Range of Birds in Colorado. *Auk*, *II.* 1885, *p. 11.*

One of the most notable articles ever written on Colorado birds. It gives: 1. The highest altitude at which each species is known to range in the spring. 2. The same for the summer. 3. The same for the autumn. 4. The upper and lower limits of altitude, between which the species ranges during the winter. 5. The upper and lower limits of the breeding range.

The list is preceded by a short sketch of the topography of the state and a brief summary of its meteorological conditions.

The article is intended to present a complete list of the birds of Colorado known to that time. It contains 277 species classified as follows:

1. Residents, 51. 2. Summer residents, known to breed, 156. 3. Total breeders, 207. 4. Migrants, 21. 5. Winter visitants, 22. 6. Summer visitants, not known to breed, 5. 7. Known to occur within the state, but not classified, 22. TOTAL, 277.

The article contains the first records for Colorado of *Colymbus holbœllii*, *Colinus virginianus*, *Callipepla californica* and *Cardinalis cardinalis.*

DWIGHT, JONATHAN, JR. The Horned Larks of North America, *Auk*, *VII.* 1890, *p. 138.*

Breeding birds of Colorado said to be *arenicola.*

FISHER, A. K. U. S. Department of Agriculture. Division of Ornithology and Mammalogy. Bulletin No. 3. The Hawks and Owls of the United States in their Relation to Agriculture. Prepared under the direction of Dr. C. Hart

Merriam, Ornithologist, by A. K. Fisher, M. D., Assistant Ornithologist. Published by authority of the Secretary of Agriculture. pp. 210. Washington: Government Printing Office, 1893.

Specific Colorado references to 12 species.

GOSS, B. F. Notes on the Breeding Habits of Maximilian's Jay (*Gymnocitta cyanocephala*) and Clarke's Crow (*Picicorvus columbianus*). *B. N. O. C. VIII.* 1883, *p. 43.*

Description of nests and eggs found near Fort Garland, Colorado.

GOSS, N. S. Notes on the Breeding Habits of the American Eared Grebe (*Dytes nigricollis californicus*). *Auk*, *I.* 1884, *p. 19.*

Observations on the notes of Mr. Henshaw concerning the nesting of this species in the San Luis Valley.

GOSS, N. S. Additions to the Catalogue of Kansas Birds. *Auk*, *III.* 1886, *p. 114.*

Records the Chapparel Cock in southeastern Colorado and southwestern Kansas.

GOSS, N. S. Additions to the Catalogue of the Birds of Kansas with Notes in Regard to their Habits. *Auk*, *VI.* 1889, *p. 123.*

Describes nest of Clarke's Nutcracker taken at Fort Garland, Colorado.

HASBROUCK, E. M. The Carolina Paroquet (*Conurus carolinensis*) *Auk*, *VIII.* 1891, *p. 378.*

Refers to its former occurrence in Colorado.

HASBROUCK, E. M. The Geographical Distribution of the Genus *Megascops* in North America. *Auk*, *X.* 1893, *p. 250.*

The distribution of *M. a. maxwelliæ* and of *M. a. aikeni* in Colorado is given with the authorities and references; also full records to date of all the captures of *M. flammeola* in Colorado.

HENSHAW, H. W. Engineering Department, U. S. Army. Geographical and Geological Explorations and Surveys west of the one hundredth meridian. First Lieutenant Geo. M. Wheeler, Corps of Engineers, in Charge. Report upon Ornithological Specimens collected in the years 1871, 1872 and 1873. Washington: Government Printing Office, 1874, pp. 148.

In addition to various other articles on the birds of New Mexico, Arizona and Utah, it contains an article by Mr. Henshaw on 82 species found at Denver, May, 1873, and another on 104 species at Fort Garland, Colorado.

HENSHAW, H. W. Eared Grebe (*Podiceps auritus* var. *Californicus* Coues.) *Am. Nat. VIII.* 1874, *p. 243.*

An account of its breeding in San Luis Park.

HENSHAW, H. W. Engineering Department, U. S. Army. Report upon Geographical and Geological Explorations and Surveys west of the one hundredth meridian, in charge of First Lieut. Geo. M. Wheeler, Corps of Engineers, U. S. Army, under the direction of Brig. Gen. A. A. Humphreys, Chief of Engineers, U. S. Army. Published by Authority of Hon. Wm. W. Belknap, Secretary of War, in accordance with Acts of Congress of June 23, 1874, and February 15, 1875. In six volumes, accompanied by one topographical and one geological atlas. Washington: Government Printing Office, 1875. Vol. V. Zoology, Chapter III. Report upon the Ornithological Collections made in portions of Nevada, Utah, California, Colorado, New Mexico and Arizona, during the years 1871, 1872, 1873 and 1874, by H. W. Henshaw. pp. 133-507, plates XV.

Observations on the distribution and breeding of birds as noted by the various parties. So far as Colorado is concerned, it is a reprint of the paper noted above by Mr. Henshaw and all that had been previously written by Mr. C. E. Aiken on Colorado birds, with the addition of much new matter. It gives specific Colorado records for 170 species, of which 14 are here for the first time attributed to the State. The whole makes one of the most valuable contributions to Colorado ornithology.

HENSHAW, H. W. The Shore Larks of the United States and Adjacent Territory. *Auk, I.* 1884, *p. 257.*

States that *leucolæma* occurs in Colorado only as a winter visitant and that all breeding birds are *arenicola.*

HENSHAW, H. W. List of Birds Observed in Summer and Fall on the Upper Pecos River, New Mexico. *Auk, II.* 1885, *p. 333*, and concluded in *Auk, III.* 1886, *p. 79.*

Contains Colorado notes on Baird's Sparrow, Red Crossbill and Pigmy Owl.

HERSEY, J. CLARENCE. The Little White Egret (*Ardea candidissima*) in Colorado. *Am. Naturalist, X.* 1876, *p. 430.*

A specimen taken at Boulder, May 4, 1876.

HOLDEN, C. H., JR. and AIKEN, C. E. See Aiken, C. E. and Holden, C. H., Jr.

INGERSOLL, EARNEST. Our Present Knowledge of the Nidification of the American Kinglets. *B. N. O. C. I.* 1876, *p.* 77.

Records a nest with five young and one egg, found by Mr. J. H. Batty, near Buffalo Mountain, June 21, 1873, being the first ever known to science.

INGERSOLL, EARNEST. The Flammulated Owl (*Scops flammeola*) in Colorado. *B. N. O. C. V.* 1880 *p. 121.*

Records a second specimen for Colorado, shot by Dr. Walbridge at Mosca Pass, the third week in August, 1879.

"J" [CAPT. P. M. THORNE]. Range of *Carpodacus frontalis. Forest and Stream*, *XXI.* 1883, *No. 26*, *p. 493.*

A pair killed at Fort Lyon, Colorado, June 3, 1883, the female containing eggs nearly ready to lay.

JEFFRIES, J. AMORY. Notes on an Hermaphrodite Bird. *B. N. O. C. VIII.* 1883, *p. 17.*

A Green-tailed Finch from Colorado Springs, Colorado.

KELLOGG, V. L. Summer Birds of Estes Park, Colorado. *Trans. Kans. Acad. Science*, *XII.* 1889-90, *p. 86.*

Annotated list of 89 species, among them being *Colinus virginianus*, *Columba fasciata*, *Pinicola enucleator* and *Sitta carolinensis* [typical].

LAMB, W. F. Nest and Eggs of Townsend's Flycatcher. *B. N. O. C. II.* 1877, *p. 77.*

First nest ever known to science found by him in Summit County, Colorado, in July, 1876, at an elevation of 10,000 feet.

LOWE, W. P. Some Spring Arrivals at Pueblo County, Colorado. *O. & O. XVII.* 1892, *p. 101.*

Dates of arrival of about 70 species, including *Polioptila cærulea.*

LOWE, W. P. A List of the Birds of the Wet Mountains, Huerfano County, Colorado. *Auk*, *XI.* 1894, *p. 266.*

Annotated list of 76 species, giving their vertical distribution.

LOWE, W. P. The Scarlet Ibis (*Guara rubra*) in Colorado. *Auk*, *XI.* 1894, *p. 324.*

A fine specimen shot in the Wet Mountains in May, 1876. This is the fourth record of its capture in the United States.

LOWE, W. P. An Addition to the Birds of Colorado. *Auk*, *XII.* 1895, *p. 298.*

Capture of *Callipepla squamata*, June 10, 1895, in the eastern foothills of the Wet Mountains, Pueblo County, Colorado, at an altitude of 6,000 feet.

LOWE, W. P. The arrival of the English Sparrow at Pueblo. *Nidiologist*, *II.* 1894-5, *p. 99.*

First seen there February 20, 1895, and quite common a week later.

LOWE, W. P. Notes from the Field. *Nidiologist*, *II*, 1894-5, *p. 169.*

Heights of nesting sites of several hawks and owls.

MAYNARD, CHAS. J. Eggs of North American Birds. By Chas. J. Maynard. Illustrated with ten Hand-colored Plates. pp. IV. 159. Boston: DeWolfe, Fiske & Co., 1890.

Specific Colorado breeding references for 22 species.

MCGREGOR, R. C. *Junco ridgwayi* in Colorado. *Auk*, *X.* 1893, *p. 205.*

One taken near Boulder.

McGregor, R. C. Two Runts. *The Nidiologist, II. May, 1895, p. 119.*

A set of eggs of Swainson's Hawk, taken in Weld County, Colo., June 1, 1887, contained one "runt" egg.

McGregor, R. C. Birds of Estes Park. *Nidiologist, IV. 1896-7, p. 38.*

Short notes on the occurrence of 76 species.

Merrill, J. C. Oölogical Notes from Montana. *B. N. O. C. VI.* 1881, *p. 204.*

Refers to the fact that the first four nests of the Ruby-crowned Kinglet known to science came from Colorado.

Miller, Olive Thorne. A Bird Lover in the West. Boston and New York: Houghton, Mifflin & Company. The Riverside Press, Cambridge, 1894. pp. I-VII. 1-278.

Notes on the habits and nesting of several species of birds found in the vicinity of Colorado Springs.

Minot, H. D. Notes on Colorado Birds. *B. N. O. C. V.* 1880, *p. 223.*

Annotated notes on 44 species taken at Boulder, 5,000 feet altitude; Nederland, 8,000 feet, and Seven Lakes, near Manitou, 11,000 feet altitude. The first and only record for *Saxicola œnanthe*, taken at Boulder, May 14, 1880.

Morrison, C. F. Field Notes on some Birds of Colorado. *O. & O. XI.* 1886, *pp. 153 and 164*, continued in *O. & O. XII.* 1887, *p. 27 and 35, 58 and 106.*

Notes on 31 species taken at Fort Lewis, Colorado. The "Pinnated Grouse" referred to is of course the "Sharp-tailed Grouse."

Morrison, C. F. A List of Some Birds of La Plata County, Colorado, with Annotations. *O. & O. XIII.* 1888, *p. 70, 107, 115 and 139.*

Quite full notes on 116 species, with the first record for Colorado of *Meleagris gallopavo mexicana.*

Morrison, C. F. A List of the Birds of Colorado. *O. & O. XIII.* 1888, *p. 145, 165 and 181*, continued in *O. & O. XIV.* 1889, *p. 6, 65 and 145*, concluded in *O. & O. XV.* 1890, *p. 36.*

The most extensive list of Colorado birds published up to this time. Begins with No. 1 of the A. O. U. Check List and closes with No. 570 a, enumerating 233 species. The list was never completed, owing to the destruction by fire of much of the material. In addition to records of Colorado birds already in print, the author had the use of a large amount of unpublished notes sent him by local collectors. The list, if completed at that time, would have shown 326 species; but as the records of some fourteen species recorded here have since been ascertained to be incorrect, it would reduce the real number to 312, or 35 more than Mr. Drew's list published three years previous. In this list appear for the first time *Ajaja ajaja, Tringa fuscicollis, Callipepla gambeli, Nyctea nyctea*, and *Junco phæonotus dorsalis.*

NASH, H. W. Notes on Some Birds Breeding in Colorado. *Forest and Stream, Feb. 5*, 1880.

Short observations on the nests and eggs of 28 species breeding near Pueblo.

NASH, H. W. Colorado Bird Arrivals. *Forest and Stream, XX. April 19*, 1883, *p. 225*.

Dates of arrival of the Eastern Bluebird and the Western Meadow Lark.

NORRIS, J. P. A series of Eggs of Sitta pygmæa. *O. & O. XIII.* 1888, *p. 173*.

One set was taken in Estes Park, Colorado, May 29, 1886.

OSBURN, WM. Nesting of the Grebes. *O. & O. XV.* 1890, *p. 68*.

Notes on the breeding of *Podilymbus podiceps* near Loveland, Colorado.

OSBURN, WM. Birds of Rare occurrence in Northern Colorado. *Science, XXII.* 1893, *p. 212*.

Notes on nine species seldom found there, among which *Zonotrichia coronata* is the first and only record for Colorado.

PEABODY, P. B. Glossy Ibis at Heron Lake. *Nidiologist, II.* 1895, *p. 116*.

Refers to a mounted specimen in his possession taken near Colorado Springs, Colorado.

PEARCE, GORDON D. Water Ousel or American Dipper. *The Sunny South Oölogist, I. No. 1.*

POLK, BURR H. A Mallard's Strange Nesting Place. *Forest and Stream, XVIII.* 1882, *p. 427*.

On the open prairie in eastern Colorado.

RIDGWAY, ROBERT. On Some New Forms of North American Birds. *Am. Nat. VII.* 1873, *pp. 603 and 615*.

Describes *Catherpes mexicanus conspersus* taken in Colorado by Aiken and Allen and *Junco hyemalis aikeni* taken by Aiken near Fountain, El Paso County, in the winter of 1871–2.

RIDGWAY, R. The Birds of Colorado. *Bull. Essex Inst. V.* 1873, *p. 174*.

The first list of Colorado birds ever published; 243 species, of which 156 are noted as breeding. The center of abundance of each species during the breeding season is also given. The list is preceded by several tables. Eastern species found in Colorado, 30. Others found at more western points, not yet detected in Colorado, 15. [Eleven of these have since been taken in Colorado, and one more only three miles north of the State in Wyoming.] Species of the southern border of the United States found in Colorado, 10. Western species found in Colorado not occurring in corresponding latitudes in the Great Basin, 5. The list is followed by critical notes on several species.

RIDGWAY, ROBERT. Description of a New Bird (*Leucosticte atrata*) from Colorado. *Am. Sportsman, IV.* 1874, *p. 241*.

Four specimens taken by C. E. Aiken at Canon City, in April, 1874.

RIDGWAY, ROBERT. Mrs. Maxwell's Colorado Museum; Catalogue of the Birds. *Field and Forest II.* 1887, *pp. 195-198 and 208-214.*

A list of the 234 species in the collection, several of which are the first and some the first and only records for Colorado.

RIDGWAY, ROBERT. Mrs. Maxwell's Colorado Museum; Additional Notes. *Field and Forest III.* 1887, *p. 11.*

Notes on two species *Junco caniceps* and *Junco annectens.*

RIDGWAY, ROBERT. *Scops flammeola* in Colorado. *B. N. O. C. V.* 1880, *p. 185.*

Calls attention to the fact that his record of the specimen in Mrs. Maxwell's collection is the real first record of the species for Colorado.

RIDGWAY, ROBERT. A Review of the American Crossbills (*Loxia*) of the *L. curvirostra* Type. *Proc. Biolog. Soc. of Washington, II.* 1883, *p. 84.*

Describes a new subspecies, *L. c. bendirei,* as the form occurring in Colorado and adjacent territory. [The A. O. U. have since refused to admit the validity of this subspecies.]

RIDGWAY, ROBERT. On the Possible Specific Identity of *Buteo cooperi* Cass. with *B. harlani* (Aud.). *Auk, I.* 1884, *p. 253.*

A specimen taken by Mr. C. E. Aiken at Colorado Springs.

RIDGWAY, ROBERT. On *Buteo harlani* (Aud.) and *B. Cooperi* Cass. *Auk, II.* 1885, *p. 165.*

Shows that Aiken's Colorado specimen should be considered *harlani* instead of *cooperi.*

RIDGWAY, ROBERT. A Manual of North American Birds. By Robert Ridgway. Illustrated by 464 Outline Drawings of the Generic Characters. *pp. XI. 631. Plates CXXIV.* Philadelphia: J. B. Lippincott Company, 1887.

Gives specific Colorado references to 34 species, one of which, *Coccyzus americanus occidentalis* is here described for the first time and attributed to Colorado, and *Guiraca cærulea eurhyncha* is for the first time stated to be the form found in Colorado.

"R. V. R. S." Winter Snipe in Colorado. *Forest and Stream XXVI.* 1886, *No. 1, p. 5.*

Wilson's Snipe reported as occurring about warm spring holes in the coldest winter weather.

SAY, THOMAS. Account of an Expedition from Pittsburg to the Rocky Mountains, performed in the years 1819 and '20 by order of the Hon. J. C. Calhoun, Secretary of War; under the command of Major Stephen H. Long. From the notes of Major Long, Mr. T. Say, and other gentlemen of the party. Compiled by Edwin James, botanist and geologist for the expedition. In two vols. With an atlas. Vol. I. [II.]. Philadelphia: H. C. Carey and I. Lea, Chestnut St. 1823.

All Colorado matter is contained in the second volume, where eight species new to science are described and the type localities given; also short notes on three species previously described.

SCOTT, W. E. D. Notes on Birds observed at Twin Lakes, Lake County, Colorado. *B. N. O. C. IV.* 1879, *p. 90.*

Annotated list of 60 species, giving dates of nesting and notes on occurrence.

SMITH, H. G. JR. The Shore Lark (*Eremophila cornuta*). *O. & O. IX.* 1884, *p. 95.*

Notes on its habits and breeding at Denver.

SMITH, H. G. JR. Notes from Denver, Colorado. *O. & O. IX.* 1884, *p. 120.*

Notes on the Bohemian Waxwing, House Finch and Say's Flycatcher.

SMITH, H. G. JR. Cassin's Purple Finch (*Carpodacus cassini*). *O. & O. X.* 1885, *p. 90.*

Several seen at Denver, February 26 to March 25, 1885.

SMITH, H. G. JR. Some Additions to the Avi-fauna of Colorado. *Auk, III.* 1886, *p. 284.*

Ten species not given in Mr. Drew's list of Colorado birds. Of these the Rusty Grackle, Cormorant and Herring Gull are the first and only records for Colorado.

SMITH, H. G. JR. Food of the Great Northern Shrike. *O. & O. XIII.* 1888, *p. 163.*

Occurs as a winter resident at Denver, capturing Shorelarks and Longspurs; also feeding on grasshoppers and other insects.

SMITH, H. G. Another *Megascops flammeolus* for Colorado. *Auk, X.* 1893, *p. 364.*

One taken in Jefferson County.

SMITH, H. G. City Birds of Denver, Colorado. *Science XXII.* 1893, *p. 244.*

Short notes on 32 species.

SMITH, H. G. Some Birds New to Colorado. With notes on others of little known distribution in the State. *The Nidologist III.* 1896, *pp. 48, 65, 76.*

An important contribution to our knowledge of several species. Notes on 35 species, mostly water birds, of which *Æchmophorus occidentalis*, *Larus atricilla*, *Sterna paradisæa*, *Oidemia perspicillata*, *Gaura alba*, *Arenaria interpres*, *Strix pratincola*, *Dendroica cærulescens* and *Turdus aonalaschkæ* are the first records for Colorado.

SMITH, W. G. [Winter Birds in Larimer County, Colorado.] By W. G. S[mith]. *Random Notes, III.* 1886, *p. 13.*

SMITH, W. G. [Nest of Rock Wren.] *Random Notes, III.* 1886, *p. 17.*

SMITH, W. G. [Nest and Eggs of *Myiadestes townsendii.*] *Random Notes, III.* 1886, *p. 25.*

SMITH, W. G. [Notes from Colorado.] *Random Notes, III.* 1886, *pp. 66 and 67.*

SMITH, W. G. Nesting of Audubon's Warbler. *O. & O. XVIII.* 1888, *p. 114.*

SMITH, W. G. Nesting of the Ruddy Duck. *O. & O. XIII.* 1888, *p. 132.*

SMITH, W. G. Nesting of the Water Ousel. *O. & O. XIII.* 1888, *p. 149.*

SMITH, W. G. Nesting of the Pied-billed Grebe. *O. & O. XIV.* 1889, *p. 138.*

SMITH, W. G. Breeding Habits of the Mountain Plover. *O. & O. XIII.* 1888, *p. 187.*

SMITH, W. G. Nesting of the Cinnamon Teal. *O. & O. XIV.* 1889, *p. 77.*

SMITH, W. G. Sabine's Gull. *O. & O. XIV.* 1889 *p. 176.*

One killed at Loveland, October 12, 1889.

SMITH, W. G. Nesting of the Eared Grebe. *O. & O. XV.* 1890, *p. 140.*

SMITH, W. G. Nesting of the Flammulated Screech Owl. *O. & O. XVI.* 1891, *p. 27.*

Eggs at 10,000 feet on June 2, 1890, and another nest June 4. On June 20, a nest at 8,000 feet. [It is probable that all these were found in Estes Park.]

STONE, D. D. Water Ousel and Canada Jay. *O. & O. VII.* 1882, *p. 181.*

A Water Ousel seen at 11,000 feet in October near an open place in the ice on a small lake during a snow storm. Canada Jay so tame as to alight on his arm and take bread from his hand.

STONE, D. D. Notes from Colorado. *O. & O. VII. 1882, p. 191.*

Notes on 16 species taken at about 11,000 feet, Pine Grosbeak in July. Description of nest and eggs of "Oregon (?) Snowbird" and "Mountain Mocking Bird."

[In *O. & O. VIII.* 1883, *p. 13*, Mr. R. Ridgway has a note saying that Mr. Stone's "Mountain Mocking Bird" is *Myiadestes townsendii*, the "Oregon Snow Bird" is *Junco caniceps*, the "Stellar's Jay" is the Long-crested and the "Canada Jay" is the White-headed Jay, *Perisoreus capitalis.*]

STONE, D. D. Ruby-Crowned Kinglet. *O. & O. VIII.* 1883, *p. 83.*

Description of nests and eggs taken near Hancock, Colorado.

STONE, D. D. Colorado Notes. Extracts from may Note-book. *O. & O. IX.* 1884, *Part 1, p. 9. Part 2, p. 20.*

Notes on the nests and eggs of 18 species of birds nesting above 11,000 feet.

STONE, D. D. [*Myiadestes townsendii* and *Sialia sialis.*] *Random Notes, III.* 1886, *p. 42.*

THORNE, P. M. The Eastern Bluebird at Fort Lyon, Colorado. *Auk, III.* 1886, *p. 489.*

A pair nested there in 1886.

THORNE, P. M. Additions to Drew's List of Colorado Birds. *Auk, IV.* 1887, *p. 264.*

Notes on 20 species taken in the vicinity of Fort Lyon. [Of these *Contopus pertinax*, *Melospiza georgiana*, *Vireo belli*, *Anthus spragueii*, *Thryothorus ludovicianus*, *Thryothorus bewickii* and *Turdus fuscescens* are now known to be errors of identification.]

THORNE, P. M. Abnormal Plumage of *Xanthocephalus xanthocephalus.* *Auk, V.* 1888, *p. 112.*

Taken in Las Animas County, Colorado.

THORNE, T. W. [P. M.] The Olivaceous Flycatcher and Phœbe in Colorado. *Auk, VI.* 1889, *p. 276.*

Both taken at Fort Lyon; the first and only records for the state.

[WOOD, C. S.] *Scops flammeola. Colorado Springs Gazette, Sept. 3*, 1879.

Exhibition by C. E. Aiken of the fourth specimen from the United States.

WOODBURY, A. H. Ring-billed Gull in Colorado. O. *& O. XII.* 1887, *p. 116.*

One taken at Monte Vista.

THE HISTORY OF COLORADO ORNITHOLOGY.

In an old State like Massachusetts or New York whose birds have been studied and written about for nearly two centuries, it would be almost a hopeless task to collect and digest the enormous mass of material. In Colorado the case is far different. Less than fifty years have elapsed since the first systematic study of Colorado birds was made and but little was done previous to 1870. Yet in twenty-five years many records have been lost and the Colorado list shows already nearly a dozen species known to have been taken in the State, but the data of whose capture, when, where and by whom, cannot now be found.

This shows that it is high time a permanent record should be made of the principal facts in Colorado Ornithology while these facts are obtainable.

1807. **Pike.** The first reference to any birds residing in Colorado is found in Lieut. Pike's account of his trip through the State. He mentions the raven, magpie, turkey and pheasant. From what is now known it seems probable that he refers to *corvus corax sinuatus*, *pica pica hudsonica*, *meleagris gallopavo* and *dendragapus obscurus*, but as this is guess work in the case of two of these species, all of them are repeated under the name of the next one who reported them.

1823. **Say.** The expedition of Maj. Long was accompanied by the first trained ornithologist, who entered the bounds of the present State of Colorado. Thos. Say has left us records of the capture during that trip of *dendragapus obscurus*, *columba fasciata*, *tyrannus verticalis*, *pica pica hudsonica*, *carpodacus mexicanus frontalis*, *spinus psaltria*, *passerina amœna*, *petrochelidon lunifrons*, *mimus polyglottos*, *salpinctes obsoletus* and *merula migratoria.*

1858. **Baird.** The government parties of the Pacific Railroad surveys traveled but little in Colorado. The following is a list of all the government expeditions that entered Colorado previous to 1860:

1806–7. Lieut. Pike. Up the Arkansas River to Canon City, across into South Park; then by a round-about way into the San Luis Valley and to New Mexico.

1820. Maj. Long. Up the South Platte to Denver; across the "Divide" to Colorado Springs and south into New Mexico.

1844 and 1845. Capt. Fremont. Across the State via Grand River, Pueblo, Denver and Fort Morgan.

1851. Capt. Pope. Came from New Mexico north and east to La Junta and east to Kansas.

1853. Capt. Gunnison. Crossed the plains to the Arkansas River, up that stream and its branches to Trinidad, Colorado, across southern Colorado to Fort Massachusetts, over the Continental divide to the Gunnison River, down this stream and the Grand River to Utah.

1855. Lieut. Warren. Just touched Colorado at Julesburg.

1856. Lieut. Bryan. Up the South Platte to Fort Morgan and north into Wyoming.

1859. Col. Loring and Capt. Macomb. Across the southwest corner of Colorado in passing from Utah to New Mexico.

The specimens collected by these various expeditions, together with the field notes of the naturalists were worked up by Prof. Baird and his assistants, and incorporated in the ninth volume of the Pacific Railroad Reports. There occur here the first specific Colorado references to *anas discors*, *aythya americana*, *grus mexicana*, *lagopus leucurus*, *centrocercus urophasianus*, *zenaidura macroura*, *circus hudsonius*, *buteo swainsoni*, *falco sparverius*, *asio wilsonianus*, *speotyto cunicularia hypogœa*, *dryobates villosus hyloscopus*, *colaptes auratus*, *otocoris alpestris arenicola*, *xanthocephalus xanthocephalus*, *oroscoptes montanus*, *troglodytes aedon aztecus*, *parus atricapillus septentrionalis* and *sialia arctica*.

[NOTE. It may seem an anchronism to say that Baird added *d. v. hyloscopus* to the Colorado list, since it was not separated as a variety until many years later. What is meant, of course, is that Baird added the bird which is now called *d. v. hyloscopus*, though he himself used a different name for it.]

1859. **Baird.** In volume ten of the Pacific Railroad Reports, in giving the list of the birds taken by Capt. Gunnison's party, Baird notes specifically as from Colorado, several species that were on hand when volume nine was written, but which are not specially mentioned there as having been taken in Colorado. They are *buteo borealis calurus*, *chordeiles virginianus henryi*, *perisoreus canadensis capitalis*, and *corvus corax sinuatus*.

1870. **Baird.** *Cooper's Birds of California*, *I.* 1870, *p. 163*. *Leucosticte tephrocotis* taken by Wernigk at Denver.

1872. **Allen.** *Bul. Mus. Comp. Zool. III.* 1872, *pp. 113-183*. The visit of J. A. Allen to Colorado laid the foundation of our knowledge of the birds of the State. Passing across the plains, collecting along the base of the foothills and ascending above timber-line on one of the highest mountains, he presented the first "local list" from Colorado and the first statement of the vertical range of the different species. Mr. Allen's opportunities for observation were neither so good nor so extensive as those of Mr. C. E. Aiken, but his notes being published a few months earlier, makes his records antedate those of Mr. Aiken, though really taken somewhat later. Mr. Allen's list adds 84 species to Colorado birds as follows: *anas strepera, tringa minutilla, totanus melanoleucus, totanus flavipes, totanus solitarius, bartramia longicauda, actitis macularia, ægialitis vocifera, ægialitis montana, bonasa umbellus umbelloides, pediocætes phasianellus campestris, cathartes aura, aquila chrysaëtos, haliæetus leucocephalus, falco peregrinus anatum, ceryle alcyon, picoides americanus dorsalis, sphyrapicus varius nuchalis, sphyrapicus thyroides, melanerpes erythrocephalus, melanerpes torquatus, colaptes cafer, phalænoptilus nuttalli, aëronautes melanoleucus, selasphorus platycercus, tyrannus tyrannus, sayornis saya, contopus borealis, contopus richardsoni, empidonax wrightii, cyanocitta stelleri macrolopha, aphelocoma woodhousei, nucifraga columbianus, molothrus ater, agelaius phœniceus, sturnella magna neglecta, icterus spurius, icterus galbula, icterus bullocki, scolecophagus cyanocephalus, carpodacus cassini, leucosticte australis, spinus tristis, spinus pinus, poocætes gramineus confinis, ammodramus sandwichensis alaudinus, chondestes grammacus strigatus, zonotrichia leucophrys, spizella socialis arizonæ, junco caniceps, melospiza fasciata montana, melospiza lincolni, pipilo maculatus megalonyx, oreospiza chlorura, zamelodia melanocephala, spiza americana, calamospiza melanocorys, piranga ludoviciana, chelidon erythrogastra, tachycineta bicolor, tachycineta thalassina, lanius ludovicianus excubitorides, vireo olivaceus, vireo gilvus, vireo solitarius plumbeus, dendroica æstiva, dendroica auduboni, geothlypis macgillivrayi, icteria virens longicauda, sylvania pusilla, setophaga ruticilla, anthus pensilvanicus, cinclus mexicanus, galeoscoptes carolinensis, harporhynchus rufus, catherpes mexicanus conspersus, sitta carolinensis aculeata, sitta pygmæa, parus gambeli, regulus calendula, myadestes townsendii, turdus fuscescens salicicolus, turdus aonalaschkæ auduboni, sialia mexicana bairdi.*

1872. **Aiken.** *Proc. Bost. Soc. Nat. Hist. XV.* 1872, *pp. 193-210.* For several years, previous to 1872, Mr. C. E. Aiken had been living in Colorado and studying its bird life. His observations were from time to time communicated to Prof. Brewer and Mr. Ridgway. They constitute the largest mass of material on Colorado ornithology collected by any one person. Mr. Aiken's notes, published by Prof. Brewer in 1872, constitute the first records of the movements of the birds in Colorado in winter, and these winter species form, with the water birds, a large part of the 59 species that this list contains in addition to those already given by Mr. Allen. The following are the additions: *hydrochelidon nigra surinamensis, anas boschas, anas americana, anas carolinensis, anas cyanoptera, spatula clypeata, dafila acuta, aix sponsa, aythya vallisneria, aythya affinis, aythya collaris, clangula clangula americana, charitonetta albeola, erismatura jamaicensis, branta canadensis hutchinsii, botaurus lentiginosus, ardea hero-*

dias, grus americana, rallus virginianus, recurvirostra americana, gallinago delicata, tringa maculata, numenius longirostris, bubo virginianus subarcticus, geococcyx californianus, dryobates pubescens homorus, sphyrapicus varius, tyrannus vociferans, myiarchus cinerascens, empidonax traillii, otocoris leucolæma, corvus cryptoleucus, corvus americanus, cyanocephalus cyanocephalus, coccothraustes vespertina, leucosticte tephrocotis, zonotrichia leucophrys intermedia, spizella monticola ochracea, spizella socialis, junco aikeni, junco hyemalis, junco hyemalis connectens, junco mearnsi, pipilo maculatus arcticus, pipilo fuscus mesoleucus, clivicola riparia, ampelis garrulus, ampelis cedrorum, lanius borealis, helminthophila virginiæ, helminthophila celata, compsothlypis americana, dendroica coronata, dendroica nigrescens, geothlypis trichas occidentalis, cistothorus palustris paludicola, parus inornatus griseus, psaltriparus plumbeus, regulus satrapa, sialia sialis.

1873. **Aiken.** *Am. Nat. VII.* 1873, *13*, Mr. Aiken records here *ammodramus bairdi* for Colorado.

1873. **Ridgway.** *Bull. Essex Inst. Nov.* 1873, *179*. This is one of the most important and, at the same time, one of the most unsatisfactory publications ever issued concerning Colorado birds. It gives a list of 243 species known to occur in Colorado, of which 59 had never before been credited to the State. The list is entirely a compilation and much of it from manuscript notes of various persons and collections, yet, for the most of these species, no source of authority is given; for several the source is given incorrectly, and for some it is impossible at this day to ascertain the basis for including them in the list. The list is based largely on the records of Mr. Aiken, and to him belongs most of the credit for the notes on distribution during the breeding season. Many of the species are included on the authority of Mr. Henshaw who had lately taken them and allowed of their publication here in advance of his own notice that appeared at a later date. Several of the rarer species owe a place in the list to their occurrence in the Maxwell collection, a complete list of which was not published until 1877. And, as stated above, there are some species whose source cannot be now ascertained. The following species appear in this list for the first time; those marked with one star having been taken by Mr. Aiken, those with two stars by Mr. Henshaw, and those with the asterisk are in the Maxwell Collection. ***Colymbus nigricollis californicus*, †*podilymbus podiceps*, †*urinator imber*, †*larus delawarensis*, *sterna forsteri*, †*pelecanus erythrorhynchos*, †*merganser americanus*, †*lophodytes cucullatus*, **anas obscura*, *aythya marila nearctica*, †*branta canadensis*, *olor buccinator*, †*plegadis guarauna*, †*ardea candidissima*, †*porzana carolina*, ***fulica americana*, †*steganopus tricolor*, ***tringa bairdii*, †*tringa alpina pacifica*, ***ereunetes pusillus*, ***symphemia* *semipalmata inornata*, *charadrius dominicus*, **meleagris gallopavo*, *accipiter velox*, *accipiter cooperi*, *accipiter atricapillus*, *archibuteo lagopus sancti-johannis*, ***archibuteo ferrugineus*, ***falco mexicanus*, *falco columbarius*, *falco richardsoni*, †*pandion haliaëtus carolinensis*, **glaucidium gnoma*, **melanerpes carolinus*, *trochilus alexandri*, ***empidonax difficilis*, ***empidonax minimus*, ***empidonax hammondi*, ***dolichonyx oryzivorus*, ***quiscalus quiscula æneus*, †*pinicola enucleator*, *loxia curvirostra stricklandi*, †*plectrophenax nivalis*, †*calcarius ornatus*, †*rhynchophanes mccownii*, *ammodramus savannarum perpallidus*, †*spizella pallida*, ***spizella breweri*, *amphispiza bilineata*, *amphispiza belli nevadensis*, *passerella iliaca schistacea*, **guiraca cærulea eurhyncha*, **passerina cyanea*, ***progne subis*, ***stelgidopteryx serripennis*, **helminthophila peregrina*, *troglodytes hiemalis*, *certhia familiaris montana*, **polioptila cærulea*, †*turdus ustulatus swainsonii*.

1874. **Ridgway.** *Am. Sportsman, IV.* 1874, *241.* Records *leucosticte atrata* taken by Aiken at Colorado Springs.

1874. **Coues.** *Birds of the Northwest.* In addition to a recapitulation of what has been written by Allen and Aiken on Colorado birds, this book contains some long and valuable notes by T. M. Trippe on the birds of Idaho Springs and vicinity. Also several extended notes by J. A. Allen, supplementary to those he had already published. There is here published the first and only record of the species taken by Stevenson during the trip made by Dr. Hayden's party in 1869. This party started at Cheyenne, passed south to Denver, up Clear Creek and over Berthoud's Pass to Middle Park, back to Denver and south via Colorado City and Trinidad to New Mexico. The first records for Colorado given in Birds of the Northwest are *phalaropus lobatus*, *acanthis linaria* and *seiurus aurocapillus*.

1874. **Baird, Brewer** and **Ridgway.** *History of North American Birds.* *Icteria virens* taken by Thos. Say near the headwaters of the Arkansas.

1876. **Henshaw.** *Surveys West of One Hundredth Meridian, Vol. V.* Though some of these notes were really published two years previous, it will be better for present purposes to refer to the above which is the complete report of Mr. Henshaw's work.

In 1873 Henshaw and his assistants visted Denver and after a prolonged stay there during May, visited the San Luis Valley, making their headquarters at Fort Garland. The next year C. E. Aiken, as assistant ornithologist of the party, collected in the vicinity of Colorado Springs and Pueblo and then crossing the range into San Luis Park collected as far west as

Pagosa Springs. In addition to the species communicated to Mr. Ridgway and published by him in 1873, the following are given: *chen hyperborea*, *himantopus mexicanus*, *macrorhampus scolopaceus*, *limosa fedoa*, *selasphorus rufus*, *spinus psaltria arizonæ*, *pipilo aberti*, *piranga rubra cooperi*, *dendroica maculosa*, *dendroica rara*, *dendroica striata*, *dendroica townsendi*, *seiurus noveboracensis notabilis*, *sitta canadensis*.

1877. **Ridgway.** *Maxwell's Colorado Museum. Field and Forest*, *II.* 1876-7, *pp. 195 and 208*. This is the finest collection ever made of Colorado birds. It has been claimed that every bird in this collection was actually taken in Colorado. There seems good and sufficient reasons for believing that some of the skins bought by Mrs. Maxwell were really taken outside the State. They were all mounted by Mrs. Maxwell and largely collected by her. Most of them were taken in the vicinity of Boulder, but many were sent to her by friends in other parts of the State. Unfortunately nearly all of the data accompanying these specimens have been lost and there is now no means of ascertaining when or where they were captured.

Besides the species already given from this collection in Ridgway's List there are the following: *stercorarius parasiticus*, *rissa tridactyla*, *larus philadelphia*, *xema sabinii*, *phalacrocorax dilophus*, *mergus serrator*, *clangula islandica*, *oidemia americana*, *anser albifrons gambeli*, *olor columbianus*, *tantalus loculator*, *nycticorax violaceus*, *charadrius squatarola*, *asio accipitrinus*, *nyctala acadica*, *megascops asio maxwelliæ*, *megascops flammeola*, *coccyzus americanus occidentalis*, *leucosticte tephrocotis littoralis*, *calcarius lapponicus*, *vireo solitarius cassinii*. Two of these, *rissa tridactyla*, and *nycticorax violaceus*, still remain the first and only records for Colorado.

This completes the record of all work done in Colorado by the government surveying parties and by the individual workers that did so much for the ornithology of the state from 1869 to 1876. The state list at this time numbered 279 species or two more than those included ten years later by Mr. Drew in his list of Colorado birds. The Maxwell collection is the last large addition to the Colorado list. The 81 species that have since been added are nearly all rare or accidental visitants and have been added a few at a time by a large number of different workers.

1877. **Coues.** *B. N. O. C. II.* 1877, *pp. 50 and 83*. Adds *conurus carolinensis* and *melopelia leucoptera* taken by E. L. Berthoud.

1880. **Minot.** *B. N. O. C. V.* 1880, *223*. First record for *mniotilta varia* and the first and only record for *saxicola œnanthe*, taken at Boulder.

1881. **Drew.** *B. N. O. C. VI.* 1881, *pp. 85 and 138.* The government expeditions under Mr. Henshaw extended over much of southern Colorado and their work is supplemented by that of Mr. Drew, which gives us the results of several years' active field work in the extreme southwest corner of the State. Several new species are added as follows: *histrionicus histrionicus, ceophlœus pileatus, cypseloides niger borealis, loxia leucoptera, dendroica graciæ* and *merula migratoria propinqua.*

1883. **Brewster.** *B. N. O. C. VIII.* 1883, *57.* Records the capture of *harporhynchus bendirei* at Colorado Springs.

1883. **Allen & Brewster.** *B. N. O. C. VIII.* 1883, *151 and 189. Gallinula galeata* taken at Colorado Springs.

1884. **Ridgway.** *Auk, I.* 1884, *50. Buteo borealis harlani* taken by Aiken at Colorado Springs.

1885. **Drew.** *Auk, II.* 1885, *11.* Includes *colymbus holbœllii* but gives no authority for the record. Also mentions that *colinus virginianus* and *callipepla californica* have been introduced in the State. Includes *cardinalis cardinalis* probably based on Anthony's specimen at Denver.

1885. **Beckham.** *Auk, II.* 1885, *139. Numenius hudsonicus* and *thryothorus bewickii leucogaster* taken at Pueblo.

1886. **H. G. Smith.** *Auk, III.* 1886, *284.* Records *larus argentatus smithsonianus, nycticorax nycticorax nævius, philohela minor* and *scolecophagus carolinus* from near Denver, and *syrnium occidentale* as taken by C. E. Aiken near Colorado Springs.

1887. **Beckham.** *Auk, IV.* 1887, *120. Zonotrichia querula* and *zonotrichia albicollis* taken at Pueblo.

1887. **Thorne.** *Auk, IV.* 1887, *264. Branta bernicla, grus canadensis* and *micropalama himantopus* taken by him at Fort Lyon.

1887. **Dille.** *O. & O. XII.* 1887, *97. Buteo borealis krideri* taken in Weld County.

1887. **Ridgway.** *Manual of North American Birds. Helminthophila celata lutescens* noted as occurring in Colorado.

1888. **Morrison.** *O. & O. XIII.* 1888, *pp. 70, 107, 115 and 139. Meleagris gallopavo mexicana* added from La Plata County.

1888. **Morrison.** *O. & O. XIII.* 1888, *pp. 145, 165 and 181, XIV.* 1889, *pp. 6, 65 and 145, XV.* 1890, *p. 36. Ajaja ajaja* taken at Silverton, *tringa fuscicollis* taken by Capt. Thorne at Fort Lyon, *callipepla gambeli* taken by Mr. Morrison in southwestern Colorado, *nyctea nyctea* and *junco phæonotus dorsalis.*

1888. **Thorne.** *Auk, V.* 1888, *p. 112.* *Turdus aonalaschkæ pallasii* from Fort Lyon.

1889. **Thorne.** *Auk, VI.* 1889, *276.* *Myiarchus lawrencei olivascens* and *sayornis phœbe* taken by him at Fort Lyon.

1890. **Kellogg.** *Trans. Kans. Acad. Science, XII.* 1889–90, *86.* *Sitta carolinensis* taken by him in Estes Park.

1891. **Brewster.** *Auk, VIII.* 1891, *139.* Description of *megascops asio aikeni*, the type taken by Aiken at Colorado Springs.

1893. **McGregor.** *Auk, X.* 1893, *205.* *Junco annectens* taken near Boulder.

1893. **Osburn.** *Science, XXII.* 1893, *212.* *Accipiter atricapillus* and *zonotrichia coronata* taken at Loveland.

1894. **Cooke.** *Auk, XI.* 1894, *182.* *Ardetta exilis*, at Colorado Springs; *oidemia deglandi*, *calidris arenaria* and *coccyzus erythrophthalmus*, in the museum of the Agricultural College, at Fort Collins.

1894. **Lowe.** *Auk, XI.* 1894, *324.* *Guara rubra* taken in the Wet Mountains near Pueblo in May, 1876.

1895. **Deane.** *Auk, XII.* 1895, *292.* *Harelda hyemalis* taken near Denver.

1895. **Lowe.** *Auk, XII.* 1895, *298.* *Callipepla squamata* taken by him in the Wet Mountains.

1895. **Lowe.** *Nidologist, II.* 1894-5, *99.* *Passer domesticus* first seen at Pueblo, February, 1895.

1896. **Bendire.** *Life Histories of North American Birds. Part II.* *Coccyzus americanus*, *dryobates pubescens* and *phalænoptilus nuttalli nitidus* are credited to Colorado, but no authority given.

1896. **Smith.** *Nidologist, III.* 1895-6, *48, 65 and 76.* *Æchmophorus occidentalis*, *larus atricilla*, *sterna paradisæa*, *oidemia perspicillata*, *guara alba*, *arenaria interpres*, *strix pratincola*, *dendroica cærulescens* and *turdus aonalaschkæ* all taken in the vicinity of Denver.

1897. **Cooke.** *Colorado Experiment Station Bulletin No. 37.* The present publication contains the first records for Colorado of several species as follows: *ardea rufescens*, *elanoides forficatus* and *bubo virginianus arcticus*, by Aiken; *carpodacus purpureus*, by Anthony; *ictinia mississippiensis*, *buteo lineatus elegans*, *milvulus forficatus* and *sylvania pusilla pileolata*, by Breninger; *dryobates* *scalaris bairdi*, by Lowe; *larus californicus*, *larus occidentalis*, *larus franklinii*, *ereunetes occidentalis* and *ægialitis semipalmata*, by Osburn; *chen hyperborea nivalis* and *megascops asio*, by Snyder; *colymbus auritus*, *melospiza fasciata* and *dendroica æstiva sonorana*, by Thorne.

RECAPITULATION.

Date	Authority.	Number of Species added	Total number of Species to date
1823	Thos. Say	11	11
1858	S. F. Baird	19	30
1859	S. F. Baird	4	34
1870	S. F. Baird	1	35
1872	J. A. Allen	84	119
1872	C. E. Aiken	59	178
1873	C. E. Aiken	1	179
1873	R. Ridgway	60	239
1874	R. Ridgway	1	240
1874	E. Coues	3	243
1874	Baird, Brewer and Ridgway	1	244
1876	H. W. Henshaw	14	258
1877	R. Ridgway	21	279
1877	E. Coues	2	281
1880	H. D. Minott	2	283
1881	F. M. Drew	6	289
1883	Wm. Brewster	1	290
1883	Allen and Brewster	1	291
1884	R. Ridgway	1	292
1885	F. M. Drew	4	296
1885	C. W. Beckham	2	298
1886	H. G. Smith	5	303
1887	C. W. Beckham	2	305
1887	P. M. Thorne	3	308
1887	F. M. Dille	1	309
1887	R. Ridgway	1	310
1888	C. F. Morrison	1	311
1888	C. F. Morrison	5	316
1888	P. M. Thorne	1	317
1889	P. M. Thorne	2	319
1890	V. L. Kellogg	1	320
1891	Wm. Brewster	1	221
1893	R. C. McGregor	1	322
1893	Wm. Osburn	2	324
1894	W. W. Cooke	4	328
1894	W. P. Lowe	1	329
1895	R. Deane	1	330
1895	W. P. Lowe	1	331
1895	W. P. Lowe	1	332
1896	C. Bendire	3	335
1896	H. G. Smith	9	344
1897	W. W. Cooke	19	363

THE BIRDS OF COLORADO.

1. **Æchmophorus occidentalis.** WESTERN GREBE.

Migratory; rare. A western species that finds its eastern limit at the western edge of the plains. The only certain record for the State is that of H. G. Smith (Nidologist, III. 1896, 48) who saw the skins of one that had been shot near Denver about October 25, 1888, and of two others taken in the vicinity a few days earlier. It may eventually be found to breed in Colorado, since it is an abundant summer resident in Utah.

2. **Colymbus holbœllii.** HOLBŒLL'S GREBE.

Migratory; rare; a northern species coming south in the winter. It is a widely distributed species, liable to be found anywhere but so far has been noted in Colorado only in the southwestern corner in La Plata County, where F. M. Drew noted it in the autumn at 10,000 feet (Auk, II. 1885, 11) and C. F. Morrison notes it as "rare" in the same locality (O. & O. XIII. 1888, 70). It breeds far north.

3. **Colymbus auritus.** HORNED GREBE.

Migratory; rare. Inhabits the whole of North America, but its only Colorado record is that of Capt. P. M. Thorne who writes, "I find in my journal under date of October 8, 1887, the following. 'Killed a *C. auritus.* Was alone. Not seen here before.' I do not think a mistake as to identification possible. I am familiar with *C. n. californicus* and *P. podiceps.*" This was at Ft. Lyon on the Arkansas River. The Horned Grebe breeds from the northern United States northward and comes south in the winter.

4. **Colymbus nigricollis californicus.** AMERICAN EARED GREBE.

Summer resident; rare in eastern, not uncommon in western Colorado; breeds in suitable localities throughout its range from the plains to 8,000 feet, especially on the alkali lakes. Mr. Henshaw found it nesting abundantly in the San Luis Valley, most of the eggs being fresh June 23. He also found the birds quite numerous in migration at Denver as late as May 15, 1874. Its nest has been taken at Loveland, with fresh eggs June 20, and it is not uncommon on the lakes and reservoirs in the Big Thompson and Cache La Poudre Valleys. A few pass across the State and enter Kansas.

6. **Podilymbus podiceps.** PIED-BILLED GREBE.

Summer resident, rare; in migration, common. The only records of breeding come from the vicinity of Loveland, though it probably will be found breeding over much of the northern third of the State below 7,000 feet. In the southern portion of Colorado it is known only as a migrant, but in open seasons a few may remain through the winter.

7. **Urinator imber.** LOON.

Found throughout the State as a migrant and occasionally in winter, but not so common as in most of the country farther east. It has not been known to breed in Colorado, and probably all leave the State for their northern breeding grounds.

37. **Stercorarius parasiticus.** PARASITIC JAEGER.

Breeds at the far north and comes south to Colorado as a rare visitant in fall and winter. Three cases have been recorded. One, in Mrs. Maxwell's collection, was taken at Boulder in December, some time previous to 1874. A young bird in the dark phase was shot at Sloan's lake near Denver during the fall of 1889. (H. G. Smith, Nidologist, III. 1896, 48.)

Mr. W. P. Lowe, of Pueblo, writes that one was secured on the Arkansas River a mile below Pueblo in the fall of 1894, and is now in his collection.

40. **Rissa tridactyla.** KITTIWAKE.

A northern species, rare or accidental in Colorado in the winter. The only known specimen is the one in Mrs. Maxwell's collection, which was taken at Boulder in December.

49. **Larus occidentalis.** WESTERN GULL.

A Pacific Coast bird; accidental in Colorado. The only record for the State is the one Prof. Wm. Osburn writes that he took at Loveland, September 30, 1889.

51a. **Larus argentatus smithsonianus.** AMERICAN HERRING GULL.

Inhabits the whole of North America and occurs rarely in Colorado during migration. One was seen for several days by Mr. Breninger, near Fort Collins, and a young bird was shot at Denver, November 17, 1883. (Auk, III. 1886, 284.)

53. **Larus californicus.** CALIFORNIA GULL.

A western species that has been found breeding in immense numbers in Utah and has also been once taken in Kansas. It would be supposed then that it would be not uncommon in Colorado and it may yet be found rarely in the western part of the State, or even breeding, but at present the only record for Colorado is the one taken by Prof. Wm. Osburn, at Loveland, May 7, 1890.

54. **Larus delawarensis.** RING-BILLED GULL.

Summer resident, rare; in migration, common. The only gull that is commonly found throughout Colorado. Many are seen in the spring migration and they are very common in autumn on all bodies of water below 9,000 feet. They migrate early, appearing in southern Colorado by the middle of March. F. M. Drew records it as breeding at 6,000 feet. (Auk, II. 1885, 11.)

58. **Larus atricilla.** LAUGHING GULL.

A gull of the South Atlantic and Gulf States accidental once in Colorado. One was shot at Sloan's Lake near Denver in December, 1889. (H. G. Smith, Nidologist, III. 1896, 48.)

59. **Larus franklinii.** FRANKLIN'S GULL.

Migratory; rare. Has been taken by Wm. G. Smith, at Loveland, and A. W. Anthony saw a freshly mounted specimen said to have been taken near Denver.

60. **Larus philadelphia.** BONAPARTE'S GULL.

Migratory; rare. Eight specimens have been recorded, and every one has been taken along the edge of the plains from Colorado Springs to Fort Collins. Nearly all were captured in the fall, when it is reported as not uncommon in some localities.

62. **Xema sabinii.** SABINE'S GULL.

Winter visitant; rare. Breeds far north and comes south for the winter. Five occurrences have been recorded, all in the fall and early winter from October to December. They were noted at Denver, Boulder, Loveland and Fort Collins.

69. **Sterna forsteri.** FORSTER'S TERN.

Summer resident, rare; in migration, not uncommon. According to Mr. Ridgway a few breed in the State (Bull. Essex Institute, V. Nov. 1873, 174), but most of them are merely migrants. They are almost as common in the spring as in the fall. They reach northern Colorado the last of April and early in May.

71. **Sterna paradisæa.** ARCTIC TERN.

Migratory; very rare. But two instances are on record. Prof. Wm. Osburn has an adult male that was shot at Loveland, July 9, 1889, and Mr. Ridgway has identified for H. G. Smith one that was shot near Denver in the spring of 1887. (Nidologist, III. 1896, 48.)

[74. **Sterna antillarum.** LEAST TERN.

In the Auk, XI. 1894, 182, the present writer added this to the list of Colorado birds on the strength of a mounted specimen at Colorado Springs that he was told had been taken in that vicinity. Further investigation has convinced him that the specimen was secured outside of Colorado. There is now no certain record for this State. It is a southern species that breeds as far north as Kansas, and will undoubtedly some day be obtained in Colorado.]

77. **Hydrochelidon nigra surinamensis.** BLACK TERN.

Summer resident; not uncommon; in a few localities, nests quite abundantly; somewhat more common in migration. It is found on both sides of the range almost anywhere that the natural conditions are suitable. Reaches northern Colorado the middle of May.

120. **Phalacrocorax dilophus.** DOUBLE-CRESTED CORMORANT.

All the records for Colorado come from the eastern foothills. There was one in Mrs. Maxwell's collection and H. G. Smith records four instances near Denver; one about November 1, 1885, one about October 1, 1891, from a flock of about 20, one in the fall of 1886, and a fourth from Jones' Lake, near Denver. (Auk, III. 1886, 284, and Nidologist, III. 1896, 48.) Since it has been found breeding abundantly in Utah, it will probably yet be found in the western half of Colorado.

125. **Pelecanus erythrorhynchos.** AMERICAN WHITE PELICAN.

Formerly not uncommon in migration and some remained to breed; now rare in migration and no late record of its breeding. It is still occasionally noted from both sides of the range. Has been taken in the San Luis valley in October, 1887, at 8,000 feet, but usually is found below 5,500 feet. Still breeds in Wyoming and Montana. Passes across Colorado late in April and early in May.

129. **Merganser americanus.** AMERICAN MERGANSER.

Resident; winter sojourner not uncommon; rather more common in migration; breeds along the northern boundary of the United States and northward and a few breed in the mountains and mountain parks of the north half of Colorado. It is found in winter wherever there is open water along the South Platte, especially near Fort Morgan, and is likely to be noted on any open water on the plains. It is most common in April, moving northward. It has been reported less commonly from the western half of Colorado, but as it is of general distribution in North America, it probably occurs throughout the State.

130. **Merganser serrator.** RED-BREASTED MERGANSER.

Winter sojourner, rare; in migration, not uncommon. Breeds far north. Occurs in winter on the Platte, and in migration throughout the plains district of eastern Colorado. Undoubtedly occurs, though not yet reported, on the lower waters of western Colorado.

131. **Lophodytes cucullatus.** HOODED MERGANSER.

Resident; a few remain in the State during the winter, and a still smaller number nest irregularly over eastern Colorado and in the mountains. It is a little more common in migration, especially late in the fall, just before the lakes freeze. Capt. Thorne found it at Fort Lyon on June 20 and July 2.

132. **Anas boschas.** MALLARD.

Resident; in winter, not uncommon; in migration, one of the most common ducks, especially in the fall; breeds throughout the State below 9,000 feet, on the plains as well as among the mountains. Chas. F. Morrison makes the statement that in La Plata County the Mallards are never seen in the fall (O. & O. XIII. 1888, 70), however in the lower portions of the State they are abundant at that season, and they have been known to ascend to 10,500 feet during the autumn. The larger part of migration takes place in March, and by the latter part of April few are left except those that remain to breed.

133. **Anas obscura.** BLACK DUCK.

Migratory; rare. An eastern species finding in Colorado its most western extension. One was taken by C. E. Aiken prior to 1873 (Ridgway, Bull. Essex Institute, V. 174), and Prof. Wm. Osburn writes that he took one on the Big Thompson, near Loveland, March 15, 1889.

135. **Anas strepera.** GADWALL.

Summer resident, not common; in migration, common. C. F. Morrison says: "It breeds in the sloughs and small lakes at 11,000 feet in southwestern Colorado. I secured ten young from the La Plata River, unable to fly. These with the parent birds came down from the mountains. They started quite young on their southern migration." (O. & O. XIII. 1888, 145.) V. L. Kellogg found them breeding in Estes Park. (Trans. Kans. Acad. Science, VII. 1889-90, 86.) Other observers have noted their breeding on the plains. It is never as common in migration as many of the other ducks, but old hunters expect to get a few each season. They are most common during the spring migration early in March.

137. **Anas americana.** BALDPATE.

Summer resident; tolerably common, locally; in migration, commonly distributed all over the State and occasionally in the fall migration is locally abundant. Breeds mostly in the north, but a few remain behind to breed on the prairies of Kansas and eastern Colorado, while Dr. Coues found them breeding in large numbers in North Park at an altitude of about 8,000 feet. (B. N. O. C. II. 1877, 51.)

139. **Anas carolinensis.** GREEN-WINGED TEAL.

Summer resident; common, locally; in migration, abundant. One of the earliest ducks to migrate in the spring and on the plains one of the most abundant. The bulk breed farther north and it is a rare breeder on the plains, but among the mountains and mountain parks it is not uncommon through the summer. Henshaw found it in the San Luis Valley breeding in considerable numbers June 24, but not yet through laying. Morrison reports its breeding near Fort Lewis in southwestern Colorado, and Kellogg found it as a common summer resident of Estes Park.

140. **Anas discors.** BLUE-WINGED TEAL.

Summer resident, common; in migration, abundant. Whatever has been given above concerning the Green-winged Teal would apply equally to the Blue-winged.

141. **Anas cyanoptera.** CINNAMON TEAL.

Summer resident; common. A western species abundant over all the country west of the Rocky Mountains. Many cross the range and are found along the eastern foothills; farther east they are rare. H. G. Hoskins writes that he found one at Beloit, near the eastern boundary of the state, on October 27, 1895, and they have several times been taken in Kansas. There is no record of their breeding far out on the plains of Colorado, but judging from their known habits it is probable that a few breed locally over much of the country from the mountains to Kansas. In north central Colorado, at the western edge of the plains, a scattered pair or two can be found breeding in most of the sloughs or marshes. West of the range, Henshaw found them breeding in southern Colorado in June and Dr. Coues notes them as very abundant breeding at small lakes in North Park. They are among the later migrants of the ducks arriving in northern Colorado early in April, and by the middle of June have full clutches of eggs.

142. **Spatula clypeata.** SHOVELLER.

Summer resident; common, locally; in migration, abundant. This duck inhabits the whole of North America and is among the few that breed throughout their range. It has been taken all over Colorado, but apparently is more common as a breeder in the western half, not because it is more common there in migration, but it seems to prefer the higher altitude. Records of its breeding on the plains are not numerous, but in the mountain parks at about 8,000 feet it is one of the most numerous of the summer resident ducks.

143. **Dafila acuta.** PINTAIL.

Summer resident; rare; in migration, common; winter resident, rare. Some days during spring and fall migration this duck is very common on the plains. It is a bird of the plains, seldom going above 6,000 feet. A few remain around open water on the plains through the winter. It was recorded several years ago as breeding in the State (Ridgway, Bull. Essex Inst. V. 1873, 174), though it usually breeds from the northern row of states in the United States northward. Both W. G. Smith and G. F. Breninger write that it breeds in Larimer County, east of the foothills.

144. **Aix sponsa.** WOOD DUCK.

Summer resident; rare. Occurs over all of the United States and breeds throughout its range, but it must be considered as one of the rare ducks in Colorado. It has been taken at Loveland and is occasionally taken on the lakes near Denver. C. F. Morrison says, "I found this duck at Fort Lewis, where it no doubt breeds, although I found no nest. Abundant about the headwaters of the Rio La Plata at an elevation of 9,500 feet." (O. & O. XIII. 1888, 165.)

146. **Aythya americana.** REDHEAD.

Migratory; common. Breeds far north. Is more common in Colorado than the Canvas-back and occurs throughout the State. Is one of the earlier ducks to move in the spring and occasionally a few appear in the fall by the middle of September, sometime before the regular flight begins.

147. **Aythya vallisneria.** CANVAS-BACK.

Migratory; not common. A few are observed spring and fall over all of the State, and sometimes quite large flocks are noted. It lingers late in the fall and has even been noted in the winter on the plains. Breeds far north.

148. **Aythya marila nearctica.** AMERICAN SCAUP DUCK.

Migratory; rare. Occurs on both sides of the range, but never common anywhere. Has been seen as late as December in southwestern Colorado at 9,000 feet. (Drew, B. N. O. C. VI. 1881, 85.) Breeds far north.

149. **Aythya affinis.** LESSER SCAUP DUCK.

Migratory; not common. Its range is much the same as the last species, but it is rather more common. Occasionally found in southern Colorado in winter. Reaches northern Colorado early in March.

150. **Aythya collaris.** RING-NECKED DUCK.

Migratory; rare. It is a little strange that this duck should be so uncommon as it seems to be in Colorado, since it is more common in Kansas than either of the others. Probably occurs on both sides of the range, though all the records are on the plains east of the foothills. Breeds far north.

151. **Clangula clangula americana.** AMERICAN GOLDEN-EYE.

Migratory; rare. Occurs throughout the State, but never common. Breeds far north, but begins to migrate early. C. E. Aiken took one in southern Colorado at 9,000 feet on August 30, 1874.

152. **Clangula Islandica.** BARROW'S GOLDEN-EYE.

Resident; not common. The distribution of Barrow's Golden-eye in Colorado is rather strange. It is a northern species, coming south in the winter to Colorado, and then when spring returns quite a share of these winter birds remain to breed in the mountains. So there results the queer condition of a northern species breeding in the mountains almost at the extreme southern limit of its range. On the plains it is a rare migrant and winter visitant; in the mountains it has been found breeding throughout the whole western half of Colorado, usually at about 8,000 feet. Chas. F. Morrison has the following note concerning its occurrence: "This species might almost be called a resident in southwestern Colorado. I can record its breeding in Dolores County, and have taken them all through the winter in the ponds below Fort Lewis." (O. & O. XIII. 1888, 165.) It nests in trees. There are no records of its extending much east of the mountains far out on the plains, and it never has been taken in Kansas.

153. **Charitonetta albeola.** BUFFLE-HEAD.

Migratory; common. Occurs throughout the State in migration, and is likely to be found near any open water in the winter. Breeds far north.

154. **Harelda hyemalis.** OLD-SQUAW.

Winter visitant; rare. A northern species coming south into Colorado in the late fall and winter. The only records come from the north central part of the state where G. F. Breninger writes that he found a dead bird on the shore of one of the lakes near Fort Collins. J. B. Sibley shot a male and female on McKay Lake near Denver, November 13, 1892. (Deane, Auk, XII. 1895, 292.)

155. **Histrionicus histrionicus.** HARLEQUIN DUCK.

Resident; not common. This is regularly a northern species, breeding far north and coming into Colorado in the winter as it does over the Mississippi Valley to the eastward. But a few remain to breed at about 10,000 feet in the mountains more particularly of western Colorado. C. F. Morrison says: "I believe it breeds in both the San Juan and La Plata counties. * * * I have often seen it through the winter below Fort Lewis on the Ute reservation together with *G. islandica.*" (O. & O. XIII. 1888, 165.) F. M. Drew gives it as breeding from 7,000 to 10,000 feet. (Auk, II. 1885, 11.)

163 **Oidemia americana.** AMERICAN SCOTER.

Winter visitant; rare. This and the next two are "Surf Ducks" that breed far north and come south in the winter, principally along the coast, but a few visit the larger inland waters. One would suppose them out of place in arid Colorado, but professional hunters expect to see a few of them each year. An American Scoter is in Mrs. Maxwell's collection and G. F. Breninger writes that he found a dead one near Fort Collins.

165. **Oidemia deglandi.** WHITE-WINGED SCOTER.

Winter visitant; rare. G. F. Breninger reports the capture of three specimens, one of which, taken November 3, 1890, is now in the cabinet of the State Agricultural College at Fort Collins. H. G. Smith reports four specimens as follows: one at Marston's Lake, near Denver, October, 1887; one on Lee's Lake, near Fort Collins, October 23, 1888; one taken by Wm. G. Smith, at Loveland; one at Sloan's Lake, near Denver, October 16, 1890. (Nidologist, III. 1896, 48.)

166. **Oidemia perspicillata.** SURF SCOTER.

Winter visitant; rare. Prof. Wm. Osburn writes that he saw one in the collection of Wm. G. Smith, taken at Loveland. H. G. Smith says that one was taken at Marston's Lake, near Denver, October, 1887, in company with the specimen of *O. deglandi* mentioned above. (Nidologist, III. 1896, 48.)

167. **Erismatura jamaicensis.** RUDDY DUCK.

Summer resident; common. Occurs on both sides of the range in migration and during the breeding season is not uncommon in the mountains up to 10,000 feet. East from the mountains it becomes less common in summer until along the eastern border of Colorado it rarely nests, though still common in migration. It is rather late to arrive in the spring and the eggs are laid by the middle of June.

169. **Chen hyperborea.** LESSER SNOW GOOSE.

Migrant and winter resident ; not common. A few are seen during migration spring and fall along the plains east of the mountains. There is no record of their wintering on the plains though probably they are at least an occasional winter visitant to the open waters of southeastern Colorado. Twenty years ago Henshaw heard of them as wintering abundantly in the San Luis Valley. But they are much less common everywhere in the Rocky Mountain region now than they were then. West and southwest of Colorado they still remain fairly abundant. Breeds far north.

169a. **Chen hyperborea nivalis.** GREATER SNOW GOOSE.

Migratory; rare. The eastern form, not coming regularly as far west as Colorado, being confined mostly to the Atlantic coast. A specimen shot by Pres. Z. X. Snyder east of Greeley, March 20, 1895, is a little longer than the greatest length given for the Greater Snow Goose. This is the only certain Colorado record.

171a. **Anser albifrons gambeli.** AMERICAN WHITE-FRONTED GOOSE.

Migratory; rare. Probably the rarest Goose that regularly occurs in Colorado. A few have been taken in migration in eastern Colorado.

172. **Branta canadensis.** CANADA GOOSE.

Summer resident, rare except locally; winter resident, not common; in migration, common. The most common Goose of the State. It might almost be called resident since there is no time in the year when there are not some in the State, but it is probable that the same individuals do not remain here throughout the year, those that breed in Colorado going farther south for the winter and their places being taken by those that nested further north. On the plains of eastern Colorado they are known only as migrants and winter residents. In the mountains they breed along the higher secluded lakes at about 10,000 feet, especially in North Park, where Dr. Coues found them breeding in large numbers. (B. N. O. C. II. 1887, 51.) A few remain in southern Colorado through the winter and they are likely to appear irregularly anywhere east of the range except in the severest weather.

172a. **Branta canadensis hutchinsii.** HUTCHINS'S GOOSE.

Migratory; common. Not quite so common as the Canada Goose and breeding only north of the United States. Passes through in migration spring and fall and a few may winter, since it has been taken as late as December.

173. **Branta bernicla.** BRANT.

Migratory; rare or accidental. An eastern species seldom coming so far west as Colorado. A specimen was shot by Capt. P. M. Thorne at Fort Lyon, April 11, 1883, and though it was not preserved there can scarcely be any doubt of the correctness of the identification.

180. **Olor columbianus.** WHISTLING SWAN.

Migratory; not common. In former years Swans were fairly common over much of western North America. Now they are rare anywhere but are still found in migration in Colorado. H. G. Smith mentions four cases of the occurrence of the Whistling Swan at various places in eastern Colorado and says he has heard of others. (Nidologist, III. 1896, 48.) One was shot from a flock of three at Fort Collins, March 16, 1895 and preserved by a local taxidermist.

181. **Olor buccinator.** TRUMPETER SWAN.

Migratory; rare. Apparently not so common as the last species. There was a specimen in the Maxwell collection and H. G. Smith reports two instances that have come to his knowledge. It has never been known to breed in Colorado, though breeding but a little farther north in the Mississippi Valley. One was shot during the fall of 1896 near Fort Collins.

183. **Ajaja ajaja.** ROSEATE SPOONBILL.

Accidental visitant; two instances. A southern species not regularly occurring north of the Gulf States. In a letter dated June 17, 1888, T. M. Trippe, of Howardsville, Colo., writes to C. F. Morrison, as follows: "A Rosy Spoonbill was captured at Silverton, Colo., the other day. It was caught alive, but died in a day or two. It was a female in fine spring plumage." (O. & O. XIII. 1888, 181.) H. G. Smith notes a specimen in very worn plumage August 8, 1890. Said to have been taken near Pueblo. (Nidologist, III. 1896, 65.)

184. **Guara alba.** WHITE IBIS.

Migratory; rare. A southern species, but once known to have been taken in Colorado, but since it has been taken at Great Salt Lake to the west and up the Mississippi Valley to South Dakota, its occurrence in Colorado may not be accidental. The only record for Colorado is the one noted by H. G. Smith that was shot in 1890 at Barr Lake, east of Denver. (Nidologist, III. 1896, 65.)

[185.] **Guara rubra.** SCARLET IBIS.

Accidental. A tropical species that is recorded but four times from the United States. The first three were found, one each, in Florida, Louisiana and Texas; the fourth and last in Colorado. A finely plumaged adult male was shot in the Wet Mountains, May, 1876. The mounted bird is still in the possession of Mr. Livesey, who until 1894 resided in Pueblo. This is the most wonderful record in the whole list of Colorado birds, but there is no doubt whatever of its correctness.

187. **Plegadis guarauna.** WHITE-FACED GLOSSY IBIS.

Summer visitant; rare. Though fairly common locally in New Mexico and Arizona, the Ibis seldom goes as far north as Colorado. H. G. Smith says that it is occasionally reported by sportsmen. He has examined three specimens from Marston's Lake, near Denver, and one from Pueblo. Other specimens have been purchased in the Denver market. (Nidologist, III. 1896, 65.) P. B. Peabody reports one purchased at Colorado Springs and killed in that vicinity. (Nidologist, II. 1895, 116.) There was a specimen in the Maxwell collection, and Prof. Wm. Osburn writes that Wm. G. Smith of Loveland had one in his collection. From its occurrence in Colorado in the summer Mr. Ridgway concludes that it breeds in the State in the "marshes of valleys." (Bull. Essex Institute, V. 1873, 174). The present writer knows of no nests that have ever been taken in Colorado.

188. **Tantalus loculator.** WOOD IBIS.

Summer visitant; rare. There was a mounted specimen of this southern species in the Maxwell collection and this seems to be the basis for the earlier references to its occurrence in Colorado. When and where this specimen was taken can not now be learned. There seems to be no authentic basis for a certain published statement that it breeds in Colorado, except the well-known fact that it ordinarily breeds throughout its range. Mr. C. E. Aiken informs the present writer that he knows of two specimens that have been taken in Colorado.

190. **Botaurus lentiginosus.** AMERICAN BITTERN.

Summer resident; common. Occurs throughout the State, breeding from the plains to about 7,000 feet. Arrives late in April and begins laying by the middle of May.

191. **Ardetta exilis.** LEAST BITTERN.

Summer visitant; rare. The only record for Colorado is a stuffed specimen now at Colorado Springs that was killed in the immediate vicinity. It is a little strange that no more is known of this bird in Colorado. It is a common bird in Kansas and extends clear across to the Pacific Ocean, though less common west of the Rocky Mountains. Under these conditions it must be more common in Colorado than its record would indicate.

194. **Ardea herodias.** GREAT BLUE HERON.

Summer resident, not uncommon; in migration, common. Occurs throughout the lower portions of the State seldom going much above 5,000 feet, but a few find their way into the mountain parks. Around Fort Collins it is a rather common breeder, all the nests being placed on the tops of the tallest cottonwoods on the banks of the Cache La Poudre. In other parts of the State it sometimes selects more lowly nesting sites. Arrives in northern Colorado early in April.

197. **Ardea candidissima.** SNOWY HERON.

Summer visitant; rare; not known to breed. At least seven specimens have been secured in Colorado and several others reported, representing both sides of the range, but all from the lower portions, not above 5,000 feet.

198. **Ardea rufescens.** REDDISH EGRET.

Summer visitant; rare or accidental; not known to breed. In the collection of C. E. Aiken, of Colorado Springs, there is a young bird of this species shot near that city. The bird is not young enough to indicate that it was hatched in the vicinity, but probably wandered north in the fall after having been reared much farther south. This is the only record for Colorado.

202. **Nycticorax nycticorax nævius.** BLACK-CROWNED NIGHT HERON.

Summer resident; not common and local; in migration, not uncommon. Since it occurs through most of the United States, this Heron probably will be found west of the range, but at present all of the records refer to the plains country east of the Rockies and not above 5,500 feet. It breeds throughout its range. There is a heronry of this species a few miles from Fort Collins. Six years ago it consisted of about fifty pairs; now it is reduced to about half that number. The nests are close together occupying less than half an acre on an island in the Cache La Poudre River. The eggs are laid about the first of June, the birds arriving the middle of April.

203. **Nycticorax violaceus.** YELLOW-CROWNED NIGHT HERON.

Summer visitant; rare. A southern species coming casually north to Colorado. Not known to breed. The only recorded specimen is the one in Mrs. Maxwell's collection and that is known to have been taken in Colorado, but where can not now be learned.

204. **Grus americana.** WHOOPING CRANE.

Migratory; rare. A Mississippi Valley species reaching its most western extension in Colorado at the western edge of the plains, where it was first recorded by C. E. Aiken who marks it as "seen occasionally in migration." It has since been noted by Wm. G. Smith at Loveland and there is a very fine mounted specimen in the museum of the State Agricultural College at Fort Collins. Passes through during the first half of April.

205. **Grus canadensis.** LITTLE BROWN CRANE.

Migratory. Not enough material has yet been accumulated to give a satisfactory statement of the distribution of this bird in Colorado. All of the earlier records of "*G. canadensis*" refer to the next species now called *G. mexicana.* It is certain that the Little Brown Crane occurs in Colorado in migration for Capt. P. M. Thorne has taken it at Fort Lyon and there is a mounted specimen at the Agricultural College at Fort Collins.

206. **Grus mexicana.** SANDHILL CRANE.

Summer resident; not uncommon locally; in migration, common; winter resident in the southern part of the State. The Rio Grande Valley in Colorado used to be the winter home of thousands of Cranes and even yet they are abundant enough in the fall to induce many parties to go to the San Luis Valley for the express purpose of hunting Cranes. They breed locally throughout their range from 5,000 to 7,500 feet. F. M. Drew mentions that one of their breeding grounds is in Animas Park at 7,000 feet. (B. N. O. C. VI. 1881, 85.) They are also known to breed in Routt County. In the autumn they move higher up, having even been seen passing over above the highest mountain peaks of the State. In the San Luis Valley the migrating birds appear in large numbers about the middle of September and remain until the first of November; they return in the spring any time between the first and twentieth of March, depending on the season, and leave about the first of May. If the Little Brown Crane occurs there it is not distinguished by the hunters from the Sandhill.

212. **Rallus virginianus.** VIRGINIA RAIL.

Summer resident; not uncommon. Though not often seen on account of its retiring habits, this species undoubtedly occurs in migration over all the plains region of Colorado below 5,500 feet. C. E. Aiken took the nest and eggs June 4, presumably in El Paso County. It breeds near Loveland, according to Prof. Wm. Osburn, and a pair is now (June, 1896,) breeding a few miles from Fort Collins.

214. **Porzana carolina.** SORA.

Summer resident; common in suitable localities. One can scarcely go by a marshy spot in Colorado on a summer evening without hearing the note of this bird. It breeds throughout its range from the plains to 7,000 feet. More common during the breeding season in the northern part of Colorado than in the southern.

219. **Gallinula galeata.** FLORIDA GALLINULE.

Summer visitant; rare; not known to breed. Colorado is rather out of the normal range of the Gallinule, but since it is found to the east, south and west of the State, its occurrence here can hardly be considered as accidental. The only record for Colorado is that of Allen and Brewster, who took one at Colorado Springs, May 9, 1883. (B. N. O. C. VIII. 1883, 151.)

221 **Fulica americana.** AMERICAN COOT.

Summer resident, common; in migration, abundant. Breeds throughout the State in suitable places on the plains and in the mountain parks up to 8,000 feet. Reaches northern Colorado the last of March.

223. **Phalaropus lobatus.** NORTHERN PHALAROPE.

Migratory; not uncommon. Breeds far north. Occurs throughout the State from the plains to well up in the mountains. F. M. Drew notes that "May 22, six were killed by flying against telegraph wires at Howardsville, Colo., at 9,500 feet. Unless the flock turned back and retraced fifty miles of their course, they would have to cross the range at 12,000 feet." (B. N. O. C. VI. 1881, 249.) They are usually found below 8,000 feet. Mr. Aiken has taken them several times near Colorado Springs. They cross the plains of northern Colorado the first half of May.

224. **Steganopus tricolor.** WILSON'S PHALAROPE.

Summer resident; not uncommon; in migration, common. The Wilson's Phalarope is more common than the Northern, but there are no records of its occurrence in the mountainous parts of the State. It is a common breeder around the ponds of northern Colorado ,below 6,000 feet, even within a few rods of cultivated ground. Eggs have been taken near Fort Collins on June 8. In southern Colorado it is known only as a migrant. Reaches northern Colorado the last of April.

225. **Recurvirostra americana.** AMERICAN AVOCET.

Summer resident; common. Most common on the plains, but occurs in the mountain parks up to 8,000 feet. Rather rare in western Colorado. Henshaw found them breeding abundantly in the San Luis Valley, with nearly all the eggs hatched by June 21. In northern Colorado on the plains the eggs are mostly laid by the first week in June, the birds having come the middle of April.

226. **Himantopus mexicanus.** BLACK-NECKED STILT.

Summer resident; not uncommon. It is found at the same places and at the same time as the Avocet, but the order of abundance is reversed, the Stilt being more common west of the range though still occurring in eastern Colorado. Breeds at the same time as the Avocet from the plains to 8,000 feet.

228. **Philohela minor.** AMERICAN WOODCOCK.

Summer visitant; rare. Colorado marks the extreme western range of the Woodcock and it is found here only to the base of the foothills. The five known instances are all within 50 miles of Denver. H. G. Smith reports one August 12, 1885, and one in October, 1885, within the city limits of Denver. He also reports that one was seen by Mr. John Bently during the fall of 1887 near Boulder and that one was recently shot near Fort Lupton. (Auk, III. 1886, 284 and Nidologist, III. 1896, 65.) Dr. W. H. Bergtold, of Denver, writes that he saw one in Denver, June, 1895. Since the Woodcock breeds throughout its range and since it has been noted here in June and August, it is fair to presume that it breeds occasionally in Colorado, but no nests have as yet been found in the State.

230. **Gallinago delicata.** WILSON'S SNIPE.

Summer resident, rare; in migration, common; winter resident, rare. Found throughout the State in migration anywhere below 10,000 feet, but more common on the eastern slope than the western. F. M. Drew found it breeding in San Juan County (B. N. O. C. VI. 1881, 85), and W. E. D. Scott found a few pairs breeding in June at Twin Lakes at over 9,000 feet. (B. N. O. C. IV. 1879, 90.) On the plains it is known only in migration and a few in winter. Aiken, Morrison and Bennett report it in winter, the first on the plains, the second at Fort Lewis, and the last in Routt County. It has been known to winter at open marshy springs even 150 miles north of Colorado in central Wyoming.

232. **Macrorhampus scolopaceus.** LONG-BILLED DOWITCHER.

Migratory; not uncommon. Probably occurs throughout the lower regions of the State, though all the records are confined to the plains region east of the mountains. It is not uncommon there in migration, passing through about the middle of April. Breeds far north, but a record of one taken by H. W. Henshaw at Denver, July 24, 1873, would lead one to suspect that it may yet be found breeding in the State.

233. **Micropalama himantopus.** STILT SANDPIPER.

Migratory; rare. Only found on the plains of eastern Colorado where it is occasionally met in spring migration in May and early June and less commonly in the fall. It has been reported by Capt. P. M. Thorne, from Fort Lyon, where he killed a female May 22, 1883, with the largest egg the size of No. 6 shot (Auk, IV. 1887, 264), by Prof. Wm. Osburn, from Loveland, by F. Bond, from Cheyenne, and by H. G. Smith, from near Denver. Breeds north of the United States.

239. **Tringa maculata.** PECTORAL SANDPIPER.

Migratory; common. Occurs throughout the State in migration, both on the plains and even up to 13,000 feet in the mountains (Morrison O. & O. XIII. 1888, 107), though of course less common at the higher altitudes. Breeds in the Arctic regions.

240. **Tringa fuscicollis.** WHITE-RUMPED SANDPIPER.

Migratory; not uncommon. A bird of the plains finding its western limit at the base of the Rockies. It has been reported by Thorne, Breninger and Osburn. Breeds far north.

241. **Tringa bairdii.** BAIRD'S SANDPIPER.

Migratory; abundant. In fall migration this is one of the commonest of the Sandpipers, and is also common in spring. Breeds far north but returns early, entering the State again in the latter part of August. When moving northward it is a bird of the plains and the parks below 7,000 feet, but Trippe, Drew and Morrison agree that after the breeding season is over in August and September, it roams to the tops of the loftiest peaks, 13,000 to 14,000 feet, feeding on grasshoppers. Passes through during April and the first half of May.

242. **Tringa minutilla.** LEAST SANDPIPER.

Migratory; common. Arrives the latter part of April and is mostly gone by the middle of May. Is found principally on the plains and below 7,000 feet in the mountains.

243a. **Tringa alpina pacifica.** RED-BACKED SANDPIPER.

Migratory; rare. There are but three Colorado records for this species, which is found throughout North America. There was an adult in winter plumage in Mrs. Maxwell's collection, and Wm. G. Smith took it at Loveland, April 29 and May 9. Breeds far north.

246. **Ereunetes pusillus.** SEMIPALMATED SANDPIPER.

Migratory; not uncommon. Arrives the last of April and first of May. Mostly on the plains and below 7,000 feet.

247. **Ereunetes occidentalis.** WESTERN SANDPIPER.

Migratory; rare. Should not be an uncommon species in Colorado, but so far has been reported but three times. Prof. Wm. Osburn writes that he shot one at Loveland, July 4, 1889, and another May 12, 1890. W. P. Lowe, of Pueblo, shot two on a lake near there in the fall of 1894. Wm. G. Smith took one at Loveland, May 9, 1890. Breeds far north.

248. **Calidris arenaria.** SANDERLING.

Migratory; rare. Though occurring over most of the world, it is quite rare on the plains region of the United States. Prof. Wm. Osburn reports three captures at Loveland, September 24, 1889, September 30, 1889, and May 12, 1890. H. G. Smith saw one May 16, 1888, that had been taken a few days before at Sloan's Lake, near Denver. There is a mounted specimen at the college at Fort Collins that was shot in the vicinity. Breeds far north.

249. **Limosa fedoa.** MARBLED GODWIT.

Migratory; not common. A bird of the plains not often seen; arrives about the first of May. Has once been taken in the mountains by C. E. Aiken at the San Luis Lakes, October 1, 1874. Drew gives it as breeding on the plains, which it does in Nebraska, but there seems to be no record as yet of its nests being found in Colorado.

254. **Totanus melanoleucus.** GREATER YELLOW-LEGS.

Migratory; common. Found both spring and fall everywhere in favorable localities below 7,000 feet. It is a little strange that neither the Greater nor the Lesser Yellow-Legs is know to breed in Colorado, since they both breed in Nebraska but a few miles from the northeast corner of Colorado. They reach northern Colorado about the first of April.

255. **Totanus flavipes.** YELLOW-LEGS.

Migratory; common Distribution and migration the same as that of the Greater Yellow-Legs but in most places not quite so numerous. Capt. Thorne shot one at Fort Lyon July 23, which would indicate that it nested not far distant.

256. **Totanus solitarius.** SOLITARY SANDPIPER.

Summer resident, not common; in migration, common. Occurs both on the plains and in the mountains. Arrives in April and most pass on to breed north of the United States, but a few remain to breed from the plains at the eastern base of the mountains up to 10,000 feet.

258a. **Symphemia semipalmata inornata.** WESTERN WILLET.

Summer resident; not uncommon. Rather common in migration on the plains, especially in the fall. In the spring it is most common from the first to the middle of May. Breeds throughout its range in favorable localities, but it is not a common breeder anywhere in Colorado and will not be found breeding at many places apparently well suited to its needs. Usually breeds from the plains to 7,000 feet, but occasionally much higher.

261. **Bartramia longicauda.** BARTRAMIAN SANDPIPER.

Summer resident, common; in migration, abundant. A bird pre-eminently of the plains, where it breeds abundantly; only rarely met west of the mountains. Arrives the latter part of April and extends into the mountains only to 6,000 feet.

263. **Actitis macularia.** SPOTTED SANDPIPER.

Summer resident; abundant. It is strange to think of a Sandpiper nesting on the top of a mountain, but so far up as this species can find a pond or small lake, it will build its nest, even to 12,000 feet. In the fall it ranges above the pines to 14,000 feet. It also breeds on the plains and at all intermediate altitudes. As abundant in Colorado as anywhere. Arrives about the first of May; leaves the higher altitudes in August, and most of them leave the State in September. A few remain until far into the winter, if not through the entire cold season.

264. **Numenius longirostris.** LONG-BILLED CURLEW.

Summer resident; common. Arrives about the last of April and breeds in suitable localities on the plains. Occurs on both sides of the range, but only in the lower portions, usually not above 5,000 feet. A few have been seen as high as 7,500 feet.

265. **Numenius hudsonicus.** HUDSONIAN CURLEW.

Migratory; rare. All the records of this Curlew in Colorado come from the plains region east of the mountains, but as it occurs over all of North America, it will probably yet be taken on the prairies of western Colorado. Arrives about the first of May and breeds far north.

[266. **Numenius borealis.** ESKIMO CURLEW.

Migratory; rare. There is no reason to doubt that of the enormous flocks of this Curlew that pass over western Kansas, some occasionally enter Colorado; but to date there is no certain record of its capture in the State. It has been previously listed as a Colorado bird, but the record was based on error.]

270. **Squatarola squatarola.** BLACK-BELLIED PLOVER.

Migratory; not common. Passes north through Colorado in May and returns in October. More common in fall than in spring. It is a bird of the plains below 5,000 feet. There are eight recorded instances of its capture at Denver, Loveland and Fort Collins, and Mr. C. E. Aiken has taken it several times near Colorado Springs. Breeds far north.

272. **Charadrius dominicus.** AMERICAN GOLDEN PLOVER.

Migratory; not common. A few pass in the spring and fall over the plains region of Colorado below 5,000 feet. Breeds far north.

273. **Ægialitis vocifera.** KILLDEER.

Summer resident; abundant. One of the earliest migrants, arriving early in March and remaining until the last of September and a few much later. Breeds abundantly on the plains and at the base of the foothills. Is less common in the mountains, but is far from scarce up to the pines at about 10,000 feet. The eggs are laid from the middle of May to the first of June.

274. **Ægialitis semipalmata.** SEMIPALMATED PLOVER.

Migratory; not common. Passes through Colorado on its way from its breeding grounds near the Arctic Circle to its winter habitation which is sometimes far south of the equator. One was shot by Harry Smith at Loveland, May 6, 1890, and the specimen is now in the collection of Prof. Wm. Osburn. This is the only record to date for Colorado.

281. **Ægialitis montana.** MOUNTAIN PLOVER.

Summer resident; common. A bird of the plains rather than the mountains, but also found in the mountain parks and prairies up to 8,000 and rarely to 9,000 feet. Is among the earliest spring arrivals, reaching central Colorado by the last of March to the first week in April. Eggs are laid the latter part of May to the middle of June. On the plains the young are hatched by the last of June; in the mountain parks newly hatched young can be found all through July. Breeds throughout its range. Leaves the state in the fall, the latter part of October. Its number can be judged by the fact that in one day of August at Fort Lyon, Capt. Thorne shot one hundred and twenty-six birds.

283. **Arenaria interpres.** TURNSTONE.

Migratory; rare. A few pass through Colorado on their way to and from their far northern breeding grounds. According to H. G. Smith an adult was shot April 26, 1890, at Sloan's Lake near Denver. (Nidologist, III. 1896, 95.)

289. **Colinus virginianus.** BOB-WHITE.

Resident; somewhat common locally. There is some dispute as to whether or not this should be called a native species in Colorado. It has been introduced at various places from Pueblo north along the foothills to Fort Collins near the Wyoming line. In many of these places it is quite common, being protected by law. There seems good reason to believe that all of the Quail along the foothills are the descendents of introduced birds. On the plains of eastern Colorado, near the Kansas line, the case is different. The birds are there beyond doubt, and though many of the original settlers are still there, no one knows of their having been introduced. They are known to be native and common in western Kansas and enormously abundant in Indian Territory, but a few miles from southeastern Colorado, so that it is fair to presume that some of the Quail of eastern Colorado are native. Eastern Colorado is well adapted to their needs and if it was not for the cayotes that destroy their eggs and young, they would easily become numerous. Nearly all the Quail are confined to the plains and the foothills below 5,500 feet. A few years ago several pairs were turned loose in Estes Park at about 8,000 feet and occasionally are still heard from. They have also been introduced along the Arkansas River below La Junta and are prospering. They are certainly native on Bear Creek in the extreme southeastern corner of Colorado.

293. **Callipepla squamata.** SCALED PARTRIDGE.

Rare or accidental visitant. A southern species coming north regularly only to southern Arizona and New Mexico. The first record for Colorado is the specimen taken by W. P. Lowe the first week in June, 1895, in the eastern foothills of the Wet Mountains. (Auk, XII. 1895, 298.) A. W. Anthony writes that he saw one in the shop of a taxidermist of Denver during the winter of 1892–3. It was freshly killed and said to have been taken on the Platte River east of Denver.

294. **Callipepla californica.** CALIFORNIA PARTRIDGE.

Resident; local. According to F. M. Drew this species has been introduced in the vicinity of Denver. (Auk, II. 1885, 11.)

295. **Callipepla gambeli.** GAMBEL'S PARTRIDGE.

Resident; rare. Known to occur only in southwestern Colorado, where C. F. Morrison shot three of them 40 miles southwest of Fort Lewis. Across the line in southern Utah and in Arizona they are common.

297. **Dendragapus obscurus.** DUSKY GROUSE.

Resident; common in the mountains. Its only migration is a slight vertical one. Breeds from 7,000 feet to the border of timber-line, 4,000 feet higher. At the lower altitude the eggs are laid about the middle of May; at timber-line about June 1. Raises but one brood which is hatched about the middle of June. In August they begin to gather into flocks of ten to fifteen individuals and visit the grain fields or the more open gulches and foothills for berries. In September they wander above timber-line to feed on grasshoppers, reaching 12,500 feet. In winter they come down into the thick woods during the severest weather, but many remain the whole year close to timber-line.

300b. **Bonasa umbellus umbelloides.** GRAY RUFFED GROUSE.

Resident; rare. So rare that the present writer has not yet been able to find a hunter who has seen it or even heard of it. Occurs mostly farther north, only a few coming as far south as Colorado. Is found from 7,000 to 10,000 feet; breeds among the pines just below timber-line and retires to the higher foothills in fall and winter.

304. **Lagopus leucurus.** WHITE-TAILED PTARMIGAN.

Resident; common. One of the most strictly alpine birds of the Rocky Mountain region. Fifty years ago the surveying parties of the Pacific Railroads found them breeding on the Snowy Range, and to-day the tourist who visits the highest peaks does not consider he has completed his sight seeing until he has been shown a family of Ptarmigan, or "Mountain Quail" as they are commonly called. They breed entirely above timber-line from 11,500 to 13,500 feet, wandering to the summits of the peaks a thousand feet higher. Nesting begins soon after the first of June, and the young are hatched the early part of July. In southern Colorado eggs have been found as early as the first part of May. Only in the severest winter weather do they come down into the timber, usually to 10,000 feet, but occasionally to 8,000. At that season the sexes are in separate flocks and subsist largely on willow buds. In the winter they are white, changing to the darker mixed color in March and April; by the breeding season in June they have become so close in color to the moss and rocks that they are apt to depend on this for safety and allow a very close approach. The returning change to white begins in September and is completed in December.

308b. **Pediocætes phasianellus campestris.** PRAIRIE SHARP-TAILED GROUSE.

Resident; not common. There are few parts of the State where the "Pin-tail" can now be called common. Twenty years ago it was plentiful in the northern half of Colorado on the plains and in the foothills up to 7,000 feet on both sides of the range. Even as late as ten years ago it was not uncommon throughout Larimer County. It can be said now to inhabit the same regions, but in such small numbers that its early extermination is probable. A few are still found across the whole of northern Colorado from Nebraska to Utah and south on the plains to at least Burlington and the "Divide" south of Denver. Formerly a few were found throughout the southern half of Colorado, but there are no late records of its occurrence south of the places named. So far as known the present small and scattered flocks of Sharp-tailed Grouse are strictly resident. When they were more abundant they used to perform a short migration in eastern Larimer County, moving into the foothills in the summer and coming down onto the plains in immense flocks in the fall.

[NOTE. It may be that the Sharp-tailed Grouse of Routt County are variety *columbianus*, but all the Colorado birds examined by the present writer are *campestris*.]

309. **Centrocercus urophasianus.** SAGE GROUSE.

Resident; common. As its name implies, it is an inhabitant of the artemesia or sage-brush plains, and is scarcely found elsewhere. It inhabits these favorable localities throughout the State, but it is much more common in the northern than the southern half of the State. It is resident where found, except possibly at some of the higher points to which it moves during the summer. It winters from the plains to 7,000 feet, and regularly breeds to 8,000 feet. A few range in summer as high as 9,500 feet.

310. **Meleagris gallopavo.** WILD TURKEY.

Resident; rare, and will probably soon be exterminated. There still remains a doubt as to whether the eastern Wild Turkey is the variety that occurs in southeastern Colorado. A few years ago these birds were enormously abundant along the Arkansas River in Kansas and Indian Territory, hence it is fair to presume that any found along that river in Colorado would be the same variety especially if found on the plains east of the mountains. Those taken by C. E. Aiken in this locality have been referred by Ridgway to this form (Bull. Essex Institute V. 1873, 174) with the remark that this is the first Colorado record. This latter statement however is an error, for Lieut. Pike in his memorable journey through Colorado in 1806, found Turkeys so abundant from about where Canon City now stands to the present city of Salida, that they formed a large part of the food of his soldiers. From other sources we know that they extended north along the foothills to within a few miles of the northern boundary of the state. One was taken on the Buckhorn in Larimer County as late as 1861. Turkeys still exist in Bent, Prowers, Baca and Las Animas Counties in southeastern Colorado. A flock of thirty was seen in 1883 on the Purgatoire River east of Trinidad and near the Spanish Peaks as late as 1890. During the winter of 1896-1897 they were seen in Bent County.

310a. **Meleagris gallopavo mexicana.** MEXICAN TURKEY.

Resident; rare, locally. There are a few Turkeys yet to be found in the wilder parts of southwestern Colorado and they are known to belong to the Mexican variety. Chas. F. Morrison found them abundant ten years ago on the Rio los Pinos which runs through the Ute reservation in La Plata County. At an earlier date they were not uncommon along the southern boundary of Colorado from the front range westward. They ascend the mountains only to 7,000 feet.

312. **Columba fasciata.** BAND-TAILED PIGEON.

Summer resident; local. Generally considered as a rare bird in Colorado, but on bringing together all of its records in the State, it is found to have been noted as follows: "Most abundant in southwestern part in scrub oak, feeding on acorns." (Morrison.) "Breeds at Durango up to 7,000 feet." (Osburn.) West base of Spanish Peaks in September, and on September 25 on the Rio Grande at Del Norte. Had been there through the summer. (Henshaw.) "Abundant in the Wet Mountains west of Pueblo from 7,800 to 10,000 feet." (Lowe.) This includes what may be considered its regular range, i. e., from Cañon City west and south. Northeastward it has wandered nearly two hundred miles farther as these records will show. In the fall of 1887 John Bentley saw many of them at Dome Rock in Platte Cañon. The following summer he captured several, some of which were young birds evidently reared in the vicinity. (H. G. Smith.) Seen by my father near Morrison. (Anthony.) In 1820 it was first taken, described and named by Maj. Long's Expedition on the South Platte at the "foot of the mountains" on a small tributary running north and south. This would make it not far from Denver. The most northern record is that of V. L. Kellogg who saw a small flock in Estes

Park during the summer of 1889. (Trans. Kans. Acad. Science, XII. 1889-90, 86.) Breeds from 5,000 to 7,000 feet and occasionally higher.

316. **Zenaidura macroura.** MOURNING DOVE.

Summer resident; very abundant. Arrives the last of March and the early part of April, begins laying early in May and fresh eggs have been found as late as August 12. Breeds everywhere below the pine region up to 10,000 feet, but rather rare above 8,000 feet. In the fall wanders upward to 12,000 feet. Remains late in the fall even to the middle of December in Larimer County.

319. **Melopelia leucoptera.** WHITE-WINGED DOVE.

Accidental. The only claim of this southern species to a place in the list of Colorado birds, rests on the following statement of Dr. Coues: "Mr. E. L. Berthoud informs me of its occurrence near timber-line (11,500 feet), on the head of Cub Creek, Jefferson County. He saw a dozen or more July, 1869." (B. N. O. C. II. 1877, 83). If this is not a case of mistaken identity, it is a strange case of wandering.

325. **Cathartes aura.** TURKEY VULTURE.

Summer resident; common. Occurs throughout the State and breeds from the plains to 10,000 feet. C. F. Morrison found one nest at 12,000 feet on the La Plata Mountains. Is most common on the plains along the base of the mountains. Arrives early in April and nests in the latter part of April and in May.

327. **Elanoides forficatus.** SWALLOW-TAILED KITE.

Summer visitant; rare or accidental. The only record for Colorado is the one seen by Mr. C. E. Aiken, near Leadville, in August, 1871. This is a bird of the plains, not coming regularly west of middle Kansas. It would not be surprising to find it occasionally in southeastern Colorado, but its occurrence west of the range, and at 11,000 feet, is purely accidental.

329. **Ictinia mississippiensis.** MISSISSIPPI KITE.

Accidental. G. F. Breninger writes me that there is a mounted specimen at Denver that was taken at Trinidad. It is rare in eastern Kansas and common southward.

331. **Circus hudsonius.** MARSH HAWK.

Resident; common. Is most common in migration, but is still common as a breeder and a few remain through the winter. On the plains it is one of the most common Hawks. In the mountains it breeds up to 10,000 feet, and in the fall has been seen as high as 14,000 feet. Spring migration begins early in March. It winters on the plains to the northern boundary of Colorado.

332. **Accipiter velox.** Sharp-shinned Hawk.

Resident; common. In migration is common throughout the State, and breeds throughout its range, but much more commonly in the mountains than on the plains. Breeds up to 10,000 feet. C. F. Morrison took a set of eggs at Fort Lewis, June 22, 1886.

333. **Accipiter cooperi.** Cooper's Hawk.

Resident; common. Breeds both on the plains and in the mountains to about 9,000 feet. Along the main range of the mountains it is not so common as the Sharp-shinned Hawk. Dennis Gale found eggs at Gold Hill June 25 and young July 2.

334. **Accipiter atricapillus.** American Goshawk.

Resident; not uncommon. Is rather more common in winter than in summer. In winter it occurs throughout the State below 9,500 feet; in summer the few that remain are restricted to the mountains, breeding from 9,000 to 10,000 feet.

334a. **Accipiter atricapillus striatulus.** Western Goshawk.

Winter visitant; rare, if not accidental. Most of the numerous records of the occurrence of the Western Goshawk in Colorado really refer to the eastern form, which is the common Goshawk of this State. The only certain record of the western form is that of Prof. Wm. Osburn, who says: "A male of this species was captured at Arkins, February 26, 1889, and a female at the same place, March 5. The male was much darker than the female with finer markings on the under parts, corresponding to the description of variety *striatulus*." (Science, XXII. 1893, 212.) This is the Pacific Coast Goshawk coming east regularly to Idaho.

337a. **Buteo borealis kriderii.** Krider's Hawk.

Resident; not uncommon. There is a slight question yet as to the distribution of the three varieties of Red-tailed Hawks that occur in Colorado. It has been taken for granted that all the records of typical *borealis* for Colorado should be referred to some of the other forms, though it is not unlikely that it may rarely visit the extreme eastern portion of the State. There can be no doubt that Krider's Hawk occurs on the plains in Colorado during migration, and the present writer feels sure that the record of its nesting there is also correct. F. M. Dille reports that it nests on plains and large cliffs; one nest in Weld County was taken May 24. Of the occurrence and breeding of Krider's Hawk in the mountains there is more question. It probably does occasionally visit the eastern foothills of the main range, but there is as yet no unquestionable record of its nesting above 6,000 feet.

337b. **Buteo borealis calurus.** WESTERN RED-TAIL.

Resident; abundant. Is the common Rocky Mountain form overlapping the range of Krider's Hawk and breeding from the plains to 12,000 feet in the mountains. Is one of the most common hawks of the State through the summer and not a few spend the winter in Colorado.

337d. **Buteo borealis harlani.** HARLAN'S HAWK.

Winter visitant; rare. One specimen taken by C. E. Aiken at Colorado Springs. (Ridgway, Auk, II. 1885, 165.) One was probably taken by Capt. P. M. Thorne at Fort Lyon.

339b. **Buteo lineatus elegans.** RED-BELLIED HAWK.

Migratory; rare. Included in the list of Colorado birds on the strength of the following note from Geo. F. Breninger: "I saw one at Table Rock, a full plumaged bird with the breast to me; saw one at Fort Collins. I have handled them here in California and there is not the least doubt in the matter."

342. **Buteo swainsoni.** SWAINSON'S HAWK.

Resident; common. More common on the plains than in the mountains. Breeds throughout the State everywhere below 11,000 feet. Begins building its nest the last of April, eggs are laid the middle of May and the young appear early in June. Sometimes very abundant locally. A. S. Bennet of Lay, Colo., says he saw a flock of five hundred July 10, 1889.

347a. **Archibuteo lagopus sancti-johannis.** AMERICAN ROUGH-LEGGED HAWK.

Winter resident; not uncommon. Arrives from the north in November and remains until March. Is usually found in the lower parts of the mountains and on the plains.

348. **Archibuteo ferrugineous.** FERRUGINOUS ROUGH-LEG.

Resident; rather common. Breeds both in mountains and on plains, but in the winter is mostly confined to the plains and the lower streams below 6,000 feet. Breeds at least as far south as Pueblo and thence to British America. Eggs have been taken in Colorado as early as April 13, and well-grown young by May 24; but three to four weeks later than these dates is the more common time.

349. **Aquila chrysaëtos.** GOLDEN EAGLE.

Resident; common in favorable localities. In few, if any, parts of the United States is the Golden Eagle more common than in the more mountainous portions of Colorado. They breed from the foothills to at least 12,500 feet. In the winter they wander occasionally over the plains, but are also found in the mountains to 11,000 feet. The nest is repaired for the season about the first of March, and the young are hatched about three months later.

352. **Haliæetus leucocephalus.** BALD EAGLE.

Resident; fairly common. Mostly in the mountains in the summer time and on the plains during the winter. Breeds in the mountains to 9,000 feet and occasionally higher; breeds less commonly on the plains. Capt. Thorne found a nest with two young, June 12, near Fort Lyon on the Arkansas River.

355. **Falco mexicanus.** PRAIRIE FALCON.

Resident; not uncommon. Breeds from the plains to 10,000 feet. In some of the more open portions of western Colorado it is quite numerous. Nearly all leave the State in the winter, returning in March and April. The eggs are laid in May.

356. **Falco peregrinus anatum.** DUCK HAWK.

Resident; not uncommon, locally. Has been reported from many places in the State. W. P. Lowe found the nest and young in St. Charles Cañon, near Pueblo, during the summer of 1895. Dennis Gale took a set of eggs on the Poudre River, April 30, 1889. Others report it as breeding up to 10,000 feet in the mountains.

357. **Falco columbarius.** PIGEON HAWK.

Summer resident; rather uncommon; in migration fairly common; a few remain through the winter in the lower portions. The eggs have been taken in various parts of the State, from the plains to about 9,000 feet, but more commonly from 8,000 to 9,000. Eggs are laid about the first of June.

358. **Falco richardsonii.** RICHARDSON'S MERLIN.

Summer resident; rare; in migration not uncommon. There are several references to its breeding in the State, as it undoubtedly does, but this seems to have been inferred from its being seen here in summer rather than from its nest and eggs having been actually taken. Drew states that it breeds from the plains upward. It has been taken in summer as high as 11,000 feet. In migration occurs throughout the State.

360. **Falco sparverius.** AMERICAN SPARROW HAWK.

Resident; abundant. The most common hawk from the plains to 11,000 feet. In mild winters, like that of 1895-6, quite a number remain throughout the lower portions of the state, but the bulk winter farther south, returning early in March. Eggs are laid the latter part of April and fully fledged young are around by the middle of July. Breeds from the plains to 11,500 feet and in the fall ascends to the highest peaks, feeding on mice and grasshoppers.

364. **Pandion haliaëtus carolinensis.** AMERICAN OSPREY.

Summer resident; not uncommon, locally. W. E. D. Scott found a pair breeding at Twin Lakes at about 9,000 feet. (B. N. O. C. IV. 1879, 90.) It is said to begin laying the last of April, but Mr. Scott found eggs as late as the middle of June. Has been taken in the fall as high as 10,500 feet.

365. **Strix pratincola.** AMERICAN BARN OWL.

Resident; very rare. The only record for Colorado is the one mentioned by H. G. Smith as caught in the Town Hall of South Denver. (Nidologist, III. 1896-7, 76.) A southern species rarely coming so far north as Colorado. The above record of "resident" is made not so much from the instance cited, as from its general distribution and the fact that it has been found breeding in Nebraska near the Colorado line.

366. **Asio wilsonianus.** AMERICAN LONG-EARED OWL.

Resident; common. Winters from the plains to 10,000 feet and breeds from the plains to 11,000. Eggs are laid early in April.

367. **Asio accipitrinus.** SHORT-EARED OWL.

Resident; not common. Much less common than the Long-eared and nearly confined to the plains. The highest record is a little below 8,000 feet. Breeds throughout its range in Colorado, but rather more common in summer in northern than southern Colorado. Begins laying in April.

369. **Syrnium occidentale.** SPOTTED OWL.

Resident. There is no reason to doubt the occurrence of this species in the State, but its record for Colorado is badly mixed. All Colorado records are known to be incorrect except the statement by H. G. Smith that C. E. Aiken has taken several Owls of this species. (Auk. III. 1886, 284.) Though the correctness of this statement has been challenged, yet Mr. Aiken has lately informed the present writer that there can be no question of the identification.

372. **Nyctala acadica.** SAW-WHET OWL.

Resident; not uncommon. Occurs throughout the State below 8,000 feet, but all the records of breeding come from the mountains between 7,000 and 8,000 feet. Eggs are laid the latter part of May. H. G. Hoskins writes that he found one at Beloit, near the Kansas line, April 9, 1894. H. G. Smith records three cases in the vicinity of Denver.

373. **Magascops asio.** SCREECH OWL.

Resident; rare. The western range of *asio* and the eastern extension of *maxwelliæ* and *aikeni* have not been satisfactorily determined. *Asio* is the common form of western Kansas and western Nebraska, and *maxwelliæ* is the common form of the foothills and extending at least thirty miles out on the plains. Between these known points lie nearly two hundred miles of plains, which form an unknown land so far as Screech Owls are concerned. That *asio* does sometimes come into Colorado is proved by the capture of one in the mottled phase near Greeley, as reported to the present writer, by Pres. Z. X. Snyder. According to Capt. P. M. Thorne, there is a Screech Owl inhabits the timber along the Arkansas River at Fort Lyon. No specimens were obtained. It must be either *asio* or *aikeni*, and of the two it is more likely to be *asio*.

373e. **Magascops asio maxwelliæ.** ROCKY MOUNTAIN SCREECH OWL.

Resident; common. According to present ideas this form occurs in the mountains of Colorado from the central part of the State northward, and from the foothills to about 6,000 feet. It has been reported breeding from Denver, Boulder and Loveland. Eggs are usually laid about the middle of April, but have been found as early as the first of April and as late as the last of May. V. L. Kellogg records it as a rare visitant at Lamb's ranch in Estes Park. (Trans. Kans. Acad. Science, XII. 1889-90, 86.) This ranch has an altitude of nearly 9,000 feet.

373g. **Megascops asio aikeni.** AIKEN'S SCREECH OWL.

Resident. Type from El Paso County. E. M. Hasbrouck, in summarizing the records of this species, says that it probably does not occur north of Douglas County anywhere in Colorado. It is a bird of the more open country along the foothills of the Rocky Mountains, south to central New Mexico and northeastern Arizona. Apparently not found below 5,000 feet nor above 9,000. Hasbrouck refers to this variety, Morrison's "Mccalli," from La Plata County. (Auk, X. 1893, p. 250.) W. P. Lowe, of Pueblo, writes that a Screech Owl, presumably this variety, is rather common in the foothills of the Wet Mountains and that he once found it breeding at 7,800 feet.

374. **Megascops flammeola.** FLAMMULATED SCREECH OWL.

Resident; rare. The rarest owl in Colorado, if not in the United States. All the known specimens from Colorado have been taken along the main front range of the Rocky Mountains, from Estes Park to the San Luis Valley. The first record for Colorado is the specimen in the Maxwell Collection, taken at Boulder, in March of some year previous to 1876.

(Ridgway, Field and Forest, II. 1876-77, 195 and 208). The second, by C. E. Aiken, at Poncha Pass, Fremont County, June 15, 1875, and the nest with one egg, being the first nest of this species known to science. (Deane, B. N. O. C. IV. 1879, 188.) The third was shot by Dr. Walbridge, at Mosca Pass in the San Luis Valley, the third week in August, 1879. (Ingersoll, B. N. O. C. V. 1880, 121.) The fourth was found dead in 1883 in the same place where Dr. Walbridge took his specimen. The fifth, by C. E. Aiken, in nestling plumage, about the middle of September, 1883, near Colorado City, at an altitude of 7,500 to 8,000 feet. (Fourth and fifth specimens, Brewster B. N. O. C. VIII. 1883, 123.) The sixth, seventh and eighth, by W. G. Smith, in Estes Park, one June 2, 1890, a female and nest with three fresh eggs, at 10,000 feet; one June 4 at the same altitude, a female, nest and two fresh eggs; one June 20, a female, nest and four partly incubated eggs at 8,000 feet. (O. and O. XVI. 1891, 27.) The ninth, by Evan Lewis, near Idaho Springs, June 7, 1890, a nest with three eggs at 8,700 feet. (Bendire, Life Histories N. Am. Birds, 1892, p. 375.) The tenth was taken July 17, 1884, near Evergreen P. O., Jefferson County. (H. G. Smith, Auk, X. 1893, 364.) In addition to these only six other specimens are known from the rest of the United States, and there are no records of its breeding anywhere but in Colorado. There is a specimen in the National Museum at Washington that bears the date June 10, 1890 and was taken in Estes Park by W. G. Smith. It is presumably one of the three mentioned above, but it cannot now be learned which one it is. Mr. Dennis Gale writes that he took one twelve miles from Gold Hill in the direction of Estes Park. This makes the eleventh specimen for Colorado. Of these eleven, seven have been taken in Boulder County or vicinity.

375a. **Bubo virginianus subarcticus.** WESTERN HORNED OWL.

Resident; common. Not enough material has accumulated to define the range of the different forms of the Horned Owl in Colorado. The following statements are given with the knowledge that they are far from complete and quite liable to error. But they seem to be the best explanation that can be given of the known facts. The second edition of the A. O. U. Check List gives *subarcticus* as the only form breeding in Colorado, confining *arcticus* during the summer to Arctic America, with a southern migration in winter to Montana and Wyoming. The earlier writers went to the opposite extreme and referred all Colorado birds to *arcticus*. The present writer is inclined to accept the theory that *subarcticus* is the form of the lower portions of the State, breeding commonly along the timbered river bottoms. How far this form extends into the mountains is not now known. There certainly is a Horned Owl that breeds in the mountains even up to 11,000 feet, and either this or some closely related form is found in winter nearly to the limit of trees. It is probable that these winter birds belong to both *subarcticus* and *arcticus*, and that the summer birds are principally, if not entirely, *subarcticus*, though largely partaking of the character of both forms.

375b. **Bubo virginianus arcticus.** ARCTIC HORNED OWL.

Winter visitant; not uncommon. That this variety occurs in Colorado at any time in the year has been often denied. All doubts on the subject were lately settled by a specimen that Mr. C. E. Aiken lately sent to the present writer and which has been identified by Mr. Ridgway as undoubtedly *arcticus*. Mr. Aiken writes about these birds, that there was "an owl I had mounted twelve or fourteen years ago which I called *arcticus*. That specimen was a little more white and probably nearer the type than the present one. Both birds were brought to me by boys who had killed them near town [Colorado Springs,] but whether in the mountains or along the creek below town I cannot say. We have a flight of the lighter marked owls late in the fall, quite regularly, but I think the two under consideration are the only ones I have seen quite so light. I think both these birds were killed in November." Writing some years ago about *arcticus*, Mr. C. F. Morrison says: "This is the variety to which I refer the mountain specimens, they showing as much difference from the plains specimens of *subarcticus* as my Montana birds do, and in some cases even lighter. Do not know just where to draw the line, but I think true *arcticus* will be found as far south as the southern border of the State in the main chain of the Rockies." Prof. Wm. Osburn says that one he has referred to this variety was shot in the mountains near Loveland November 29, 1890. It was nearly white.

[375c. **Bubo virginianus saturatus.** DUSKY HORNED OWL.

Resident; not common. In time the above record of this variety will probably be shown to be correct, but at the present time it is hardly a scientific statement It has been but once formally stated as occurring in Colorado (Fisher, Hawks and Owls of the U. S., 74), and that is based on a misquotation, the birds having been found in Arizona instead of Colorado. Moreover all writers on Colorado birds agree that the Horned Owls of the mountains are a light colored race showing a tendency toward *arcticus* instead of *saturatus*. Nevertheless it is almost certain since the variety has been found common a few miles from the southwest corner of Colorado that it does really inhabit the higher mountains in the coniferous forests]

376. **Nyctea nyctea.** SNOWY OWL.

Winter visitant; rare. More than a score of cases are known of its occurring in winter on the plains and the lower foothills of eastern Colorado to about the central part of the

State. It was unusually common around Denver during the winter of 1886–7. One was captured alive near Fort Collins in the early winter of 1896–7.

378. **Speotyto cunicularia hypogæa.** BURROWING OWL.

Resident; abundant locally. Breeds from the plains to 8,000 feet regularly, less commonly to 9,000 feet and only occasionally seen at 10,000 feet. It is found clear across the State to Utah. Begins laying the latter half of April and eggs have been found in northern Colorado as late as the first of July. The Burrowing Owl is a partial migrant in northern Colorado and in the higher altitudes, but there is need of more precise knowledge concerning its movements.

379. **Glaucidium gnoma.** PYGMY OWL.

Resident; rare. Occurs throughout the whole State west of the foothills, but no records as yet for the plains, except the single specimen taken in winter at Loveland by W. G. Smith, and that was but ten miles from the foothills. Mr. Smith also found the nest, with just hatched young, May 31, 1890, in Estes Park, at 10,000 feet, while in the extreme southwestern part of the State, at 1,000 feet lower, C. F. Morrison found four nests with eggs the first half of June, 1886. W. P. Lowe reports it as common in the Wet Mountains from 7,800 to 10,000, while E. B. Darnall writes that it occurs in Routt County in northwestern Colorado, below 6,000 feet. One was taken at Denver by H. G. Smith, February 18, 1888, and one during the winter of 1888–9 near Durango.

382. **Conurus carolinensis.** CAROLINA PAROQUET.

Formerly resident. The only record for Colorado is that of E. L. Berthoud, who wrote to Dr. Coues: "I saw the Carolina Parrot at this place (Golden) and at Denver on the South Platte in 1860-61, and on the Little Thompson River, Colorado, in 1862. I have also seen it near old Fort Lyon, on the Arkansas River. (Coues, B. N. O. C. 1877, 50.)

385. **Geococcyx californianus.** ROAD-RUNNER.

Resident; not common. Has been recorded along the southern border of Colorado from the extreme southeastern to the extreme southwestern corner. Its first Colorado record was by C. E. Aiken from El Paso County, and that still remains as the most northern record. There was a specimen in Mrs. Maxwell's collection at Boulder, but it probably was taken in southern Colorado. Breeds throughout its range. Rarely found above 5,000 feet, but W. P. Lowe writes that he once saw one at 8,000 feet in the Wet Mountains. According to Henshaw the young hatch the last of July.

387. **Coccyzus americanus.** YELLOW-BILLED CUCKOO.

Summer visitant; rare. The only claim this species has for admission to the list of Colorado birds is the statement by Major C. Bendire that it extends "casually to eastern Colorado." (Life Hist. N. Am. Birds Part II, 19.) It is probably now too late to ascertain the foundation for this statement. It must be rare in Colorado for all the specimens taken at Fort Lyon, only a few miles from the eastern boundary of the State, are *occidentalis*.

387a. **Coccyzus americanus occidentalis.** CALIFORNIA CUCKOO.

Summer resident; not uncommon locally. Occurs throughout the State, below 8,000, but most common on the edge of the plains. Specimens taken almost to the Kansas line are found to be this variety. Breeds throughout its range in Colorado.

388. **Coccyzus erythrophthalmus.** BLACK-BILLED CUCKOO.

Migratory; rare. There is a mounted specimen in the museum of the Agricultural College at Fort Collins, taken near there on June 11, by G. F. Breninger. Prof. Wm. Osburn writes that he took one at Loveland, at which place one was also taken by W. G. Smith. These are all the present records for Colorado, though it probably some time will be found here breeding.

390. **Ceryle alcyon.** BELTED KINGFISHER.

Resident; common. Breeds throughout the State, from the plains to 10,000 feet, although it is more common on the lower streams. A few remain even during severe winters along the foothills almost to the northern boundary of the State.

393d. **Dryobates villosus hyloscopus.** CABANIS'S WOODPECKER.

Resident; common. Breeds from the plains to 11,000 feet and winters at almost as great an elevation. But the larger number breed among the pines in summer time and return to lower altitudes for the winter. Eggs are laid early in May.

394. **Dryobates pubescens.** DOWNY WOODPECKER.

Visitant; rare, if not accidental. Included among Colorado birds on the strength of the note of Maj. Bendire that it extends "irregularly to Colorado." (Life Hist. N. Am. Birds, part II. 55.) It is probable that this statement is based on the geographical range for this species as given in Ridgway's Manual, "Northern and Eastern North America and sporadically Western North America (Colorado, California, etc.)." The birds there referred to by Mr. Ridgway as being found in the west are now considered by him as belonging to *homorus*. As the authority for Maj. Bendire's remarks cannot be now learned they are entered here to call attention to the record.

394b. **Dryobates pubescens homorus.** BATCHELDER'S WOODPECKER.

Resident; common. Hardly as common in Colorado as its eastern representative is in the Mississippi Valley and much less common than Cabanis's Woodpecker. To this form are now referred all Colorado birds. It ranges in winter from the plains to 10,000 feet and breeds from the plains to 11,500, but is more common at the higher altitude in summer and at the lower in fall and winter.

396. **Dryobates scalaris bairdi.** TEXAN WOODPECKER.

Resident; rare and local. It is rather strange that this bird should have been overlooked by previous collectors, as W. P. Lowe writes that it occurs regularly in Pueblo and Huerfano Counties. More commonly seen in spring and fall and occasionally an old bird in winter. Mr. Lowe has taken several of the birds and the skins have been positively identified, so there can be no doubt of its occurrence as he states. This is the first and only Colorado record for the bird and carries its known range over three hundred miles to the eastward.

401b. **Picoides americanus dorsalis.** ALPINE THREE-TOED WOODPECKER.

Resident; not common. Throughout the mountains from about 8,000 to 12,000 feet. Occasionally a few feet lower, but remains even in winter in the pine belt chiefly at about 10,000 feet. It is not common anywhere but is scattered quite generally through the mountains. D. D. Stone found a nest with five young birds near Hancock, July 10, 1883, at about 10,000 feet. (O. & O. IX. 1894, 9 and 10.)

402. **Spyrapicus varius.** YELLOW-BELLIED SAPSUCKER.

Migratory; rare. The eastern variety scarcely coming west to the Rocky Mountains. It was taken by C. E. Aiken, presumably in El Paso County, and there is a single specimen in the Maxwell Collection.

402a. **Sphyrapicus varius nuchalis.** RED-NAPED SAPSUCKER.

Summer resident; common. Breeds from the plains to 12,000 feet, but the great bulk of nests are made between 8,000 and 9,000 feet. Arrives in April but eggs are not found until the first half of June.

404. **Sphyrapicus thyroideus.** WILLIAMSON'S SAPSUCKER.

Summer resident; common. Breeds from 5,000 feet to the upper limit of the pines. In southern Colorado is most common from 9,000 to 10,000 feet; in northern Colorado from 6,000 to 9,000 feet includes the great bulk of the birds. Arrives the first week in April and eggs are laid the last half of May.

405. **Ceophlœus pileatus.** PILEATED WOODPECKER.

Resident; very rare. The A. O. U. Check List gives its geographical distribution as "Formerly the heavily wooded region of North America south of about Lat. 63°, except in the southern Rocky Mountains; now rare or extirpated in the more thickly settled parts of the Eastern States." That it is rare in the Rocky Mountains of Colorado is certain, and it is not sure that it occurs there at all. F. M. Drew says that in southwestern Colorado "I have been told of a great big woodpecker and from the description think it is this bird." (B. N. O. C. VI. 1881, 85 and 138.) H. G. Hoskins writes that while passing Tuttle Ranch he saw a large crested Woodpecker that he took to be this species. Tuttle Ranch is only a few miles from the Kansas line and as this species is known to occur only a little farther east, it is probable that Mr. Hoskins' identification is correct.

406. **Melanerpes erythrocephalus.** RED-HEADED WOODPECKER.

Summer resident; common. Breeds on the plains and up to 10,000 feet. Rather more common on the plains than in the mountains. One of the latest migrants, not reaching northern Colorado until the last week in May. Eggs are not laid until late in June.

408. **Melanerpes torquatus.** LEWIS'S WOODPECKER.

Resident; common. Winters from the plains to the lower foothills and breeds from the edge of the plains to about 8,000 feet. Regularly passes but a few miles out on the plains, but has been taken in Finney County in southwestern Kansas, April 23, 1893, and Capt. P. M. Thorne saw two at Fort Lyons on the Arkansas River. A very characteristic bird of the lower foothills and has been seen as high as 10,000 feet in southern Colorado, though probably does not breed above 9,000 feet. Performs a slight southward migration, but most of its movements are merely to retire a few feet lower during the winter season. Breeds late in June.

409. **Melanerpes carolinus.** RED-BELLIED WOODPECKER.

Summer visitant; rare, if not accidental. A southern and eastern species not regularly occurring farther west than central

Kansas. One was taken by C. E. Aiken, and there are both a male and a female in the Maxwell Collection. In 1895, Pres. Z. X. Snyder saw one near Greeley.

412. **Colaptes auratus.** FLICKER.

Migratory; rare. The eastern form only extends west across the plains to the foothills and there is no record of its breeding, though a few may winter. Taken by Capt. Thorne at Fort Lyons, December 10, 1883, and by Prof. Osburn at Loveland during the fall migration, September 24, 1889. One was taken by the Pacific Railroad surveying parties on the South Platte.

413. **Colaptes cafer.** RED-SHAFTED FLICKER.

Summer resident; abundant. Breeds from the plains to 12,000 feet and is almost as common at 11,000 feet as on the plains. An early migrant reaching northern Colorado by the first week in April and in mild winters, like that of 1895-6, remains all winter throughout the plains region. Even in the severest winter a few linger in the State. Eggs are laid from the last of May on the plains to the middle of June in the mountains. Most of the birds leave the mountains early in November, and the State by the first of December.

418. **Phalænoptilus nuttalli.** POOR-WILL.

Summer resident; common. Breeds on the plains and in the mountains to at least 8,000 feet, while it has been noted as high as 10,000 feet in the mountains of southern Colorado. Arrives about the middle of May and the eggs are laid the latter part of June. Remains in the fall until October.

418a. **Phalænoptilus nuttalli nitidus.** FROSTED POOR-WILL.

Summer resident; rare. In his original description of this variety, Mr. Brewster says that Colorado birds are true *nuttalli*, and this is of course true for the great bulk of the birds all over the State. But in southeastern Colorado *nuttalli* becomes mixed with *nitidus*. Of three specimens taken by Capt. Thorne at Fort Lyon, Mr. Brewster marks two as typical *nuttalli* and the other as not typical and nearest *nitidus*. The latter specimen is now in Mr. Brewster's collection. As *nitidus* comes north regularly to western Kansas, there is no reason why it should not occur in southeastern Colorado.

420a. **Chordeiles virginianus henryi.** WESTERN NIGHT-HAWK.

Summer resident; abundant. Breeds on the plains and up to about 11,000 feet; in the fall wanders to 12,000 feet. Is rather more common on the plains and lower foothills than higher up, but is still common to 10,000 feet. Reaches northern Colorado the last of May and nests by the middle of June. Eastern Colorado is within the geographical range of *C. v. sennetti*, but it has not yet been reported from the State.

422. **Cypseloides niger borealis.** BLACK SWIFT.

Summer resident; abundant, locally. Occurs regularly in southwestern Colorado, where it was found by F. M. Drew, who says that they come late in June and leave late in September; breed from 10,000 to 12,000 feet, and range far above 13,000 feet. Are very common and always hunt in large flocks. (B. N. O. C. VII. 1882, 182 and B. N. O. C. VI. 1881, 85 and 138.) Has been taken by Dr. A. K. Fisher as far east as Trinidad. (Bendire, Hist. N. Am. Birds, Part II. 175.)

455. **Aëronautes melanoleucus.** WHITE-THROATED SWIFT.

Summer resident; not uncommon, locally. Breeds only in inaccessible rocks from the lower foothills at about 6,000 feet to at least 12,000 feet if not higher. Arrives the last of March to the middle of April. More common in the southern half of the State, but breeds at 7,000 feet on Horsetooth Mountain a few miles from Fort Collins and passes north into Wyoming.

429. **Trochilus alexandri.** BLACK-CHINNED HUMMINGBIRD.

Summer resident; not uncommon, locally. Occurs only in the extreme western and southwestern part of Colorado, and there only in the lower portions below 6,000 feet.

432. **Selasphorus platycercus.** BROAD-TAILED HUMMINGBIRD.

Summer resident; common. The most common Hummer in Colorado. Arrives early in May and breeds from the foothills to 11,000 feet. Ranges 2,000 feet above timber-line in summer time. Breeds most commonly from 7,000 to 9,000 feet. First set of eggs is laid about the middle of June and, at least in southern Colorado, two broods are reared. The young from the later brood are scarcely out of the nest by the middle of August and a few weeks later the birds start southward. Records are lacking for the plains region east of the foothills, though common clear to the edge of the plains.

433. **Selasphorus rufus.** RUFOUS HUMMINGBIRD.

Summer resident; not uncommon locally. A western species coming into southwestern Colorado, where it breeds from 7,000 to 10,000 feet and ranges in summer several thousand feet higher. Tolerably common in western Colorado and much less common along the eastern slope of the mountains.

The most northeastern record is that of Mr. W. G. Smith who took it in Larimer County. One was taken by Mr. Dennis Gale near Boulder and a specimen was taken by Henshaw at Fort Garland, August 12, during the fall migration. There is a specimen in the Maxwell Collection, but no data as to where it was captured.

443. **Milvulus forficatus.** SCISSOR-TAILED FLYCATCHER.

Summer visitant; rare, if not accidental. The only record for Colorado of this southern species is that of G. F. Breninger. He writes that he saw one at Table Rock, on the Divide, south of Denver. He says, "I saw the bird close to and there is no doubt in the matter."

444. **Tyrannus tyrannus.** KINGBIRD.

Summer resident; common. Occurs regularly only on the plains and a little way up the eastern foothills to 6,000 feet. Breeds throughout its range. Has been taken as a rare visitant in Routt County, in northwestern Colorado. Arrives about the first week in May.

447. **Tyrannus verticalis.** ARKANSAS KINGBIRD.

Summer resident; common. Gets its English name from having been originally described by Say, from specimens taken on the Arkansas River [notwithstanding the statement in Baird, Brewer and Ridgway's Birds of North America that they were taken on the Platte]. Rather more common in eastern than western Colorado, especially on the plains at the base of the foothills. Scarcely found in the mountains, rising regularly only to 7,000 feet, breeding from there down to the plains. Arrives the first week in May and nests about the middle of June. After the young are able to fly, about the first of August, a few wander into the mountains to 8,500 feet.

448. **Tyrannus vociferans.** CASSIN'S KINGBIRD.

Summer resident; common. Occurs throughout Colorado, breeding from the plains to 7,000 feet and is fairly common even to the northern boundary of the State, though more common in the southern two-thirds. Arrives the second week in May. There are no records on the plains more than about fifty miles out from the foothills.

454. **Myiarchus cinerascens.** ASH-THROATED FLYCATCHER.

Summer resident; rare. A western species, coming east to the western edge of the plains. Breeds from the plains to 7,000 feet. Arrives the last of May and departs south late in October. The most northeastern record is one taken at Golden by Prof. Osburn.

455a. **Myiarchus lawrencei olivascens.** OLIVACEOUS FLY-CATCHER.

Summer visitant; rare, if not accidental. A southern species, known from Arizona and Mexico. Taken once by Capt. P. M. Thorne, at Fort Lyon, May 11, 1883. (Auk, VI. 1889, 276.)

456. **Sayornis phœbe.** PHŒBE.

Summer visitant; rare. Comes west rarely to the eastern edge of Colorado. The only record is the one taken by Capt. P. M. Thorne at Fort Lyon, April 20, 1884. (Auk, VI. 1889, 276.)

457. **Sayornis saya.** SAY'S PHŒBE.

Summer resident; common. A bird of the plains rather than the mountains. Most common along the edge of the foot-hills, breeding in towns and around buildings like the eastern Phœbe, which it here replaces. Arrives early, from the middle of March to the first week in April, according to the season. Breeds on the plains and in the mountains to about 8,000 feet. Eggs are laid early in June.

459. **Contopus borealis.** OLIVE-SIDED FLYCATCHER.

Summer resident; common. Occurs in migration on the plains and in the mountains throughout the State. Breeds only in the mountains from 7,000 to 12,000 feet and is much less common breeding than in migrations. Breeds at least as far south as southern Colorado. Arrives late in May and breeds about the last of June. Departs southward in September.

462. **Contopus richardsonii.** WESTERN WOOD PEWEE.

Summer resident; common. Fairly common throughout the State as a breeder below 11,000 feet and very common in migration. In some places the most common Flycatcher. Extends eastward to Kansas. Arrives last of April and first week in May and breeds about the middle of June. It is most common during the breeding season from 7,000 feet to the pine region. Migrates south in September.

464. **Empidonax difficilis.** WESTERN FLYCATCHER.

Summer resident; common. Breeds from the plains to 10,000 feet, but is more common in the upper part of its range. Arrives late in May and nests early in July.

466. **Empidonax traillii.** TRAILL'S FLYCATCHER.

Summer resident; fairly common. More common on the plains, but occurs in the mountains to 8,000 feet, breeding throughout its range in Colorado. Arrives early in May and leaves late in September.

467. **Empidonax minimus.** LEAST FLYCATCHER.

Migratory; rare. Comes west only on the plains of Colorado and to the edge of the foothills. Has not been found higher than 6,000 feet. Arrives in May, and probably breeds, but no nests have as yet been taken.

468. **Empidonax hammondi.** HAMMOND'S FLYCATCHER.

Summer resident; common. Comes east only to the western edge of the plains. Pueblo is the most eastern record. Breeds from the plains to 8,000 feet. Arrives early in May.

469. **Empidonax wrightii.** WRIGHT'S FLYCATCHER.

Summer resident; abundant. In migration is abundant throughout the State west of the plains, and is equally common during the breeding season from 7,500 to about 10,000 feet. Arrives the last of April and the first week in May.

474a. **Otocoris alpestris leucolæma.** PALLID HORNED LARK.

Winter resident; abundant. The literature of the Horned Larks in Colorado is more mixed than that of any other bird. *Alpestris*, *cornuta*, *occidentalis* and *chrysolæma* have all been recorded for the State, but according to present ideas only *leucolæma* and *arenicola* really occur in Colorado. *Leucolæma* is the common "Snowbird" of the plains region and in the northern part of Colorado is enormously abundant from late in October until the middle of February. Only a few enter the mountains during the winter, probably not much if any above 8,000 feet. How far it passes up the mountains during migration has not yet been satisfactorily determined. Breeds north of the United States.

474c. **Otocoris alpestris arenicola.** DESERT HORNED LARK.

Resident; abundant. All of the summer Horned Larks of Colorado are *arenicola* and most of the winter birds of the southern half of the State belong here, as well as many from northern Colorado. Winters on the plains and a little ways into the mountains up to 9,000 feet, but only a few individuals above 7,000 feet. Breeds on the plains and in the mountains up to 13,000 feet. The bulk of migratory birds arrive on the plains in March and nesting begins early in April, two broods being raised. Eggs have been found as late as July 5. In the mountains nesting is from a month to two months later. Begins to leave the mountains early in October.

475. **Pica pica hudsonica.** AMERICAN MAGPIE.

Resident; common. A few visit the plains of the extreme eastern Colorado during the winter and breed nearly to the

Kansas line. They become more common westward, until at 50 miles from the foothills they are not uncommon locally along the banks of the larger streams. From the foothills through the mountains below 8,000 feet, they are very common and characteristic. A few breed as high as 11,000 feet and winter to 9,000 feet. On the plains and among the foothills nestbuilding begins in March and the earliest eggs the first week in April. Young are ready to fly the last of May. In the mountains the young scarcely leave the nest before the first of July.

478b. **Cyanocitta stelleri macrolopha.** LONG-CRESTED JAY.

Resident; common. Seldom strays far east of the foothills, but has been taken in winter by Capt. P. M. Thorne at Fort Lyon. Very common from the edge of the plains westward through the mountains. Breeds from the base of the foothills to timber-line, but seldom below 7,000 feet. Winters from the edge of the plains to nearly 10,000 feet. The upward movement from the plains begins early in May. Eggs are found the last of May and all through June. Fully fledged young are noted the last of June. The return movement begins the last of September.

480. **Aphelocoma woodhousei.** WOODHOUSE'S JAY.

Resident; common. Most common along the base of the foothills and the lower wooded mountains. Not often seen on the plains of eastern Colorado, but has been taken by Capt. P. M. Thorne at Fort Lyon from October to April. Breeds from 5,000 to 8,000 feet, and most commonly at about 6,000 feet. Eggs are laid the last of April and first week in May. Winters in the lower valleys and along the edge of the plains at about 5,000 feet. In the fall has been known to wander to 9,500 feet.

484a. **Perisoreus canadensis capitalis.** ROCKY MOUNTAIN JAY.

Resident; common. Remains near timber line all the year round. During the winter descends a few hundred feet, and occasionally a few wander down to the foothills, but the bulk remain above 9,000 feet even in the coldest weather. Breeds early, usually by the middle of April, which at that altitude of 8,000 to 11,500 feet is long before the snows cease. F. M. Drew says of this species in San Juan County, "In autumn, when on his first tour of inspection around the house, he hops along in a curious sidling manner just like a school girl in a slow hurry. White-headed, grave and sedate, he seems a very paragon of propriety, and, if you appear a suitable personage, he will be apt to give you a bit of advice. Becoming confidential, he sputters out a lot of nonsense in a manner which causes you to think him a veritable 'whiskey Jack.' Yet, whenever he is disposed, a more bland, mind-his-own-business appearing bird will be hard to find, as also many small articles around camp after one of his visits, for his whimsical brain has a great fancy for anything which may be valuable to you, but perfectly useless to himself." (B. N. O. C. VI. 1881, 140.)

486. **Corvus corax sinuatus.** AMERICAN RAVEN.

Resident; common, locally. More particularly a bird of western Colorado, but occurs in the mountains as a not uncommon visitant. Has been taken by Capt. P. M. Thorne at Fort Lyon, and even extends occasionally east to western Kansas. Breeds throughout its range, but more commonly in the mountains at least to timber-line. Winters from the plains to about 10,000 feet. Irregular in its movements.

487. **Corvus cryptoleucus.** WHITE-NECKED RAVEN.

Resident; rare. Formerly common along the eastern base of the front range for its entire length in Colorado and from 50 to 100 miles out on the plains. Now entirely absent from much of this region. F. M. Dille found nests and eggs May 24, 1887, in Weld County, far east of the foothills. There is no other late record north of Boulder, where R. A. Campbell saw them twice in 1894, high up in the foothills. C. E. Aiken says of its range 20 years ago: "I first saw them in October, 1871, about 25 miles south of Cheyenne on the line of the Denver Pacific Railroad where a large flock was hovering over the plain. In the city of Denver I have often seen them searching for food in the less frequented streets, and about 100 miles farther south on the Fontaine Qui Bouille, I have seen immense numbers. At the latter place a flock of probably 1,000 individuals was resident during the winter of 1871–2. Although so abundant in winter, very few are to be seen in summer; the greater number either pass to the northward or become so distributed over the country as not to attract attention. * * * *C. cryptoleucus* is mainly a bird of the plains, being replaced in the mountains by the common raven. The two birds resemble each other so closely, both in notes and habits, that it is difficult to distinguish between them at a distance; the greatest apparent discrepancy being in size, though the croak of *carnivorus* is somewhat deeper and louder than that of the other. I have sometimes found them both associated in the same flock. Each succeeding year since I first saw these birds I have noticed a marked decrease in their numbers in El Paso County, Colorado. The cause of this I do not know unless it is because as the country becomes more thickly settled, the solitude they love so well is denied them."

The narrow strip of country in Colorado where they used to be most common, now contains fully three-fourths of the entire population of the State. The White-necked Raven used to breed from the plains to 6,000 feet, and there is no reason to believe that the few survivors have changed their nesting habits. Its present scarcity can be judged by the fact that of fifteen correspondents who have spent a great deal of their time in the field for the last ten years along the eastern base of the mountains from Pueblo to Cheyenne, only two have seen the bird alive.

488. **Corvus americanus.** AMERICAN CROW.

Resident; common in northeastern Colorado, rare in the rest of the State. F. M. Dille says in substance of its distribution in Colorado: Breeds in considerable numbers along the courses of the South Platte and its tributaries in northeastern Colorado, although confined principally to the valley of the Platte. Have found it breeding in the near vicinity of Greeley, but from a point eight miles below the town their nests were quite abundant. Five nests found at one time on an island less than two acres in extent. Sometimes after a mild open winter, when the birds had been present in large numbers all the winter, they would disappear entirely as the breeding season approached. The earliest date of a full set of eggs is April 1, and the latest date May 23; average date April 27. One set taken May 5 on Clear Creek, Jefferson County, and once found nesting almost within the city limits of Denver. (Burns, Bull. No. 5, Wilson Ornith. Chapter Agassiz Assoc., Oberlin, Ohio.) In the vicinity of Fort Collins the present writer has found them not uncommon during the fall in quite large flocks, and a few nest along the Cache La Poudre, east of the foothills. H. G. Hoskins reports having seen seven at various times near Burlington, close to the Kansas line. Capt. P. M. Thorne saw a few at Fort Lyon, on the Arkansas river, while Drew and Morrison both record it from southwestern Colorado. Breeds from the plains to about 7,000 feet and winters on the plains.

491. **Nucifraga columbiana.** CLARKE'S NUTCRACKER.

Resident; abundant. The first eggs known to science were taken by Dennis Gale at Gold Hill March 9, 1888, at 8,500 feet; a second set at the same place April 16, 1889. B. F. Goss had before this, on May 21, 1879, found a nest with young at Fort Garland. Breeds from 7,000 to 12,000 feet, though most commonly from 9,000 to 10,000 feet. Breeds from the first half of March at 8,000 feet to the middle of April at its highest range. Only one brood: young are on the wing the latter half of May. Some remain in small parties during the rest of the summer, others gather in larger companies. W. E. D. Scott reports "enormous flocks" at Twin Lakes June 24,

1878. During the fall they wander up to at least 13,000 feet; in October begin to descend into the valleys. Most of them remain through the winter at 7,000 to 9,000 feet, but a few come down to the plains. H. G. Hoskins sent one for identification taken at Burlington, near the Kansas line, in January, 1896, and says that others have been seen there occasionally. They have also been taken as wanderers in South Dakota, western Nebraska and western Kansas. They begin the upward movement early in the spring, before most other migrants, and are almost the earliest birds to nest at 9,000 feet.

492. **Cyanocephalus cyanocephalus.** PINON JAY.

Resident; abundant, locally. In the summer the Pinon Jay deserves its name, for it breeds almost exclusively among the pinon pines from 7,000 to 8,000 feet. A few nests have been found as low as 5,000 feet and as high as 9,000. First eggs are laid the last of March and first of April, and eggs are found as late as the middle of May. Keeps in small parties during the breeding season, and in large flocks the remainder of the year. Continually changing location according to food supply. In autumn wanders far above the pinon pines to 13,000 feet. Late in October begins to descend, and spends the winter in the lower foothills and on the edge of the plains. At this season it wanders eastward across Colorado to Nebraska and Kansas. During the winters of 1889, 1890 and 1891 large flocks were seen in Finney County in southwestern Kansas. Returns to the pinon pines early in spring.

494. **Dolichonyx oryzivorus.** BOBOLINK.

Summer visitant; rare. Occurs only east of the range on the plains and at the base of the foothills. Henshaw saw three at the Huerfano crossing in May, 1873, Allen and Brewster noted one at Colorado Springs May 18, and two others were reported May 23. Prof. Wm. Osburn writes he has seen one at Loveland and there was one in the Maxwell Collection. This completes the record to date for Colorado. Not known to breed in the State. The bird commonly known in Colorado as the "Bobolink" is the Lark Bunting (*Calamospiza melanocorys*).

495. **Molothrus ater.** COWBIRD.

Summer resident; common. Confined principally to the lower regions, breeding from the plains to 8,000 feet. As common on the plains as anywhere in the Mississippi Valley. Arrives the last of March and leaves late in September.

497. **Xanthocephalus xanthocephalus.** YELLOW-HEADED BLACKBIRD.

Summer resident; common. In migration occurs throughout the State and breeds in suitable places on the plains and among the foothills and parks to 7,500 feet. Scott found one July 20 at Twin Lakes at 9,500 feet, but did not ascertain that it nests at that altitude. Arrives about the middle of April and breeds early in June. Usually departs in September, but Capt. P. M. Thorne found one at Las Animas as late as October 17.

498. **Agelaius phœniceus.** Red-winged Blackbird.

Summer resident; common. One of the most abundant birds on the plains in suitable places, breeding principally below 7,500 feet but occasionally up to 9,000 feet. Arrives early, usually about the middle of March and remains in flocks until the middle of May, when it pairs and breeds during the whole month of June. The bulk depart late in October; some remain a month later, and a few linger through most of the winter. During the mild winter of 1895-6 they were common even in northern Colorado, and during the winter of 1896–7 very large flocks were constantly present. It would seem probable that the presence of part of them at least was due to the increased abundance of food. Beginning in 1892, more and more sheep have been fed in the Valley of the Poudre and Big Thompson Rivers. The number during the winter of 1896–7 has reached nearly 200,000. All of these are fed on corn in open yards. The blackbirds in large numbers have made these yards their feeding grounds and have apparently derived a good share of their food from the scattered grain.

[499. **Agelaius gubernator californicus.** Bicolored Blackbird.

Has not been taken in Colorado, but one was taken by Mr. Bond at Cheyenne, Wyo., April 14, 1889. (Auk, VI. 1889, 341.) This is just over the line from Colorado and the bird must have crossed Colorado to get there. This is a Pacific Coast bird and the occurrence is of course accidental.]

501b. **Sturnella magna neglecta.** Western Meadowlark.

Summer resident; abundant. More especially a bird of the plains, but also common in the lower mountain parks. Breeds on the plains and to 8,000 feet. Also met both in summer and fall above timber-line, but does not breed so high. Arrives early in March and breeds the latter part of May. Moves southward in October, though a few winter in southern Colorado. During the winter of 1895-6 they were not uncommon over most of the plains region of the State and also during 1896-7.

506. **Icterus spurius.** Orchard Oriole.

Summer visitant; rare, if not accidental. The only record for Colorado known to the present writer is the single specimen taken by Allen at Denver. (Bull. Mus. Comp. Zool. III. 1872, 113-183.) There seem to have been other records, but they are no longer accessible.

507. **Icterus galbula.** BALTIMORE ORIOLE.

Summer resident; rare. The first record for Colorado is that by Allen, that it is rare westward to the base of the Rocky Mountains. Aiken afterwards found it in El Paso County and there was one specimen in the Maxwell Collection. Undoubtedly breeds, though there is no record as yet of the nest having been found.

508. **Icterus bullocki.** BULLOCK'S ORIOLE.

Summer resident; abundant. More common at the western edge of the plains than the Baltimore Oriole is in the east. Breeds abundantly on the plains and in all the mountain region below 10,000 feet. Arrives early in May and breeds late in June. Departs in September, though Beckham saw two at Pueblo as late as October 24.

509. **Scolecophagus carolinus.** RUSTY BLACKBIRD.

Migratory; rare, if not accidental. A pair were shot near Denver December 17, 1883. (H. G. Smith, Auk, III. 1886, 284.) Prof. Wm. Osburn took one at Loveland November, 1889. (Science XXII. 1893, 212.) These are the only authentic records for Colorado. It has been several other times reported, but was evidently mistaken for Brewer's Blackbird.

510. **Scolecophagus cyanocephalus.** BREWER'S BLACKBIRD.

Summer resident; abundant. Occurs throughout the State, breeding from the plains to 10,000 feet. Arrives on the plains the middle of April, and journeys upward as fast as open marshes appear. Nests the last of May. In August and September large flocks ascend 3,000 feet above their breeding grounds and swarm over the country above timber-line to 13,000 feet. Retire in October and are common on the plains for a month longer. A few remain through the winter in the lower portions of the State.

511b. **Quiscalus quiscula æneus.** BRONZED GRACKLE.

Summer resident; not uncommon locally. Only in eastern Colorado to the base of the Rocky Mountains. Henshaw found it rather numerous at Denver; just about to build May 14. The first arrived at Burlington, Colorado, May 9, 1896. Capt. P. M. Thorne writes that he has taken it at Fort Lyon and W. P. Lowe says that it breeds near Pueblo. There is no Colorado record of its breeding above 5,000 feet.

514a. **Coccothraustes vespertinus montanus.** WESTERN EVENING GROSBEAK.

Winter visitant; irregular and not uncommon. Is liable to occur anywhere in Colorado during the winter season. It has been seen at all times from early fall to late spring. Capt. P.

M. Thorne took one at Fort Lyon May 11, and C. F. Morrison saw a flock of 30 at Fort Lewis May 17, at an altitude of 8,000 feet. These records so late in the season, make it not improbable that it may yet be found breeding in the State. It has been noted from the plains to 10,000 feet. One was taken at Fort Collins as early as October, 1888.

515. **Pinicola enucleator.** PINE GROSBEAK.

Resident; not uncommon. Most common in late summer and in winter when the bulk are just below timber-line, but stragglers descend to the foothills and wander over the plains. Capt. P. M. Thorne saw them several times at Fort Lyon and G. F. Breninger took one at Fort Collins November 6. They breed at timber-line. Trippe found young birds fully feathered by June, before the snow was gone, while at 11,500 feet D. D. Stone saw a pair feeding young as late as July 25. (O. & O. IX. 1884, 20.)

517. **Carpodacus purpureus.** PURPLE FINCH.

Migratory; rare, if not accidental. The only certain record for Colorado of this eastern species is the following from A. W. Anthony, who writes: "I have a female, which I shot November 15, 1885, near Denver. It was in company with *C. frontalis* and *cassini*."

518. **Carpodacus cassini.** CASSIN'S PURPLE FINCH.

Resident; common. Toward the latter part of November this western representative of the Purple Finch leaves its breeding grounds in the mountains and retires to the foothills and plains. It is then common in flocks along the western edge of the plains and has been taken by Capt. P. M. Thorne as far east as Fort Lyon, which is at present the most eastern record of this species. A few remain through the winter in some of the lower parks up to 7,000 feet, and a large part go south of Colorado for that season. The last of March or early in April the return movement to the mountains begins. This is almost the only species in which the summer and winter ranges are complementary. It winters from the plains to 7,000 feet and breeds from 7,000 to 10,000. By May it has worked its way up the mountains to its summer home and breeds there the latter half of June. Capt. Thorne has taken one at Fort Lyon as late as May 28. It was a female with eggs just visible to the naked eye.

519. **Carpodacus mexicanus frontalis.** HOUSE FINCH.

Resident; abundant. Originally described by Say from specimens taken near where Cañon City now stands. One of the most abundant winter birds on the plains along the base of the foothills and breeding quite commonly in the same localities. Common in towns, breeding around the cornices of buildings and in the shades of the electric lights like the English Sparrow of the East, for which it is often taken by visitors from the portions of the United States blessed by the English importation. Rare far out on the plains, but a flock of 15 was seen in Finney County, in southwestern Kansas, January 5, 1892. Breeds on the plains and especially in the lower foothills. Less commonly in the mountains to 8,000 feet. The most eastern record of breeding anywhere is that of Capt. P. M. Thorne, who took a pair at Fort Lyon June 3, 1883. The female contained an egg with shell. He also saw one other in the fall. The height of the breeding season along the foothills is the middle of June and two broods are often reared. Eggs have been noted at Fort Collins as early as March 25 and as late as the middle of July. The most northern record noted is that of F. Bond at Cheyenne, where the first came April 14 and the nest and eggs were taken June 11, 1889. (Auk, VI. 1889, 341.)

521a. **Loxia curvirostra stricklandi.** MEXICAN CROSSBILL.

Resident; not uncommon. Under this heading are included all the Red Crossbills of Colorado, not because specimens exactly like eastern birds are not found here, but because there seems to be no satisfactory way of separating them from the western form. Occurs on the plains and the lower foothills during the winter, and breeds in the foothills and the lower mountains to about 8,000 feet. The above may be considered as the usual range, but specimens have been taken in winter at Manhattan at an altitude of 9,000 feet, and the birds have been seen in summer up to at least 11,000 feet. The breeding period is apparently quite irregular. The Red Crossbill of the east breeds in winter, and the western form must do the same at least part of the time, for C. F. Morrison found a nest and four eggs January 30, 1887, near Fort Lewis (O. & O. XIII. 1888, 70), while W. E. D. Scott at Twin Lakes found young flying June 24 that were several months old. On the contrary T. M. Trippe speaks of their breeding as late as May.

522. **Loxia leucoptera.** WHITE-WINGED CROSSBILL.

Winter visitant; rare. Only one record, that of F. M. Drew, who took one in Baker's Park, in southwestern Colorado, at 9,500 feet. (B. N. O. C. VI. 1881, 85 and 138.)

524. **Leucosticte tephrocotis.** GRAY-CROWNED LEUCOSTICTE.

Winter resident; rare. A western species breeding in the Sierra Nevada of California and probably in British America. Comes south and east in winter to Colorado, and has been taken along the eastern slope of the Rocky Mountains. To the specimens already recorded may be added two taken at Fort Collins March 31. Most of the earlier records of this species really refer to *L. australis*.

524a. **Leucosticte tephrocotis littoralis.** HEPBURN'S LEUCOSTICTE.

Winter visitant; rare. Summers in British America and comes south and east in the Rocky Mountains to Colorado. There was a specimen in the Maxwell Collection; F. M. Drew gives it as occurring in the winter from 5,000 to 8,000 feet, while C. F. Morrison says that it is a winter visitant, rare on the eastern slope and common on the western. He says he has seen it both in the spring and in the fall. There is much need of more information on the occurrence in Colorado of this variety and the typical species.

525. **Leucosticte atrata.** BLACK LEUCOSTICTE.

Winter visitant; rare. Was originally described by Ridgway (Am. Sportsman IV. 1874, 24) from four specimens taken by C. E. Aiken at Cañon City in April, 1874. The present writer has seen a mounted specimen in Colorado Springs and there is one in the Maxwell Collection. All references to the birds in Colorado apparently refer to one or the other of these instances.

526. **Leucosticte australis.** BROWN-CAPPED LEUCOSTICTE.

Resident; abundant. Ranges the highest in summer of any bird in Colorado, unless it is the White-tailed Ptarmigan. Never seen below timber-line in summer and not known to nest below 12,000 feet; thence to the tops of the highest peaks. The height of the breeding season is the latter part of July. In August young and old swarm over the summits of the peaks picking insects off the snow. By the last of October or early in November, they descend to timber-line and remain there through the winter except as they are driven a little lower by the severest storms. At the same time a few come into the lower valleys almost to the base of the foothills.

528. **Acanthis linaria.** REDPOLL.

Winter resident; common. Arrives from the north in November and is fairly common on the plains and in the mountains to 10,000. Remains high in the mountains even when the temperature is thirty degrees below zero. More especially common in the lower foothills of the northern half of the State. Leaves for the north from the middle of March to the middle of April.

529. **Spinus tristis.** AMERICAN GOLDFINCH.

Resident; not common in winter and apparently then confined to the plains; abundant in migration; rather common breeding on the plains and in the lower portions of the mountains. It seems to be most common during the summer on the plains and in the lower valleys. Although it enters the mountain parks and reaches 9,000-10,000 feet, it is not common above 7,000 feet. The great bulk move north and south in May and September, but their movements are quite irregular.

530. **Spinus psaltria.** ARKANSAS GOLDFINCH.

Summer resident; common. Comes as far north as the northern boundary of Colorado and breeds throughout its range in the State, on the plains and in the mountains to somewhat over 9,000 feet. It is the latest migrant, scarcely reaching northern Colorado before the middle of June. Breeds from the last of June to the middle of July. Nash found young at Pueblo just leaving the nest September 18, 1879. Migrates southward late in October and the first part of November. Is found rather less than a hundred miles east of the mountains out on the plains. Seems to be most common in central Colorado.

530a. **Spinus psaltria arizonæ.** ARIZONA GOLDFINCH.

Summer resident; not common and either local or else has not been separated by observers from typical *psaltria.* Brought into the fauna of Colorado by a specimen in the Maxwell Collection. In southwestern Colorado C. F. Morrison says that *psaltria* and *arizonæ* are about in even numbers and that after the young of *arizonæ* are out of the nest they go up into the mountains and appear again in abundance in October, stay a few weeks and retire south. A. W. Anthony writes that he has specimens from Pueblo and Colorado Springs taken in the breeding season. Prof. Wm. Osburn writes that he has two specimens he took at Loveland in the breeding season and that he also found them breeding at Golden. They can therefore be said to breed from the plains to 6,000 feet.

533. **Spinus pinus.** PINE SISKIN.

Resident; common. During migration this species is very abundant along the foothills. Retires to the mountains to breed, ranging in the summer from about 7,000 feet to timberline. Occasionally a few nest at the base of the foothills. Some remain through the winter, but a little below timber-line, while the bulk are scattered over the lower valleys and throughout the plains.

000. **Passer domesticus.** EUROPEAN HOUSE SPARROW.

Resident; not yet abundant anywhere. This imported pest reached Colorado only a few years ago. W. P. Lowe noticed its arrival at Pueblo in February, 1895. (Nidologist, II.

1895, 90.) It had, however, been gradually approaching the mountains for several years previous. It reached Denver during the summer of 1896, and there are probably less than twenty pairs of these sparrows now (March, 1897) in that city, where in ten years from now there will be as many thousands. The Sparrow has reached the Rocky Mountains by following the lines of railroad westward. It is not rare in the towns along the Union Pacific and Burlington roads in northern Colorado, to within fifty miles of the mountains, and it is a question of but a few years before they will over-run all of the country east of the foothills. They have not increased very rapidly so far in the State. At Las Animas, on the Arkansas River, where they have been for about four years, there are probably not more than ten pairs in the town and none in the country outside the city limits. Their habits here are the same as in the east. It will be interesting to note the result of the rivalry in Colorado of this bird and the House Finch (*Carpodacus mexicanus frontalis*). This latter bird has for years occupied the place in Colorado that the English Sparrow does farther east. Over the eastern half of the United States, the English Sparrow has not had to contend with any species of habits similar to its own. In Colorado, at the base of the mountains, it meets its first real foe. Time will tell which will be victorious.

534. **Plectrophenax nivalis.** SNOWFLAKE.

Winter visitant; rare. Comes to the plains region of northeastern Colorado during the winter season, but never in large numbers and not regularly. Has been taken at Fort Collins, Loveland, Boulder and Denver. C. F. Morrison records one from La Plata County March 1. This is the only record from west of the range.

536. **Calcarius lapponicus.** LAPLAND LONGSPUR.

Winter resident; common. Enters Colorado from the north in October and remains through the winter. When it first arrives it passes up into the lower mountain parks, but in severe weather it is confined to the plains extending to southern Colorado. Breeds far north.

538. **Calcarius ornatus.** CHESTNUT-COLLARED LONGSPUR.

Summer resident, rare; winter resident, not common; in migration, common. Has been taken during the winter at Fort Collins, Loveland, Boulder, Pueblo, Fort Lyon, and Allen and Brewster saw a flock at Colorado Springs as late as May 9. No records from west of the range. Breeds regularly in Northern United States and British America. Given by Ridgway as breeding in Colorado, though the present writer can find no authority for the statement. Known to breed in Wyoming and Nebraska just over the Colorado line.

539. **Rhyncophanes mccownii.** McCown's Longspur.

Winter resident; common. One of the commonest winter birds on the whole plains region of Colorado east of the mountains. Found by Allen and Brewster at Colorado Springs as late as May 9. Reaches southern Colorado in the fall about the first of October. McCown's Longspur has been several times given as breeding in Colorado. This is very likely true, but the present writer has been unable to find a single authentic record of its occurrence in the State during the summer. Allen found it breeding abundantly at Cheyenne, Wyo., only a few miles north of Colorado.

540a. **Poocætes gramineus confinis.** Western Vesper Sparrow.

Summer resident; abundant. During migration one of the most abundant of birds on the plains and in the foothills. It breeds sparingly on the plains of eastern Colorado, more commonly on the plains nearer the foothills, and abundantly at the base of the mountains. It is still a common breeder to 9,000 feet, and occasionally to 12,000. Arrives in southern Colorado the middle of April, and reaches the mountain parks early in May.

542b. **Ammodramus sandwichensis alaudinus.** Western Savanna Sparrow.

Summer resident; common. In migration it is very abundant and many remain to breed. On the plains they can hardly be called other than a migrant, but from the base of the foothills through the mountains it is not an uncommon breeder up to nearly 12,000 feet. Arrives early in April and remains until the middle of October. All the specimens taken by Capt. P. M. Thorne at Fort Lyon were typical *alaudinus*.

545. **Ammodramus bairdii.** Baird's Sparrow.

Migratory; not common. Has been taken at various places along the eastern edge of the mountains and on the plains during spring and fall migration. The only record west of the Front Range is the one taken by Aiken in the San Luis Valley August 22, 1874. But since it is common in Arizona during the fall and winter, it undoubtedly crosses western Colorado during its migrations. Not known to breed in the State.

546a. **Ammodramus savannarum perpallidus.** Western Grasshopper Sparrow.

Summer resident; not uncommon, but seldom noticed. Breeds mostly on the plains or in the lower foothills. Arrives the middle of April.

552a. **Chondestes grammacus strigatus.** Western Lark Sparrow.

Summer resident; common. Breeds commonly over all the plains of eastern and western Colorado, and in the mountain parks less commonly to 10,000 feet. Arrives the last of April and breeds late in May.

553. **Zonotrichia querula.** Harris's Sparrow.

Migratory; rare. Only one record for the State. One taken by C. W. Beckham at Pueblo, October 29, 1886. (Auk, IV. 1887, 120.) In the Auk, XI. 1894, 182, the present writer recorded a specimen at Colorado Springs that he was assured had been taken in the vicinity. Further investigation has revealed the fact that the specimen was obtained in Texas.

554. **Zonotrichia leucophrys.** White-crowned Sparrow.

Summer resident; abundant. During migration one of the commonest birds. Arrives in April and spends two months in working up to timber-line. F. M. Drew has noted the queer fact of their changing location between the first and second brood. He says that they are common and breed during June in Baker's Park in San Juan County at about 8,000 feet; that most of them then leave the Park and are numerous among the stunted bushes above timber-line where they raise a second brood. In September they return to the park and linger until October. (B. N. O. C. VI. 1881, 138.) Breeds most abundantly from 10,000 to 11,000 feet and July is the height of the breeding season. Known to breed as high as 12,500 feet. The last of the migrants leaves the lower valleys about the first of June. On their return the last leaves the State in November.

554a. **Zonotrichia leucophrys intermedia.** Intermediate Sparrow.

Migratory; common. Arrives from the last of March to the middle of April, and on its northward journey keeps near the level of the plains. It is abundant in the foothills and lower portions of western Colorado and is not uncommon east to the Kansas line. The bulk leave the State in April and the last about the middle of May. On their southward journey they are a little later than the White-crowned Sparrow. Breed north of the United States.

557. **Zonotrichia coronata.** Golden-crowned Sparrow.

Winter visitant; accidental. A Pacific Coast species, known once from Colorado. Prof. Wm. Osburn says that a small flock spent the winter of 1889 in the thickets along the Big Thompson. One was shot February 23. (Science, XXII. 1893, 212.)

558. **Zonotrichia albicollis.** WHITE-THROATED SPARROW.

Migratory; rare. The only records for Colorado of this eastern species are the one shot by C. W. Beckham at Pueblo, October 24, 1886 (Auk, IV. 1887, 120), and the one taken by H. G. Smith near Denver October 5, 1892. (Nidologist, III. 1896-7, 76.) Since it has been taken as a rare migrant on the Platte in Wyoming and is known to breed in northern Wyoming, it is probable that more pass through Colorado in migration than would be supposed from the meagreness of the record.

559a. **Spizella monticola ochracea.** WESTERN TREE SPARROW.

Winter resident; common. Spends the winter on the plains and in the lower parts of the mountains. Common to 7,000 feet and occasionally to 9,000. Arrives from the north about the middle of October and becomes common early in November. The bulk leave in April and the last by the first of May. The western form is found over all the plains to Kansas.

560. **Spizella socialis.** CHIPPING SPARROW.

Summer resident, rare; in migration, not uncommon. The typical Chippy of the east comes into Colorado as far as the foothills of the Rocky Mountains. There is no authentic record as high as 6,000 feet. The western variety, *arizonæ*, is the prevailing form at the base of the mountains and for several miles out on the plains. There is need of much more information as to the relative distribution of the two birds in eastern Colorado. Though not uncommon during migration, the typical form must be quite rare as a breeder. There is indeed no unquestionable record of its breeding in Colorado and it is entered above as a summer resident on the strength of its known breeding to the east and the north in Kansas and Nebraska. Arrives in northern Colorado the last of April.

560a. **Spizella socialis arizonæ.** WESTERN CHIPPING SPARROW.

Summer resident; abundant. Especially common along the foothills in migration. Allen and Brewster mention a flock of at least 1,000 birds seen May 13 at Colorado Springs. Not known to breed far out on the plains, but it breeds from the base of the foothills to nearly 10,000 feet. Breeds most commonly from 6,000 to 7,000 feet. Arrives the middle of April and most go into the foothills by the middle of May. Breeds the middle of June. Leaves the State the latter part of October. Six specimens taken by Capt. P. M. Thorne at Fort Lyon have been identified as this variety, but they are known there only during migration.

561. **Spizella pallida.** CLAY-COLORED SPARROW.

Summer resident; not uncommon. Appears not to be common anywhere in Colorado, but is scattered over all of the State east of the mountains. Breeds in north-central Colorado on the plains and at the base of the foothills, but the southern limit of its breeding range in the State has not been satisfactorily determined. V. L. Kellogg shot one in Estes Park August 10. (Trans. Kans. Acad. Science, XII. 1889–90, 86). This is the only record for the mountains and is probably a bird that had wandered upward after the breeding season. Arrives the last of April and leaves late in September.

562. **Spizella breweri.** BREWER'S SPARROW.

Summer resident; not uncommon. Arrives from the middle of April to the first of May. Most common in migration the first half of May. Rather more common in the southern half of the State. Breeds throughout its range from the plains to 8,000 feet. Principally a western species, but Capt. P. M. Thorne took it as far east as Fort Lyon.

566. **Junco aikeni.** WHITE-WINGED JUNCO.

Winter resident; common. Winters on the plains and in the mountains to at least 8,000 feet. The commonest Snowbird in the mountains in the winter. According to C. E. Aiken, "the first stragglers from the north do not make their appearance till about the 5th of October, [this is on the plains of El Paso County. In the mountains they do not arrive until late in October or early November,] and then in gradually increasing numbers till the first of December, when they come in large flocks, the last to arrive being the old and fully plumaged males. While many of the females and young birds proceed farther to the south, the greater number of the adult males winter at some point farther to the north than El Paso County, as of the whole number seen during the winter only about two-fifths are males. Early in February the old birds begin to start northward, the general migration being delayed about a month." Has been taken in Colorado as late as April 11. Breeds in northern Wyoming.

567. **Junco hyemalis.** SLATE-COLORED JUNCO.

Winter resident; not common. The typical *hyemalis* comes west to the Rocky Mountains as a rather rare visitor. If it is ever common, it is during spring migration from the last of March to the middle of April; less common during fall migration in November; still less common during the winter season. Winters on the plains and in the foothills to 7,000 feet. During spring migration goes a 1,000 feet higher. Not known to breed in the State, which is somewhat strange considering how far south it breeds in the mountains of eastern United States.

567b. **Junco hyemalis connectens.** SHUFELDT'S JUNCO.

Winter resident; abundant. Great numbers winter in southern Colorado, where F. M. Drew says that they appear first at timber line in September; later, stragglers come down and mix with *caniceps* and by October have taken full possession. When severe winter weather begins they pass lower down. (B. N. O. C. VI. 1881, 138.) They remain in numbers throughout the winter as far north as central Colorado, and are not an uncommon winter resident nearly to the northern boundary. Very common in migration during November and April. Extend eastward to Kansas.

568. **Junco mearnsi.** PINK-SIDED JUNCO.

Winter resident; common. In middle Colorado, during the winter, one of the most common Juncos, especially on the plains at the base of the foothills. Arrives rather late in the fall, and is most numerous during the spring migration. At this latter season it is principally a bird of the mountains from 6,000 to 10,000 feet. The period of greatest numbers is about the first of April. The last of the migrating Juncos to leave, remaining until the last of April. Aiken once saw females in El Paso County as late as May 4. Extends east on the plains as far as Fort Lyon, where it has been taken by Capt. P. M. Thorne.

568. I. **Junco annectens.** RIDGWAY'S JUNCO.

Winter visitant; rare. One was taken by R. C. McGregor at Boulder November 25, 1892, associated with *mearnsi*, *caniceps*, *aikeni*, and *connectens*. (Auk, X. 1893, 205.)

569. **Junco caniceps.** GRAY-HEADED JUNCO.

Resident; abundant. The only Junco at present known to breed in Colorado. The bulk winter south of the State, but a few remain on the plains and the lowest valleys of the mountains from November to April. In southwestern Colorado F. M. Drew says that they are very abundant in summer from 7,500 to 12,000 feet, raising two and perhaps three broods. Large young out of the nest taken June 26, and nest with fresh eggs a month later; young birds September 25. The commonest summer bird, taking the place of the Chippy of the east. Leave the first of November just as *oregonus* [=*connectens*] becomes plentiful. (B. N. O. C. VI. 1881, 138.) Farther north, in Clear Creek County, where it does not winter, T. M. Trippe, in "Birds of the Northwest," says that it arrives the middle or latter part of March, two or three weeks before the other varieties leave. Works upward as the snow leaves, and by the middle of June has left the region below 8,000 feet. Breeds abundantly from the upper limit of shrubs to 1,000 feet below timberline, and less commonly down to 8,500, and occasionally at 7,000 feet. In October descends to lower valleys and soon leaves the county. D. D. Stone found fresh eggs from June 8 to July 18 at 10,000 feet in Gunnison County. (O. & O. IX. 1884, 20.) Common on the plains during spring and fall migration, remaining in the spring usually to the first of May, and rarely as late as June 1. Capt. P. M. Thorne took it as far east as Fort Lyon.

570a. **Junco phæonotus dorsalis.** RED-BACKED JUNCO.

Migratory; rare. The only record for Colorado is that of Chas. F. Morrison who says that they were abundant during the spring of 1887 at Fort Lewis in the extreme southwestern corner of Colorado. (O. & O. XV. 1890, 36.) This is the resident and abundant form just south of the Colorado line and it would be strange if some did not enter the State. It has been entered above as migratory according to the record, but if it occurs as anything more than an accidental visitant, it must breed.

573. **Amphispiza bilineata.** BLACK-THROATED SPARROW.

Summer resident; not uncommon, locally. A southern and western species barely reaching to Colorado and found only in the southwestern portion. Abundant a little south of Colorado in Arizona. The only record east of the range and probably accidental, is one taken by C. E. Aiken, July 26, 1872, in a mountain park near Cañon City.

574a. **Amphispiza belli nevadensis.** SAGE SPARROW.

Summer resident; abundant. Quite common on the sagebrush plains of western and southwestern Colorado. Comes east as far as San Luis Park, where Henshaw found it not uncommon up to 8,000 feet.

581. **Melospiza fasciata.** SONG SPARROW.

Migratory; rare. Among five Song Sparrows taken by Capt. P. M. Thorne at Fort Lyon, and now in the Field Columbian Museum at Chicago, is one typical *fasciata*, the other four being *montana*. *Fasciata* is the common form found throughout Kansas and Nebraska, and in view of the above record it is probable that a few migrate across the plains of the extreme eastern Colorado and may not unlikely breed in northeastern Colorado.

581b. **Melospiza fasciata montana.** MOUNTAIN SONG SPARROW.

Summer resident; common. It might be called resident, since a few breed on the plains and in mild winters a few remain all the year. Common throughout the State in migration and not uncommon as a breeder from the plains to 8,000 feet. Breeds more commonly at the upper limit of its range. Arrives late in March.

583. **Melospiza lincolni.** LINCOLN'S SPARROW.

Summer resident; common. An abundant species in migration both on the plains and in the mountains. Breeds in the mountains from 7,000 feet to timber-line and occasionally to the base of the foothills. Most common during the summer months at or near timber-line. Arrives last of April or early in May and by the last of May has left the plains for the north or gone up into the mountains. Breeds late in June and descends to the plains again the first half of October, leaving the State about the first of November.

585c. **Passerella iliaca schistacea.** SLATE-COLORED SPARROW.

Summer resident; rare. The status of this species as a Colorado bird is very unsatisfactory. Ridgway makes the unequivocable statement that it breeds in Colorado along "streams of the mountain parks." (Bull. Essex Inst. V. 1873, 183.) The basis for this statement cannot now be ascertained and it has not been confirmed by later observers. Indeed this is the only record the bird has for Colorado. It has been commonly supposed that the type specimen of this variety was taken in Colorado and this is so stated by Bendire in his Life Histories of North American Birds. The present writer is indebted to Prof. T. S. Palmer, of the Department of Agriculture at Washington, for the information that the specimen in question was taken by Lieut. Bryan's party July 19, 1859, in Nebraska, about 20 miles east of the Colorado line.

588. **Pipilo maculatus arcticus.** ARCTIC TOWHEE.

Winter resident; not uncommon. It is somewhat difficult to draw the line between *arcticus* and *megalonyx* in Colorado. According to the best light obtainable at the present time, those birds should be referred to *arcticus* that occur on the plains east of the mountains during fall, winter and spring as migrants from the north; and that all breeding birds should be referred to *megalonyx*. *Arcticus* arrives from the north early in October and remains until April. Occurs from middle Kansas to the eastern base of the Rocky Mountains.

588a. **Pipilo maculatus megalonyx.** SPURRED TOWHEE.

Summer resident; common. Arrives last of March to the middle of April and by the middle of May has reached its upper summer limit at 9,000 feet. Breeds from the base of the eastern foothills westward. Eggs are laid from the last of May through June. Goes south late in September. So far as known extends even in migration but a few miles out on the plains.

590. **Oreospiza chlorura.** GREEN-TAILED TOWHEE.

Summer resident; common. Occurs throughout all of western Colorado and common for a few miles out on the plains. Has been taken by Capt. P. M. Thorne as far east as Fort Lyon. Arrives the last of April and early part of May; ascends into the mountains to the limit of trees. Breeds in all its range but most commonly about 8,000 feet; nests in May and often raises two broods. Leaves the State in October.

591. **Pipilo fuscus mesoleucus.** CANON TOWHEE.

Resident; common, locally. All the records for the State come from the Arkansas Valley. It is a common resident in Pueblo County nesting in juniper and sometimes cactus bushes. Most common on the plains and lower foothills but occurs sparingly up to 10,000 feet. Breeds the latter part of April. The above statements are from the notes of Beckham, Lowe and Nash, who have made a special study of the birds of the Arkansas Valley. Occurs regularly and abundantly south and southwest of Colorado.

592. **Pipilo aberti.** ABERT'S TOWHEE.

Summer resident; rare. There is no record for Colorado but that of Henshaw, who says: "Though no specimens were secured, pretty good evidence of the presence of this species at the alkali lakes northwest of Fort Garland, Colo., was obtained by the discovery of a nest, about June 25, 1873, containing two eggs, which a careful comparison with specimens in the Smithsonian Institution satisfies me, must have belonged to this bird. It had evidently been deserted a short time before." (Henshaw, 1875, 306.) In New Mexico and Arizona this species is abundant.

593. **Cardinalis cardinalis.** CARDINAL.

Winter visitant; rare, if not accidental. A. W. Anthony writes that one was taken below Denver, December 5, 1883. It is a rare resident in western Kansas and common southward.

596. **Zamelodia melanocephala.** BLACK-HEADED GROSBEAK.

Summer resident; common. Occurs throughout the whole of Colorado from the plains to 8,000 feet, and breeds everywhere. Arrives about the middle of May and breeds about the first of June. Departs south in September. W. P. Lowe reports seeing several in the Wet Mountains at an altitude of 10,000 feet.

597a. **Guiraca cærulea eurhyncha.** WESTERN BLUE GROSBEAK.

Summer resident; not uncommon, locally. A southern species, known from South Dakota, southwesterly across southeastern Colorado to southern Utah. All the records for Colorado come from the Arkansas Valley, where it is reported by Aiken, Lowe and Beckham as not uncommon and breeding at Pueblo. Capt. P. M. Thorne also saw two at Fort Lyon. Arrives late in May.

598. **Passerina cyanea.** INDIGO BUNTING.

Summer visitant; rare, if not accidental. An eastern species, coming regularly only to eastern Kansas. Taken twice in Colorado; once by C. E. Aiken in El Paso County, while the other specimen is in the Maxwell Collection, without any record as to when or where it was taken.

599. **Passerina amœna.** LAZULI BUNTING.

Summer resident; abundant. From the plains to the lower foothills, an abundant and characteristic species, breeding everywhere. A few breed at 7,000 feet and occasionally wander a thousand feet higher. Taken by Capt. P. M. Thorne at Fort Lyon and breeds east to western Kansas. Arrives early in May and breeds about the middle of June. One was taken by Prof. C. P. Gillette July 7, 1896, on Little Beaver Creek, Larimer County, at an altitude of 9,100 feet.

604. **Spiza americana.** DICKCISSEL.

Summer resident; rare. Occurs only on the plains and at the foothills east of the Rocky Mountains. A few pairs spend the summer each year on the plains near Fort Collins and they have been noted at various places from there to Fort Lyon where Capt. P. M. Thorne saw six June 22, 1884. In five years residence there, these were the only ones seen. Farther east in Kansas it becomes one of the commonest birds.

605. **Calamospiza melanocorys.** LARK BUNTING.

Summer resident; abundant. The most common summer bird on the plains. Locally known as the "Bobolink." Much more common east than west of the mountains. Breeds on the plains and in the foothills to about the limit of cultivated fields at 8,000 feet. Becomes rapidly less numerous after passing the lowest foothills. Arrives the first week in May spreading over all the plains region in a few days. The females arrive about a week later than the males. Begins to migrate south late in August and disappears the latter part of September.

607. **Piranga ludoviciana.** LOUISIANA TANAGER.

Summer resident; common. In migration occurs on the plains for 50 to 75 miles east of the foothills. It is common at Pueblo, but 80 miles east of there at Fort Lyon, Capt. P. M. Thorne did not see one in five years' residence. It was taken however at Finney County, southwest Kansas as a rare straggler, May 20 and June 1, 1893. During the breeding season it deserts the plains and is common at 10,000 feet. Few breed below 7,500 but some as low as 6,000 feet. Arrives on the plains the middle of May and moves into the mountains early in June. Breeds the last of June and remains in the mountains until September. The last leave the State late in October.

[608. **Piranga erythromelas.** SCARLET TANAGER.

A male was taken by Mr. Bond at Cheyenne, Wyo., May 28, 1889. (Auk, VI. 1889, 341.) The bird is common a little farther east, but has no Colorado record. This individual may have crossed Colorado to reach Cheyenne, which is just over the Colorado line, or it may have passed westward up the Platte].

610a. **Piranga rubra cooperi.** COOPER'S TANAGER.

Summer visitant; rare or accidental. A southern species common in New Mexico and Arizona, but scarcely coming north to Colorado. Only one specimen known, taken by Henshaw at Denver, May 10, 1873. (Henshaw, 1875, 239.)

611. **Progne subis.** PURPLE MARTIN.

Summer resident; not common and local. Appears to be almost entirely lacking along the eastern slope of the Rocky Mountains and the plains at their base. As common in Utah as in the east and not uncommon in the extreme western part of Colorado. Again to the eastward, it is common in Kansas and extends a little way across the border into Colorado. In eastern Colorado, it arrives the last week of April and remains to breed on the plains. In western Colorado it arrives about the same time, but goes into the mountains for the summer, breeding from 6,000 to 8,000 feet; farther west in Utah it breeds both in towns on the plains and in the mountains.

612. **Petrochelidon lunifrons.** CLIFF SWALLOW.

Summer resident; abundant. Breeds everywhere from the plains to 10,000 feet, nesting both on cliffs and under eaves. Arrives the last of April and first half of May. Breeds late in June. There is so long a time between its arrival and the beginning of nest building that breeding occurs at about the same time on the plains and in the mountains over the whole of Colorado.

613. **Chelidon erythrogastra.** BARN SWALLOW.

Summer resident; common. Breeds on the plains and in the mountains to 10,000 feet, but nowhere in such numbers as *lunifrons* or *thalassina*. Arrives the last of April. Breeds in June and often raises two broods. H. G. Smith says that the same pair returned to his place in Denver to breed for fifteen consecutive years.

614. **Tachycineta bicolor.** TREE SWALLOW.

Summer resident; not uncommon, but rare for a Swallow. Breeds occasionally on the plains and more frequently in the mountains to 10,000 feet. Arrives in April and breeds from the last of May to the last of June. Departs in September.

615. **Tachycineta thalassina.** VIOLET-GREEN SWALLOW.

Summer resident; abundant, locally. Throughout western Colorado and east to the edge of the plains. A few breed on the plains, but more commonly from 6,000 to 10,500 feet. Arrives from the first week in May on the plains to the last of the month in the mountains. Begins laying late in June to the first of July. Deserts the higher regions in August and the lower early in September.

616. **Clivicola riparia.** BANK SWALLOW.

Summer resident; rare. The rarest Swallow in Colorado. Arrives the last of April and breeds on the plains and at the base of the foothills.

617. **Stelgidopteryx serripennis.** ROUGH-WINGED SWALLOW.

Summer resident; not uncommon. Much more common than the Bank Swallow. Breeds near streams on the plains and in the lower portions of the mountains below 7,500 feet. Arrives early in May.

618. **Ampelis garrulus.** BOHEMIAN WAXWING.

Winter resident; not uncommon. Irregular in its movements and numbers. Has been noted at one time or another from most of the State; rather rare on the plains and more common in the mountains to at least 8,000 feet. Breeds north of the United States and reaches southern Colorado in November; remaining through the winter. The bulk leave late in February or early March. Has been taken at Denver by H. G. Smith as late as March 22, 1884.

619. **Ampelis cedrorum.** CEDAR WAXWING.

Resident; not common; local and irregular. Scattered over the lower portions of the State during the fall, winter and spring. Breeds on the plains and in the mountains to about 9,000 feet. Breeds about the middle of June.

621. **Lanius borealis.** NORTHERN SHRIKE.

Winter resident; common. Breeds north of the United States and comes south to Colorado in October. Makes its first appearance high up on the mountains above timber-line and later descends to the plains. Quite common at the western edge of the plains where food, in the shape of Shore Larks, is abundant. Also winters less commonly in the mountain parks to 9,500 feet. Departs northward in March.

622a. **Lanius ludovicianus excubitorides.** WHITE-RUMPED SHRIKE.

Summer resident; common. Arrives from the south soon after the Northern Shrike leaves, early in April, and is quite common through the summer on the plains. Less common in the mountains to about 9,500 feet. On the plains breeds late in May and sometimes raises two broods.

624. **Vireo olivaceus.** RED-EYED VIREO.

Summer resident; rare. An eastern species coming only west to the base of the foothills. Allen took it in the mountains at 11,000 feet, but this must be considered as an accidental occurrence. Arrives late in May and leaves in September. Capt. P. M. Thorne took it at three different times at Fort Lyon, where he marks it as tolerably common. Prof. Wm. Osburn saw but one at Loveland in several years of active collecting. There are both male and female in the Maxwell Collection.

627. **Vireo gilvus.** WARBLING VIREO.

Summer resident; common. The most common Vireo in Colorado. Arrives on the plains the first week in May and at its upper range in the mountains by the last of the month. Breeds sparingly on the plains and abundantly in the mountains; almost as common at 10,000 feet in summer as lower down. Breeds about the first of July.

629a. **Vireo solitarius cassinii.** CASSIN'S VIREO.

Rare or accidental summer visitant; not known to breed. A southwestern species not regularly reaching north to Colorado. There was a specimen in the Maxwell Collection that may or may not have been taken in this State. Mr. H. G. Smith took one near Denver May 13, 1888, and the specimen was identified by Ridgway. (Nidologist, III. 1896-7, 76.)

629b. **Vireo solitarius plumbeus.** PLUMBEOUS VIREO.

Summer resident; common. Extends east at least to the base of the mountains and a few miles out on the plains. Arrives early in May. Breeds in the foothills and among the mountains to rather over 9,000 feet. Nests among the pines, but in migration occurs everywhere.

636. **Mniotilta varia.** BLACK AND WHITE WARBLER.

Summer visitant; rare. An eastern species scarcely coming west of central Kansas. Has been taken twice, once by Minot at Boulder, June 1, 1880 (B. C. N. O. V. 1880, 223), and Geo. F. Breninger writes that he took one at Table Rock, on the Divide between Denver and Colorado Springs. Not known to breed in Colorado, though breeding in corresponding latitudes in Kansas.

644. **Helminthophila virginiæ.** VIRGINIA'S WARBLER.

Summer resident; common. Most common at the limit of its eastern extension at the base of the foothills and though so common there it is not known a few miles out on the plains at Pueblo. This is one of the few exceptions to the rule that any western species found in the foothills follows down the Arkansas at least as far as Pueblo. Through western Colorado it is abundant in migration and in many places is the most common Warbler during the breeding season. Breeds very commonly along the eastern slope of the Rocky Mountains from the foothills to 7,500 feet. Arrives the first week in May and breeds about the middle of June. Leaves the State late in September.

646. **Helminthophila celata.** ORANGE-CROWNED WARBLER.

Summer resident; not uncommon. Quite common in migration, extending over the plains and a little ways into the mountains. Over the former it is known only as a migrant; in the latter it breeds from about 6,000 to 9,000 feet, but is rare above 8,000 feet. Arrives the first week in May and leaves late in September or early October.

646a. **Helminthophila celata lutescens.** LUTESCENT WARBLER.

Summer resident; not uncommon. The western form of the Orange-crowned Warbler, coming east as far as the eastern base of the Rocky Mountains at Denver and at Colorado Springs. Movements and habits so far as known the same as the Orange-crowned Warbler. There is no doubt that the two forms occur in Colorado, and that in general one inhabits eastern Colorado and the other western, but whether their habitats meet or overlap, and their relative distribution in the mountains during the breeding season, are points that need further elucidation.

647. **Helminthophila peregrina.** TENNESSEE WARBLER.

Migratory; rare. Only known from eastern Colorado at the base of the Rocky Mountains, where it has been taken in El Paso County by Aiken, at Boulder by Minot, at Loveland by

Osburn and Smith, and there are both male and female in the Maxwell Collection. Passes through Colorado the latter half of May.

648. **Compsothlypis americana.** PARULA WARBLER.

Summer resident; rare. An eastern species coming scarcely west to the foothills of the Rocky Mountains. Has never been taken in the northern part of Colorado, but from Colorado Springs south and southeast a few occur each summer. Arrives early in May.

652. **Dendroica æstiva.** YELLOW WARBLER.

Summer resident; abundant. The commonest Warbler that breeds on the plains. Arrives the first week in May and breeds both on the plains and in the mountains to 8,000 feet, though rather more common at the lower altitudes.

652a. **Dendroica æstiva sonorana.** SONORA YELLOW WARBLER.

Summer resident; probably common. To the southwestward the eastern form of the Yellow Warbler shades into the Sonora variety. It is not yet known with definiteness, where the dividing line should be drawn. In his original description of *sonorana*, Mr. Brewster says that a Colorado specimen is a fair intermediate between *sonorana* and *morcomi*. (Auk, V. 1888, 139.) A specimen taken by Capt. P. M. Thorne at Fort Lyon, Mr. Brewster marks as not typical but nearest *sonorana*. If this view is finally adopted, it will probably include under *sonorana* many of the Yellow Warblers of southern and especially southwestern Colorado.

654. **Dendroica cærulescens.** BLACK-THROATED BLUE WARBLER.

Migratory; rare. The only Colorado record is that of a specimen taken in the vicinity of Denver by Mr. H. G. Smith, May 24, 1888. (Nidologist, III. 1896-7, 76.) In the Auk, XI. 1894, 182, the present writer recorded a specimen at Colorado Springs that he was assured had been shot in that vicinity. Further investigation has shown that the bird came from without the State.

655. **Dendroica coronata.** MYRTLE WARBLER.

Migratory; not uncommon. Arrives the last of April or early in May and is not uncommon for two or three weeks along the base of the foothills and on the plains. Migrates from ten days to two weeks ahead of *auduboni*, but in May the two species are often found together. A few go into the foothills to 9,000 feet. Scarcely known west of the Rocky Mountains. The last leave by the middle of May. Breeds from the northern United States northward. Much less common during fall migration.

656. **Dendroica auduboni.** AUDUBON'S WARBLER.

Summer resident; abundant. During the summer this is the most common Warbler among the higher mountains. Arrives on the plains early in May and in migration is very common at the western edge of the plains and less and less common eastward to western Kansas. Is known on the plains only as a migrant. Extends into the mountains the middle of May and by the last of the month has reached the upper limit of its range. Breeds from 7,500 to 11,000 feet and is most common above 9,000 feet. Laying begins from the last of May in southwestern Colorado to the middle of June in the north-central part of the State. The last leaves the plains for the mountains the last week in May. Begins to return in August; during September is common in the lower parks and appears on the plains. Leaves the State in October.

657. **Dendroica maculosa.** MAGNOLIA WARBLER.

Migratory; rare. In migration extends westward to the western edge of the plains, where one was taken by Henshaw at Denver May 17, 1873. Capt. P. M. Thorne has also taken one at Fort Lyon May 17, 1884. Breeds in the northern United States and northward.

658. **Dendroica rara.** CERULEAN WARBLER.

Migratory; rare. The only Colorado record is the one seen by Henshaw at Denver May 17, 1873. An eastern species common in Kansas during migration and rarely breeding in that State.

[659. **Dendroica pensylvanica.** CHESTNUT-SIDED WARBLER.

One was taken by Mr. Bond at Cheyenne, Wyo., May 23, 1889. (Auk, VI. 1889, 341.) This is only just over the line from Colorado, and the bird, which is a common species a little farther east, may have crossed Colorado or may have passed westward up the Platte River.]

661. **Dendroica striata.** BLACK-POLL WARBLER.

Summer resident; rare. An eastern species coming rarely but regularly west to the Rocky Mountains. Occasionally common in migration, both on the plains and at the base of the foothills. The only record of breeding in Colorado, and the most southern in the United States, is that of H. D. Minot who found it as a summer resident at Seven Lakes, near Manitou, at an altitude of 11,000 feet. (B. N. O. C. V. 1880, 223.) Reaches Colorado about the middle of May.

664. **Dendroica graciæ.** GRACE'S WARBLER.

Summer resident; common in extreme southwestern Colorado. A southwestern species reaching its extreme northern limit in southern Colorado. F. M. Drew says that it is common on the tributaries of the San Juan River, breeding in the pines from 6,000 to 7,000 feet. (B. N. O. C. VI. 1881, 85.) In La Plata County, Chas. F. Morrison found them not common and took eggs in May at 8,500 feet. A most surprising occurrence was the appearance of a small flock of these birds in the spring of 1889 at Loveland, where they were seen by Prof. Wm. Osburn and one secured April 25. At the request of the present writer, the specimen has been lately re-examined and there is no doubt of the identification.

665. **Dendroica nigrescens.** BLACK-THROATED GRAY WARBLER.

Summer resident; rare. A western species coming north to north central Colorado and east to the base of the foothills, but never common. Arrives early in May. Has been taken at Silverton, 9,500 feet, May 30, and at Idaho Springs, 7,800 feet, May 23. Its breeding range in the State has not been satisfactorily determined.

668. **Dendroica townsendi.** TOWNSEND'S WARBLER.

Summer resident; not uncommon. A western species coming east regularly to the base of the foothills and a few miles out on the plains. The most eastern record is that of Capt. P. M. Thorne at Fort Lyon, one only seen, May 26, 1883. Rare on the plains at any time and then only as a migrant, passing north the latter part of May and returning in September. In the mountains it is rather common during the fall migration from 7,500 to 10,000 feet. Rather rare in summer, breeding from 5,500 to 8,000 feet in western Colorado. No record of its breeding east of the Rocky Mountains.

674. **Seiurus aurocapillus.** OVEN-BIRD.

Summer visitant; rare or accidental. The only fully authentic record for Colorado is the single specimen taken by Dr. C. Wernigk at Denver in June, 1862. It will probably yet be found as a rare visitant to northeastern Colorado, since it is not uncommon a short distance from the State line.

675a. **Seiurus noveboracensis notabilis.** GRINNELL'S WATER-THRUSH.

Migratory; rare. Recorded from Denver, Boulder, Nederland, Loveland and Fort Lyon, i. e., from the plains to 8,000 feet. Passes through Colorado the latter part of May. Not known to breed.

680. **Geothlypis macgillivrayi.** MACGILLIVRAY'S WARBLER.

Summer resident; common. Arrives early in May and breeds from the base of the foothills to 9,000 feet. Laying begins the latter part of June. Leaves the mountains in August and the State in September. One of the most common Warblers of western Colorado. Comes east commonly to the edge of the plains and rarely to Fort Lyon, where it was seen occasionally and taken by Capt. P. M. Thorne.

681a. **Geothlypis trichas occidentalis.** WESTERN YELLOW-THROAT.

Summer resident; common. Almost confined to the plains, where it is common in migration and not uncommon as a breeder. Is found on both sides of the range, but only in the lowest portions scarcely coming up to 6,000 feet; much less common in western Colorado than eastern. Arrives the first week in May, but sometimes reaches northern Colorado by the middle of April.

683. **Icteria virens.** YELLOW-BREASTED CHAT.

Summer visitant; accidental. The typical form from the east was found by Say in the Rocky Mountains at the head-waters of the Arkansas. (B. B. and R. Birds of N. Am.)

683a. **Icteria virens longicauda.** LONG-TAILED CHAT.

Summer resident; common. Scarcely found in the mountains, but common in the lower foothills and on the plains. Does not breed above 6,500 and is never seen above 8,000 feet. Found throughout the State, but most common at the western edge of the plains. Arrives the first week in May and laying begins the first week in June.

685. **Sylvania pusilla.** WILSON'S WARBLER.

Summer resident; abundant. In migration is common or abundant throughout the State, in about equal numbers on the plains and in the mountains. Arrives on the plains about the middle of May and is common for ten days to two weeks. By June 1 has left the plains for the north or gone into the mountains. During the month of June, is moving up the mountains and by the end of June is at its summer home just above timber-line where during July it is the most numerous insect-eating bird. Laying begins the last of June; young are able to fly by the latter part of July. The center of abundance during the breeding season is about 11,000 feet, but it has been known to breed from 6,000 to 12,000 feet. Is very common in the upper parks in August during its fall descent; reaches the lower parks in September; the plains in October and leaves the State late in this month.

685a. **Sylvania pusilla pileolata.** PILEOLATED WARBLER.

Migratory; rare. This is the western form, found regularly from the Great Basin to the Pacific. A specimen taken by

Geo. F. Breninger at Fort Collins May 22, and now in the museum of the Agricultural College is almost typical *pileolata*, much nearer that than *pusilla*. This is the only record for Colorado about which there is no doubt. Several other records probably refer to *pusilla*.

687. **Setophaga ruticilla.** AMERICAN REDSTART.

Summer resident; not uncommon in eastern Colorado; rather rare in western Colorado. In migration on the plains and in the foothills it is fairly common. Arrives about the middle of May. A few breed on the plains and it is not uncommon as a breeder in the mountains below 8,000 feet. Trippe saw a female in July at timber-line, but this is 3,000 feet above its normal range.

697. **Anthus pensilvanicus.** AMERICAN PIPIT.

Summer resident; common. In migration occurs throughout the State; breeds only on the summits of the mountains. Arrives on the plains the last of April and it is about a month later that the last have departed into the mountains. Through May it is in the higher mountain parks and by June has ascended above timber-line to its summer home. Laying begins early in July, as soon as the first grass has started. Most nests are made between 12,000 and 13,000 feet, the lowest known being one on Mount Audubon at 11,000 feet, found with fresh eggs July 3. Never goes below timber-line during the breeding season. In August many wander to the tops of the peaks at 14,000 feet. At this time they gather into flocks and remain high until late in the season. They descend into the upper parks the last of September and some remain above timber-line until October. During October they come back to the plains and leave the State in November.

701. **Cinclus mexicanus.** AMERICAN DIPPER.

Resident; common in suitable localities. Remains near open water all the year. In winter this brings it down to the foothills and larger mountain streams, usually between 6,000 and 9,000 feet, but it has been noted clear down to the plains. Common all winter in the Cañon of the Grand River as far down as Glenwood Springs at about 5,500 feet. Moves back into the mountains as soon as the streams thaw out in April and spends the summer from 8,000 feet to just below timber-line. No record of any nest being found lower than 8,000 feet, but the present writer saw several pairs on the Cache La Poudre the last of July, that, if they nested higher, must have descended very early. Laying begins the last of May and early in June. Remains high in the mountains as late as possible, until it is forced by the coldest weather to descend to the lower valleys.

D. D. Stone records the shooting of one at Hancock, October 16, at 10,000 feet. It was in open water in the ice on a lake. Snow had been on the ground for two weeks and it was snowing at the time. (O. & O. VII. 1882, 181.)

702. **Oroscoptes montanus.** SAGE THRASHER.

Summer resident; not uncommon. Comes east as far as the edge of the plains and is about in equal numbers along the eastern slope of the mountains and in western Colorado. Arrives early in April and breeds from the plains to nearly 10,000 feet. Leaves the State late in October.

703. **Mimus polyglottos.** MOCKINGBIRD.

Summer resident; not uncommon, locally. In southeastern Colorado, along the Arkansas from Pueblo eastward, as abundant as at any place in the south. Fairly common north to Colorado Springs and thence is not common and irregular over the rest of the State east of the mountains. According to Ridgway, C. E. Aiken was the first to record the mockingbird from Colorado (Bul. Essex Inst. V. 1873, 178) but this is an error, since it was found by Maj. Long's party, with nests and young at the Platte River near where Brighton now stands, July 4, 1823. H. G. Smith reports them as quite common in 1895 along Clear Creek near Denver and W. G. Smith says they used to breed on the Big Thompson near Loveland. F. M. Dille says that they used to breed abundantly in Greeley but left for isolated places because their young were so much sought. They breed regularly in the Republican Valley at the eastern end of Arapahoe County. During the summer of 1896, two pairs took up their residence on the grounds of the Agricultural College at Fort Collins where they had never before been seen. Four other pairs were noted in the neighboring foothills to about 6,000 feet. They have several times been seen at Cheyenne and Dr. Jesurn reports the capture of an adult male April 30, 1894, at Douglas, Wyo., 150 miles north of Cheyenne. Arrives in southern Colorado the latter part of April and breeds early in June. Breeds mostly on the plains, but occasionally in the foothills to 8,000 feet.

704. **Galeoscoptes carolinensis.** CATBIRD.

Summer resident; common. Breeds from the plains to about 8,000 feet. Arrives early in May and breeds the latter part of June. Shy, but fairly common on the plains and the eastern slope of the Rocky Mountains; rare in western Colorado. Nowhere in the State is it so common as in most parts of the Mississippi Valley. Returns from the mountains to the plains in August.

705. **Harporhynchus rufus.** BROWN THRASHER.

Summer resident; not uncommon. Almost confined to the plains and only east of the mountains, which it barely penetrates to 7,500 feet. Arrives about the middle of May and breeds throughout its range.

708. **Harporhynchus bendirei.** BENDIRE'S THRASHER.

Summer visitant; accidental. One shot by Brewster at Colorado Springs, May 8, 1882. The first and only record north of Arizona. (B. N. O. C. VIII. 1883, 57.)

715. **Salpinctes obsoletus.** ROCK WREN.

Summer resident; common. More particularly a bird of the foothills and mountains, but extending eastward over all the plains region to Kansas. Breeds on the plains, but more commonly in the mountains from 6,000 to 9,000 feet; much less commonly to 12,000 feet. Arrives on the plains the middle of April and laying begins the latter part of May. At the upper part of its range each of these dates is about a month later. Leaves the mountains in September and the State the latter part of October.

717a. **Catherpes mexicanus conspersus.** CAÑON WREN.

Resident; rare. There are but few records of this species in Colorado. It comes east to the eastern base of the Rocky Mountains and north as far as Boulder where A. W. Anthony saw several November 23, 1892. In the winter it has been noted by C. E. Aiken at Fountain and the present writer saw it the winter of 1895–6 in the Cañon of the Grand River near Glenwood Springs. Rather more common in the mountains of south-central Colorado where, according to W. P. Lowe, it breeds and is occasionally seen as high as 8,000 feet. The only nest recorded to date is the one with five fresh eggs found by H. D. Minot at Manitou June 8, 1880. (B. N. O. C. V. 1880, 223.)

719b. **Thryothorus bewickii leucogaster.** BAIRD'S WREN.

Summer resident; rare. Only four records for Colorado and all on the plains east of the mountains; known however from southern Utah and Arizona and hence will probably yet be found in the lowest portions of western Colorado. Capt. P. M. Thorne shot one at Fort Lyon, April 27, 1886. C. E. Beckham took one at Pueblo, H. G. Hoskins writes that he has seen several near Burlington and W. G. Smith took it at Loveland.

721b. **Troglodytes aëdon aztecus.** WESTERN HOUSE WREN.

Summer resident; common. Occurs in migration over all of Colorado below the pine region and though it breeds throughout its range, yet in Colorado, it breeds much more commonly in the mountains than on the plains. Arrives on the plains the last of April and in the mountains the middle of May. Breeds from the plains to 10,000 feet. Raises two broods and often three. Laying begins the first of June and continues until late in July. Comes down from the mountains in September and soon after leaves the State.

722. **Troglodytes hiemalis.** WINTER WREN.

Resident; rare. Has been noted but a few times in Colorado. The honor of including it among the breeders of the State belongs to Prof. C. P. Gillette of Fort Collins who found several July 7, 1896, in the mountains thirty miles west of Fort Collins at an altitude of 8,000 feet. They were in company with *aztecus*. Though no nests were found, they were evidently breeding at the time. Later in the same season the present writer saw several birds along the Big Thompson in Estes Park at about 7,000 feet. One was taken in Denver October 13, 1891, by Mr. H. G. Smith. (Nidologist III. 1896–7, 76.)

725a. **Cistothorus palustris paludicola.** TULÉ WREN.

Summer resident; not uncommon, locally. Rather more common in southern Colorado than northern, and more common at the base of the foothills than farther east on the plains. Arrives usually the last of April, but Prof. Wm. Osburn writes that he took two unusually early migrants at Loveland in March, 1889. Laying begins about the middle of June. Breeds on the plains and up to 8,000 feet. Remains in the State until late in September. Mr. A. A. Bennett writes that he has seen them in Routt County in January. There are some hot water swamps, and the Wrens stay in them all winter.

726b. **Certhia familiaris montana.** ROCKY MOUNTAIN CREEPER.

Resident; common. In migration and during the winter occurs on the plains, where typical *montana* has been taken by Capt. P. M. Thorne as far east as Fort Lyon. At the same time it is also found at timber-line where it is resident all the year. The center of abundance during the winter is from 7,000 to 9,000 feet. During the breeding season it is confined to the immediate vicinity of timber-line and is there quite plentiful. Leaves the plains in April and breeds in June.

727. **Sitta carolinensis.** WHITE-BREASTED NUTHATCH.

Resident; not common. The A. O. U. Check List gives the geographical distribution of the typical form as "west to the Rocky Mountains," while *aculeata* is given as coming "east to the plains." Thus the two forms would intermingle in eastern Colorado. The only one who has formally noted both forms is V. L. Kellogg, who reports finding both in Estes Park during the summer. (Trans. Kans. Acad. Science, XII. 1889-90, 86.) A specimen taken at Fort Collins is a fair intermediate between the two forms. Not enough material has been collected to define its range in Colorado.

727a. **Sitta carolinensis aculeata.** SLENDER-BILLED NUTHATCH.

Resident; common. This is the common form in Colorado occurring throughout the State from the foothills westward. Winters at the edge of the plains and in the foothills, less commonly nearly to the pines. Breeds occasionally down to the plains, but commonly from about 7,500 feet to timber-line. Its upward movement occurs in April and it breeds the last of May and early in June. Returns to the lower regions in October.

728. **Sitta canadensis.** RED-BREASTED NUTHATCH.

Resident; not uncommon. Migratory on the plains and resident in the mountains to about 8,000 feet, occasionally to 10,000 feet. Less common than the Slender-billed or the Pygmy Nuthatches. Breeds in June.

730. **Sitta pygmæa.** PYGMY NUTHATCH.

Resident; abundant. Comes east only to the edge of the plains and occurs there only in the winter. Descends from the mountains in December and remains through until February. By the first of March all have returned to the mountains. At the same time they are fully as abundant in the mountains, braving the severest cold to at least 8,000 feet. During the summer they are most common from 7,000 to 10,000 feet and a few breed as low as 6,000 feet. The great bulk scarcely make any migration, even vertical. Begins to pair in April and laying begins the latter part of May. Probably two broods are often reared.

733a. **Parus inornatus griseus.** GRAY TITMOUSE.

Resident; not common. Known only from southern Colorado, coming north to El Paso County and east to the eastern foothills. It has been taken from 5,000 to 9,000 feet and is known to breed, but its breeding range is not yet definitely determined. It seems probable that it winters in the foothills and breeds from 5,000 to 8,000 feet.

735a. **Parus atricapillus septentrionalis.** LONG-TAILED CHICKADEE.

Resident; not uncommon. Winters on the plains and in the foothills, occasionally up to 8,000 feet. Breeds in the mountains from 7,000 to 10,000, rarely above 9,000 feet and rather uncommon breeding on the plains.

738. **Parus gambeli.** MOUNTAIN CHICKADEE.

Resident; abundant. The most common Titmouse in Colorado. Occasionally comes down to the plains in the fall and winters as far east as Pueblo. Resident in the mountains nearly to timber-line. Leaves the lowlands in April and nests from 8,000 feet to timber-line, ranging in the fall to the tops of the loftiest peaks. Breeds early in June.

744. **Psaltriparus plumbeus.** LEAD-COLORED BUSH-TIT.

Resident; not common. Western Colorado, coming east to the eastern foothills, wintering up to 6,500 and breeding from the plains to 7,800. The only records are those of C. E. Aiken and W. P. Lowe.

748. **Regulus satrapa.** GOLDEN-CROWNED KINGLET.

Summer resident; rare, breeding; rather common, in migration. Arrives late in April and is present on the plains but a few days; returning, leaves the last of September. Less common than the Ruby-crown and the few that remain to breed in Colorado, range higher than the bulk of the Ruby-crowns. In migration occurs through the State; breeds only near timberline at about 11,000 feet. Breeds early in July.

749. **Regulus calendula.** RUBY-CROWNED KINGLET.

Summer resident; abundant, both in migration and breeding. Although very common during the breeding season near the timber-line, but few nests have ever been taken. The first one known to science was taken by J. H. Batty, near Buffalo Mountains June 21, 1873, and contained five young and one egg. During the same year, Henshaw found a nearly finished nest at Fort Garland June 11. W. E. D. Scott took the next nest with five eggs at Twin Lakes June 25, 1879, followed two years later by one with four young, taken by F. M. Drew in San Juan County July 5, 1881. D. D. Stone took a set of eggs in 1883, at Hancock, and saw young August 1, while J. A. Allen saw young on Mount Lincoln the last of July.

Arrives on the plains early in April, passes through the middle mountains during May, and reaches its breeding grounds the last of May and early in June. Only known as a migrant on the plains and in the foothills, the last leaving in the spring migration early in May. Returns to the plains early in October and leaves the State the last of that month. Breeds most commonly from 9,000 feet to timber-line, less commonly 2,000 feet lower. It is rather queer that it should seem to breed at a lower altitude in southern Colorado than in northern. Begins to descend early in September.

751. **Polioptila cærulea.** Blue-gray Gnatcatcher.

Summer resident; rare. Not known north of El Paso County nor west of the mountains. Breeds on the plains and in the foothills to 7,000 feet. H. W. Nash found a nest at Pueblo June 22, containing two young and a cowbird's egg. Lowe notes its arrival at the same place April 27, common May 10.

754. **Myadestes townsendii.** Townsend's Solitaire.

Resident; common. In the mountains is a permanent resident, winter as well as summer. Only visits the plains during the fall, winter and spring and then not so common as in the mountains and quite local. Leaves the plains about the first of May and returns about the middle of October, but stragglers are found at the base of the foothills, both later and earlier than these dates. Though not common except at the western edge of the plains, Capt. P. M. Thorne took four specimens at Fort Lyon and it is known as a rare fall and winter visitor in western Kansas. Through all the winter it can be found in the mountains from the lower valleys to about 10,000 feet; in summer it breeds from 8,000 to fully 12,000 feet. Pairs the last of April and first of May and laying lasts from the first week in June to the middle of July. Though so abundant and well known, it was not until 1876 that the first nest with eggs was taken. This was by W. L. Lamb in Summit County July, 1876, at 10,000 feet; eggs about ten days incubated. T. M. Trippe found a nest and four eggs at Howardsville July 9, 1880, D. D. Stone found two sets June 20 and one June 25, 1882, at Hancock, and Wm. G. Smith took fresh eggs on Buffalo Creek, Jefferson County, June 18, 1883. During the season of 1883 D. D. Stone took ten sets from June 6 to July 8 at Alpine Tunnel and Hancock. After this they could no longer be called "extremely rare."

756a. **Turdus fuscescens salicicola.** Willow Thrush.

Summer resident; not uncommon. Occurs throughout the lower parts of the State, during migration as far east as Kansas. Breeds in the foothills and parks to about 8,000 feet. Arrives early in May.

758a. **Turdus ustulatus swainsonii.** Olive-backed Thrush.

Summer resident, rare; in migration, common. The bulk pass through Colorado on the plains and in the mountains from the first week in May to the last of the month, and on the return arrive in September and leave the State in October. A few remain to breed from the plains to 10,500 feet, but most above 8,000 feet.

759. **Turdus aonalaschkæ.** DWARF HERMIT THRUSH.

Migratory; rare. The exact position of this bird in Colorado is not yet definitely settled. The prevailing form of Hermit Thrush is *auduboni*, but there is a mounted specimen of the typical Dwarf Thrush taken at Fort Collins the first day of October. H. G. Smith at Denver has taken one May 13, 1887, and one September 26, 1884, both identified by Ridgway, and a third that probably should be referred to this form was taken there October 5, 1892. These records make it sure that this form extends regularly during spring and fall migration as far east at least as the western edge of the plains. Concerning those sent to Mr. Ridgway, he says: "Not quite typical, being a little larger than the average, but are much too small for *auduboni* and altogether too gray and too slender-billed for *pallasii*." (Nidologist, III. 1896–7, 76.)

759a. **Turdus aonalaschkæ auduboni.** AUDUBON'S HERMIT THRUSH.

Summer resident; common. Sometimes called the Rocky Mountain Hermit Thrush because it is common and characteristic of that region. The most eastern record is that of Capt. P. M. Thorne and it is fairly common a few miles nearer the foothills during migration. Arrives the last of April and leaves the plains the last of May. Breeds in the mountains from 8,000 feet to timber-line and occasionally to the lower foothills. At the lower altitude in southern Colorado laying begins early in June and is continued on the mountains to the middle of July. Returns to the lower parts in September and leaves the State about the middle of October.

759b. **Turdus aonalaschkæ pallasii.** HERMIT THRUSH.

Migratory; rare. From the east the true Hermit Thrush comes only to the eastern edge of Colorado, thus just touching the range of *audoboni*. Two young-of-the-year were taken September 26, 1885, by Capt. P. M. Thorne at Fort Lyon, and identified for him by Mr. Brewster.

761. **Merula migratoria.** AMERICAN ROBIN.

Summer resident; not common. The robins of Colorado shade from nearly pure *migratoria* on the plains of eastern Colorado to typical *propinqua*. There is no definite dividing line between the two forms, and for two hundred miles east of the Rocky Mountains, birds are often found that are a fair intermediate between the two forms. Birds that can be reasonably assigned to the eastern form occur as far west as the base of the foothills, and V. L. Kellogg mentions taking Robins in Estes Park that were as bright as specimens from eastern Kansas. It is a fair presumption that the Robins of Colorado as a whole are *propinqua*, and that a few of those on the plains east of the mountains should be referred to *migratoria*. It is not possible to make any distinction between the two forms as regards migration and breeding.

761a. **Merula migratoria propinqua.** WESTERN ROBIN.

Summer resident; abundant. The prevailing form of western Colorado, though specimens have been taken by Capt. P. M. Thorne at Fort Lyon, and it is known as a rare visitant to western Kansas. Much more common in the foothills and on the western edge of the plains than farther east. Arrives from the middle of March to the middle of April, according to the season, and sometimes a few winter in southern Colorado. Nesting begins the first of May and often two broods are reared, the latter early in July. Breeds on the plains and to 11,000 feet. The bulk leave the State late in November. In January, 1897, a few were seen at 8,000 feet among the pines of Boulder County.

765. **Saxicola œnanthe.** WHEATEAR.

Accidental. A European species, straggling to New England and once taken by Minot at Boulder, May 14, 1880. (B. N. O. C. V. 1880, 223.)

766. **Sialia sialis.** BLUEBIRD.

Summer resident; rare. The eastern form comes west to the base of the Rocky Mountains, thence westward its place being taken by *S. m. bairdi.* According to Capt. P. M. Thorne it nested at Fort Lyon the summer of 1-86. Beckham took it at Pueblo, Aiken in El Paso County. There are both male and female in the Maxwell Collection, while Mr. Dennis Gale informs the present writer that he has several times taken it at Gold Hill fairly within the foothills of the Rockies. Arrives the last of April.

767a. **Sialia mexicana bairdi.** CHESTNUT-BACKED BLUEBIRD.

Summer resident; not common. Comes east as far as Pueblo, where it occurs in both spring and fall migration. Not uncommon along the base of the foothills and breeds from there up the mountains to 9,500 feet. Arrives the last of March and breeds about the middle of May.

768. **Sialia arctica.** MOUNTAIN BLUEBIRD.

Summer resident; abundant. The most common Bluebird of Colorado, far outnumbering both the other kinds. Common in migration as far east as Fort Lyon and even to Kansas. Arrives in February to the middle of March according to the season and probably sometimes winters. By the last of March has spread throughout the mountains nearly to timber-line. Breeds on the plains as far east as Pueblo, more commonly at the foothills and abundantly from 7,000 feet to timber-line. Breeds on the plains the last of April and in the mountains during May. Sometimes raises two broods. In autumn wanders upward far above timber-line to at least 13,000 feet. Returns late to the foothills and the bulk leave in November and early December.

ADDENDA.

Some material that has accumulated while this publication was passing through the press necessitates some additions to the foregoing pages.

Page 3. The total species known in Colorado should be 363, of which 230 are breeders.

Page 11. Add *Phalænoptilus nuttalli nitidus* to species that breed on the plains.

Page 12. Add *Empidonax hammondi* to species that breed principally in the mountains.

Page 14. Add *Bubo virginianus arcticus*, *Coccyzus americanus* and *Dryobates pubescens* to the stragglers or doubtful species.

Page 16. SUMMARY.

Change Total species in Colorado to ---------------- 363
Change Summer residents to --------------------- 230
Change Breeding on plains, but not in mountains to -- 35
Change Breeding principally in mountains to ------- 21
Change Stragglers to ---------------------------- 51

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The State Agricultural College

THE AGRICULTURAL EXPERIMENT STATION

BULLETIN No. 38

SHEEP SCAB

A Few Insect Enemies of the Orchard

APPROVED BY THE STATION COUNCIL
ALSTON ELLIS, President

FORT COLLINS, COLORADO

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FORT COLLINS, COLORADO

SHEEP SCAB.

Clarence P. Gillette, M. S.

The diseases known as "scab" in sheep, "itch" in man and "mange" in cattle, horses, dogs and other animals are caused by minute animal parasites that feed upon or just beneath the surface of the skin.

These parasites are spider-like in structure and belong to the true mites, which differ from spiders in being, for the greater part, minute in size, in having but six legs when young, and in having the three parts of the body, head, thorax and abdomen, all united in one. (See figure 1.)

Although the different species of mange mites look very much alike, it is seldom that a species that infests one kind of animal will live upon any other. The species (*Psoroptes communis*) that causes common scab of sheep is known to infest horses and cattle, though it seldom thrives well upon them.

Common scab has long been considered one of the worst maladies that sheep are subject to in this country, and it has also attracted a large amount of attention in Europe and Australia. As the parasites readily spread from sheep to sheep, the disease is properly considered a contagious one and rigid quarantine laws have been enacted nearly everywhere that the disease prevails to prevent, as much as possible, its spread into uninfested localities.

Sheep-feeding has become a very important industry in Colorado during the past few years. Hundreds of thousands of lambs are fattened for the eastern markets during the winter, and nearly all require to be dipped for scab. There is a wide diversity of opinion among feeders as to the best dips to use and as to the best methods of handling the flocks to prevent or cure scab, and it was with a view of settling, or, at least, throwing some light upon these questions, that the experiments and observations reported in the following pages were undertaken. The work has only been in progress during the past winter and spring and is necessarily incomplete. In fact, the present paper should be considered as a progress report rather than a report upon a finished work. I hope, next fall and winter, to make extensive tests of the more promising dips by treating a thousand or more scabby sheep in each.*

SYMPTOMS OF THE DISEASE.

The infection nearly always occurs along the back of the sheep between the base of the neck and the tail. Bad patches sometimes occur well down on the side of the sheep and even upon the tail. The presence of the mites causes uneasiness and, apparently, intense itching, which the animal endeavors to relieve by pulling the wool from the infested spot with its teeth ("digging"), or by rubbing. The first indication is usually a small loose lock of wool projecting from some place upon the side or back of the sheep. If not attended to, the scabby spot increases rapidly in size and the continual pulling entirely removes the wool so that there is soon a bare spot of greater or less extent. Fortunately the mites are gregarious in habit, i. e., living in colonies and not scattering themselves over the sheep generally, so that a thorough treatment of the infested spot will usually result in a permanent cure unless re-infection takes place from some other animal.

When a spot is just starting with, perhaps, a single mite upon it, it can be detected by one who has had a little experience, from the pale or yellowish color of the skin and its moist surface, due to an exudation of serum. The certain test is to actually find the mite or mites present, which is not a difficult matter if one has a fairly good hand lens.

A little later this patch will have increased in size, the central portion will be covered with a yellowish scaly or mealy material somewhat resembling dandruff, produced by the drying of the serum. Finally these spots become thickly covered with scales or "scabs," and the mites mostly migrate into the wool about the margin, where, with their eggs, they often almost cover the skin. I have seldom found mites or eggs under very heavy scab. Sometimes a heavy reddish scab, indicating the presence of blood and an open sore, are found, but such cases are not common in my experience.

HOW THE DISEASE IS SPREAD.

As the disease is caused by a living creature that is able to crawl freely about and to live for several days, either in the egg or mature state, off the body of the sheep, it is easy to understand how the infection may spread from animal to ani-

*The manufacturers of Zenoleum and Skabcura have already offered their dips in any quantity desired for a test, free. This certainly shows the confidence these manufacturers have in their respective dips.

mal. The spreading of the disease is greatly helped by the rubbing and pulling of the wool, which often removes numbers of both mites and eggs.

These mites are never winged and their power of locomotion is not great, so that I do not think it likely that one of these parasites would be able to travel more than a very few rods in its lifetime.

HOW LONG YARDS MAY RETAIN THE INFECTION.

It is important to know how long these mites or their eggs may remain alive in the yards or corrals after the sheep have been removed. My experiments have all been conducted since last November, so they are not as complete as could be desired. I feel very safe in concluding from them, however, that it would be impossible to carry the disease over in the corrals from one year to another, or from fall to spring or spring to fall, and it seems highly improbable that the eggs or mites can be kept alive more than a few weeks under ordinary conditions. In my experiments, a temperature of 0, or 4 or 5 degrees below, have killed both eggs and mites in every case. Eggs kept at a temperature near that of the body will hatch in from four to eight days, and mites kept at the same temperature will seldom live more than five days without food. If kept in a temperature below that at which the eggs will hatch or the mites be active, both will retain vitality for a much longer time, but just how long I have not yet fully determined. For farther information on these points, see tabulated statements and notes.

DESCRIPTIONS OF THE MITES AND THEIR EGGS.

Figure 1 will show the structure of these mites to the average reader better than a technical description. In all stages they are nearly white in color; the females are a little larger than the males, and are about one-fortieth of an inch in length, or almost exactly the size of the dot of this letter (i) when fully grown. The mature insects have four pairs of legs, like the spiders, but the last pair is small, and in the young they are entirely wanting. A very noticeable peculiarity in these mites is the long gossamer threads attached to the third pair of feet, and which trail behind them as they travel along. In a newly-hatched mite I have seen these threads fully two and one-half times the length of the body, and so slender that it required a rather high power of the microscope to see them at their distal ends. The males can be distinguished from the females by their more rounded form of body, the smaller fourth pair of legs, which do not have the gossamer threads, the two teat-like projections at the extremity of the abdomen, and the large,

Fig. 1

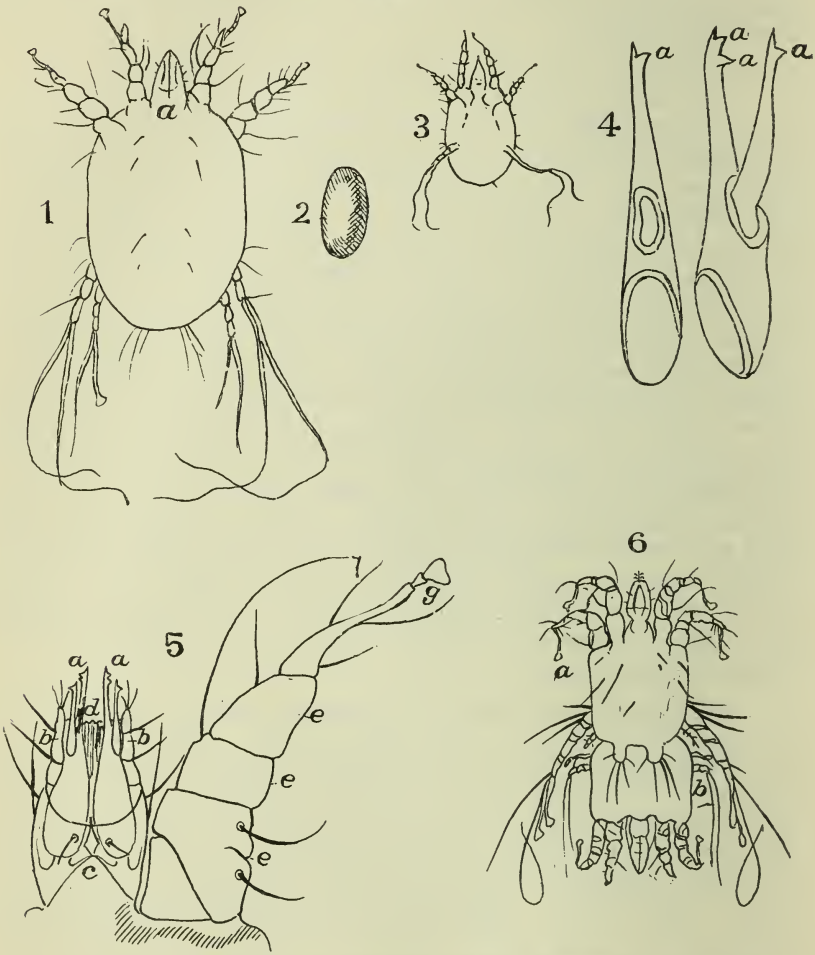

Figure I.—Sheep Scab-Mite (*Psoroptes communis*): 1, adult female, dorsal view; 2, egg; 3, newly hatched young; 4, jaws. which are also shown at 5aa; 5, head and one fore leg, showing mouth parts and sucker-like foot; 6, male above, female below. in copula. (Copied from *Animal Parasites of Sheep*, by Curtice.)

flesh-colored area on the posterior dorsal part of the body. Whenever any considerable number of specimens are taken together there will nearly always be a few pairs in copula, as shown in Figure I., 6. The eggs are white or whitish-translucent in color, about twice as long as broad and very large as compared with the mites. They are about four-tenths the length of the mature female and eight of them would entirely cover her body. They are deposited upon the surface of the skin of the sheep and not upon the wool. They stick readily to anything that touches them, especially to wool, so they are not readily lost from the sheep if anything should dislodge them from the skin.

EXPERIMENTS FOR THE DESTRUCTION OF THE MITES AND THEIR EGGS—NOTES ON SUBSTANCES USED.

The following substances were all used for the destruction of the mites or their eggs in the laboratory, but only the first ten were applied to sheep.

**The Fort Collins Lime and Sulphur Dip*—I have called this the Fort Collins dip because I know of no name previously given to lime and sulphur dip used in the same proportions. It contains lime, eleven pounds; sulphur, thirty-three pounds to 100 gallons of water. The lime and sulphur are first thoroughly mixed in a small amount of water and boiled for about two hours and then diluted to 100 gallons and used at about 110 degrees temperature. In my experiments the temperature was only about 90 degrees, and the sheep were kept in two minutes.

Dr. Headden, our station chemist, tells me that, if the lime is of good quality, it should take but one pound to cut four pounds of sulphur, and that it is the excess of lime used, or faulty preparation in the lime and sulphur dips that does the injury to the wool that is so often complained of. Mr. Drake tells me that there have been no complaints of injury to the sheep he has dipped in lime and sulphur.

California Dip—Sulphur, 100 pounds; lime, twenty-five pounds; water to make 100 gallons.

The lime and sulphur were first mixed in a small amount of water and boiled about two hours before using.

Also used at one-half the above strength.

Potassium Sulphide Dip—This substance was first suggested by Dr. Headden, who furnished me with a quantity of the crystals as purchased upon the market. These seemed less effectual

*Mr. W. A. Drake, an extensive purchaser and feeder of sheep near Fort Collins, tells me that he has put 38,000 sheep through a dip prepared in this manner the past fall and winter, and in only one instance has fresh scab appeared when the sheep were twice dipped, and he thinks that due to putting a scabby sheep in the bunch after dipping. The sheep were kept in the vat only one-half minute.

than what he afterwards prepared by boiling together sixty pounds of sulphur and nine pounds of washing soda in a small quantity of water, and then diluting this to 200 gallons of the dip. The crystals were used in the proportion of one pound to five gallons of water.

Cooper Dip—This is one of the arsenic-sulphur dips. It is manufactured in England and is one of the leading dips upon the markets. It is sold as a fine yellow powder in paper packages of about ten pounds weight. It mixes readily in either cold or warm water.

Black Leaf Sheep Dip—Manufactured by The Louisville Spirit Cured Tobacco Company, Louisville, Ky. The manufacturers claim this to be a pure and highly concentrated extract of tobacco. It mixes readily in cold or warm water, but the manufacturers recommend that it be used at 110 to 120 degrees. It is a pleasant dip to use in that it requires no stirring during the dipping and does not dry or chap the skin like the lime dips.

Skabcura—Put out by The Skabcura Dip Company, Chicago, Ill. This, like the preceding, is a tobacco dip. A bottle containing enough of the dip for 100 gallons of water is claimed to be the extract from 200 pounds of tobacco stems. It mixes with great readiness in water, cold or hot, and is a pleasant dip to use.

Zenoleum—Manufactured by The Zenner-Raymond Disinfectant Company, Detroit, Mich.

This dip, also the three succeeding ones, seem to be coal-tar dips. They are black, sirupy liquids, mixing without the slightest difficulty in cold or warm water and having a distinct tarry odor. When put in water they all form a white mixture (an emulsion) resembling milk. They are all recommended as disinfectants and washes for sores, and when put upon the skin leave the latter soft and oily with no disagreeable after effect, so that the men using these dips took pleasure in washing their hands in them to make them soft.

Chloro-Naptholeum—Put out by The U. S. Manufacturing Company, Minneapolis, Minn. Seems in all respects like the preceding except that when emulsified with water it does not form quite as white a mixture.

Quibell's Liquid Dip—Manufactured by Quibell Brothers, Newark, England. This dip seems in all respects like the preceding.

Sulpho-Napthol—Manufactured by Sulpho-Napthol Company, Boston, Mass. I have had but a small quantity of this dip to experiment with, but it seems like the preceding three dips, except that it did not form so complete an emulsion with water, a small amount of black, oily fluid rising to the top.

Australian Dip—Sulphur, 150 pounds; lime, 100 pounds, to 100 gallons of water. The lime and sulphur were mixed with a small amount of water first and heated until all became a bright red liquid and then diluted to 100 gallons.

Copperas Dip—Copperas, thirty pounds; water, 100 gallons.

Flour of Sulphur—The dry powder used pure.

Flour of Sulphur in Water—Used in the proportion of ten pounds of sulphur to 100 gallons of water.

Curtice Dip—Tobacco leaves, fifty pounds; sulphur, ten pounds, to 100 gallons of water. The tobacco was first thoroughly steeped, after which the leaves were removed and the sulphur put in the decoction and boiled for a half hour.

Milk of Lime—Lump lime, 150 pounds; water, 100 gallons. Lime slaked in the water and used at once.

Tobacco Decoction—Tobacco dust, 200 pounds; water, 100 gallons. The tobacco was steeped in the water and then the leaves squeezed and the strong decoction used in full and one-half, one-fourth and one-eighth full strength.

Quibell's Powder Dip—Put out by the same company as Quibell's Liquid Dip. This dip seems almost identical with the Cooper Dip. Like that dip, it is sold in paper packages, and was use in the proportions recommended by the directions. The powder dissolves readily in hot or cold water.

Arsenite of Soda Dip—White arsenic, one ounce; carbonate of soda, one ounce; water, one gallon. The arsenic and carbonate of soda were first put in a small amount of water together, and boiled until the arsenic became entirely dissolved, and then the remainder of the water was added. Also used in weaker solutions.

Carbolic Acid and Corrosive Sublimate—Carbolic acid, eight parts; corrosive sublimate, one part; water, 1,600 parts. (Suggested and prepared by Dr. Headden.)

Carbolic Acid—Pure carbolic acid in water in proportions varying from one part in 100 to one part in 2,000.

Kerosene Emulsion—Soap, one pound; water, one gallon; kerosene, two gallons. After making the emulsion in these proportions in the usual manner the whole was diluted to sixteen gallons. Also used in one-half this strength.

Pure Kerosene—Used without dilution.

Alcohol—Used 95 per cent. pure.

Whale-Oil Soap—Used in the proportion of one pound to two gallons of water.

**Crude Aniline*—Dissolved in water in the proportion of one to 800 by weight.

**Phenyl Hydrazine*—Dissolved in water in the proportion of one to 500 by weight.

MANNER OF APPLYING THE DIPS.

Unless otherwise stated in the notes upon the different dips, it will be understood that all were used at about 95 degrees temperature, and that the time of dipping was two minutes. In the laboratory experiments the mites were in each case procured on the day of the experiment by pulling wool from live scab. The mites were treated by dipping the wool that they were on into the various substances used, and, after two minutes, removing the wool and hanging it on pins to dry. This was thought to come as near the natural conditions as it was possible in the laboratory.

In most cases the dipping was done between five and six in the afternoon, and the first examination made between nine and ten the next morning. Examinations were made under a dissecting microscope, and all mites that could not be induced to move were accounted dead. When possible, a second or even a third examination was made, but the pressure of other work often made this impossible.

It must not be concluded that all dead mites found after treatment are necessarily dead because of the treatment, as an examination of the check lots will show that when removed from the sheep and kept in a warm atmosphere the mites died rapidly after the first few hours when untreated.

LABORATORY EXPERIMENTS.

The final test of any dip must be upon sheep infested with scab. Laboratory tests are of much value to the experimenter in that they can be conducted in larger number under conditions that can be more completely controlled, and they give information that greatly aids in the selection of dips of promise and in the rejection of those that seem worthless. As very little experimental work has been done with sheep dips as yet in this country, and, as it is probable that the subject is to attract con-

*Suggested and prepared by Dr. W. P. Headden.

siderable attention in the future, I have thought it best to record the results of all my experiments with different materials for the destruction of either eggs or mites for the guidance of those who may take up the work hereafter.

EXPERIMENTS WITH THE DIFFERENT DIPS.

Fort Collins Lime and Sulphur Dip—This dip was used upon sheep only; the laboratory tests of lime and sulphur dips were made in other proportions.

On November 18, thirty-five sheep were dipped, care being taken that all were put entirely under at least twice.

Mild cases of scab were known to exist in this bunch, but, unfortunately, the men who did the work misunderstood my directions and put in no sheep having heavy scab, as I intended that they should. December 1 the sheep were dipped again in the same preparation, no sign of scab having developed in the meantime. At this date, April 15, no fresh scab has appeared.

By purchasing the sulphur in a car-load lot, the feeders at this place were able to dip their sheep at less than one cent per head in November.

California Dip—

Laboratory Experiments—Applied October 27. Examined sixteen hours after, when several active, but no dead, mites could be found.

Experiment repeated November 5. Examined sixteen hours after, when four active and seven dead mites were found. Examined forty hours after, when only one living mite could be found.

Repeated again November 6. Sixteen hours after a single mite was found, which was very active. After using this dip the wool would dry into a hard lump, so that it was difficult to find the mites at all. The lump would crush rather easily into a mass of fine powder.

Experiment repeated in one-half the above strength, November 5. Sixteen hours after there were ten dead and five active mites found. Forty hours after there were still five active mites, but only one seemed in good condition.

Experiment on Sheep—One sheep with heavy live scab was treated with this dip November 14.

When examined, November 16, the wool was matted and heavily loaded with a fine powder. The wool was harsh and dry, and could be easily picked from the sheep with the thumb and finger. The wool did not pull from the skin, but would break near the body, where the fibres were nearly eaten off by the lime. No living mites could be found. No living scab has developed to the present time, April 15.

POTASSIUM SULPHIDE DIP.

Table Showing Results of Laboratory Experiments.

Date of Treatment	Condition After 16 Hours		Condition After 48 Hours		Strength Used
	Dead	Alive	Dead	Alive	
**November 1	13	0	----	----	Full Strength
**November 1	3	7	10	0	½ Strength
November 3	3	7	7	3	½ Strength
November 4	8	2	----	----	Full Strength
November 6	22	5	27	0	Full Strength
November 6	0	All	----	----	½ Strength
November 11	Few	0	----	----	Full Strength
November 15	5	5	----	----	Full Strength
November 16	7	2	9	0	Full Strength
November 27	9	16	----	----	Full Strength

The laboratory experiments with this dip were not at all encouraging. Experiments upon sheep did much better.

Only the crystals were used in the laboratory. The "full strength" mentioned in the table was in the proportion of one pound of crystals to five gallons of water.

Experiments on Sheep—The crystals were used in the proportion of one pound to five gallons of water, on November 10, to dip one sheep with a rather large patch of heavy scab on its back. The sheep was dipped but once. The weather being rather cold the sheep was kept in a barn for a few days.

A lock of wool was pulled twenty-four hours after the dipping, on which were found thirty-three mites, and all but one seemed dead. The wool at this time was quite wet.

Forty-eight hours after another lock of wool was examined, on which I found six apparently dead and six active mites. The wool was still moist on the sheep.

The sheep was repeatedly examined at intervals of a few days. The mites soon began to increase rapidly, and by the 1st of December the sheep had a bad case of scab again. On December 12 the sheep was dipped in Zenoleum, one part to 200 of water, and showed no signs of scab afterwards.

Experiment repeated November 18. At this time a bunch of forty sheep was dipped in a preparation made by Dr. Headden as follows:

Nine pounds of potash lye (caustic soda) were dissolved in four gallons of water, and then thirty-two pounds of flour of sulphur were added slowly, while the liquor was kept at boiling heat. After boiling one hour, the whole was put in the dipping vat and diluted to 200 gallons.

**In these two experiments the wool was put in a glass tube before it was perfectly dry and so kept moist the whole time, which probably accounts for the greater effectiveness of the dip in these than in later experiments.

Forty sheep were dipped in this mixture, several of which had heavy scab. After drying, the wool was full of a very fine yellow powder that kept the skin of the sheep completely covered. The sheep were dipped again December 1. No live scab has developed on any of these sheep since the dipping.

I have a letter from Leggett & Brother, New York, offering the lye, or caustic soda, in lots of 1,000 pounds or more at the rate of four cents a pound on board the cars. Calling the sulphur four cents and the lye five cents, after adding freight, and I think these are outside figures on large lots, it would make the dip cost only about eighty cents for 100 gallons. At these figures this dip would rival the lime and sulphur dips for cheapness, and the lye is more easily handled than the lime. It may be difficult to understand why the potassium sulphide crystals did not do as well as the same substance made by using the sulphur and lye, but the former left but little powder in the wool, while the latter left a large amount of it on drying, and I believe the mites are unable to endure, for a very long time, being covered with a dry powder of any sort. It will not do to rest the value of this dip upon a single experiment, but it seems to me to give promise of being a very cheap and practical dip. I hope to be able to test it farther at another time.

It will be noticed that all the lime and sulphur dips did better on the sheep than in the laboratory experiments. I believe it to be due to the continuous action, on the mites, of the fine dust that remains so long in the wool after dipping. There is some reason to think that the action of these dips is largely to drive the mites from the sheep and cause them thus to perish.

LABORATORY EXPERIMENTS WITH COOPER DIP.

Date of Treatment	Condition after 16 Hours		Condition after 40 hours	
	Dead	Alive	Dead	Alive
*October 31	----	----	10	12
November 3	----	----	16	1
November 4	13	1	14	0
November 5	5	1	6	0
November 9	----	----	10	3
November 11	10	4	----	----
November 27	----	----	10	3
Totals	28	6	56	16

One lock was dipped on November 5 at one-half the ordinary strength. and at the end of forty hours there were ten dead and five living mites.

*This lock of wool was dried on paper after dipping, which took the water out much more quickly than if dried like the others. This probably accounts for the lessened effect of the dip.

Experiments on Sheep—On November 10, one sheep, with moderately heavy live scab on the back, was treated with the Cooper Dip—one pound to ten gallons of water.

The sheep was kept in the barn for a few days. Twenty-four hours after dipping the wool was still very wet. A lock was pulled and examined that contained forty-seven dead and nine living mites.

At the end of forty-eight hours the wool was still moist. An examination showed a good number of dead and one living mite in the wool.

On November 13 the sheep was examined again, and an occasional living mite was found. By far the greater number were dead. The living mites were fully grown, and could not have come from eggs since dipping. The sheep was examined November 16, and again December 5, and a few living mites found on both occasions. On December 12 it was dipped again as before. The sheep has shown no scab since.

November 18, a bunch of forty sheep was treated with Cooper Dip, and the treatment was repeated December 1. In this bunch there were but three known cases of scab, and two of these were rather light. One sheep had a rather heavy, but not large, patch of scab on the rump. No farther signs of scab were noticed until January 7, when the sheep that had the somewhat heavy scab on the rump was seen "digging," and an examination showed a small spot of fresh scab near the old one. This sheep was "patched," and there have been no signs of scab in this bunch since.

This dip has been largely used in this vicinity for some years, and is considered by many feeders as a good dip, but most of the men who have used it tell me that unless there is very slight signs of scab among their sheep they have to dip twice, and if the sheep are very scabby they nearly always have to do some "patching" after twice dipping. The expense of the dip is about twice that of the lime and sulphur.

BLACK LEAF DIP.

Table Showing Results of Laboratory Experiments.

Date of Treatment	Condition after 16 hours		Condition after 48 hours		Condition after 4 days		Strength Used
	Dead	Alive	Dead	Alive	Dead	Alive	
November 2	6	1	----	----	----	----	
November 3	10	3	13	0	----	----	
November 6	3	6	6	3	6	3	$\frac{1}{40}$
November 27	9	9	----	----	----	----	
December 12	12	3	----	----	----	----	
November 5	5	6	9	2	----	----	$\frac{1}{50}$
November 6	0	18	4	14	Few	Several	$\frac{1}{80}$
November 5	6	13	14	5	----	----	$\frac{1}{100}$

Experiments on Sheep—One sheep with a patch of moderately heavy scab, the size of a man's hand, was dipped with Black Leaf Dip, in the proportions of one to forty by measure, on November 10.

The sheep was examined twenty-four hours after, and several mites seen crawling about in the wool. The wool was still quite wet. Two days after the application a lock of wool was pulled, upon which ten living and about an equal number of dead mites were found. The living mites seemed rather sluggish.

November 13, the sheep was examined and only an occasional living mite could be found. Those found were too large to have hatched from eggs since dipping. On November 16, a careful search revealed but two mites, and on the 19th I looked in vain to find a living mite. The sheep was also carefully examined on December 5 and again on the 19th, without my finding mites or living scab.

On February 6 the sheep was noticed rubbing its tail against a feeding trough, and on examination it was found that there was a bad patch of scab covering most of the dorsal surface of that organ and two small spots were starting on the rump at the roots of the tail. The mites that survived the effect of the dip seem to have migrated to the tail and were there overlooked in previous examinations.

Experiment Repeated on a Larger Scale—On November 18, three bunches of sheep of forty each were treated with Black Leaf Dip in the proportion of one gallon to forty-two gallons of water. These bunches were treated again December 1. There were a few cases, only, of rather mild scab among these sheep. On the second day after dipping, one sheep was found with a few living but apparently sick mites. Since that time no scab has developed in any of the pens containing these sheep.

Three sheep known to have some scab when first dipped were kept out at the second dipping, and one of these on January 8 was found to have a small spot of live scab near the old patch of moderately heavy scab. The other two cases, which were rather mild, were entirely cured by the one treatment.

All my experiments seem to indicate that this dip kills slowly but quite surely. Moderately bad cases were in some instances entirely cured by once dipping, while others broke out again. The dip is a pleasant one to use but is rather expensive. I hope to test it further.

SKABCURA DIP.

Laboratory Experiments—November 3, mites were dipped in this preparation in twice the recommended strength.

Sixteen hours after, seven mites were active and about an equal number (not counted) seemed dead. At the end of forty-eight hours only four mites remained active.

Another lot was dipped on the same date in the recommended strength of this dip. Sixteen hours after, all seemed perfectly active. After fifty-six hours many were still active. No count was made.

This dip seemed much more effectual when applied to sheep.

Experiment on Sheep—On November 10, one sheep with moderately heavy scab was dipped with this preparation.

A lock pulled from the sheep twenty-four hours after, gave four dead and ten active mites.

Another lock, taken forty-eight hours after treatment, gave ten apparently dead and nineteen active mites. On November 13 only a very few living mites could be found on this sheep, and on the 16th of the same month I was unable to find any, and none have appeared since.

My early laboratory experiments with this dip were so unpromising that I dropped it to take up dips of more promise, but in following through the effects of the dip on the one sheep treated, it seems that the effect of Skabcura is much like that of Black Leaf, namely, having a cumulative effect, extending over a number of days. This dip seems to me to promise well.

ZENOLEUM.

Laboratory Experiments—My first experiments with this dip were in the proportion of one part to twenty-five and one part to fifty of water. All were killed that were thus treated.

Table Showing Results of Laboratory Experiments.

Date of Treatment	Condition after 16 Hours		Strength Used
	Dead	Alive	
November 4	6	0	
November 5	18	0	$\frac{1}{100}$
November 6	12	0	
November 6	13	0	
November 9	10	0	
November 11	8	0	
December 2	13	0	
December 5	14	0	$\frac{1}{200}$
December 26	10	0	
February 6	30	0	
February 6	20	0	
November 9	9	0	
November 11	16	0	
November 12	19	0	
November 13	6	0	$\frac{1}{400}$
December 12	14	1	
February 6	43	1	
February 6	27	1	
November 11	20	0	
November 12	36	11	
November 13	12	10	$\frac{1}{800}$
December 12	10	10	
November 11	2	7	
November 12	0	8	$\frac{1}{1600}$
November 12	0	Many	$\frac{1}{3200}$

The experiments with this dip gave such promising results from the start that I was led to test it more thoroughly than any other, both in the laboratory and upon sheep.

Experiments on Sheep—One sheep with very heavy scab covering a space about six inches wide and twelve inches long on the shoulders and back was dipped with Zenoleum, diluted 100 times with water, on November 10.

The sheep was examined the next day and many times thereafter, but no live scab appeared again and no living mites have since been found. The scab healed quickly and the sheep has done well ever since.

On the same date another sheep with heavy live scab was dipped in Zenoleum diluted 200 times. Twenty-four hours after dipping, wool was pulled showing many dead mites but no living ones. The sheep has been frequently examined since, but no live scab has appeared during the six months.

On December 12, one sheep not cured by previous dipping with potassium sulphide, was dipped in Zenoleum diluted 200 times, and has shown no live scab since.

On the same date, two sheep, one with a small patch of light scab, and one with a small patch of rather heavy scab, were dipped in Zenoleum diluted 600 times. In both cases the scab seems to have been completely cured, no signs of live scab appearing since.

A Bunch of Sheep Dipped Once—On November 18 a bunch of forty sheep, many of them with heavy live scab, was dipped in Zenoleum diluted 200 times. No scab was afterwards found in this bunch until February 9, at which time six cases of live scab were found, all but one very light. It was found that the one sheep with heavy scab was put in the bunch on December 13 in order to make this bunch of sheep compare in numbers with other bunches that were to be used in a feeding experiment. The scab had gone unnoticed, as it had developed in a large patch of short wool that could not be pulled by the sheep. It seems to me that the presence of this one sheep would readily account for the five incipient cases. However this may be, there were several bad cases that never showed any scab after the dipping.

A Bunch of Sheep Dipped Twice in Zenoleum, Diluted 200 Times—Another bunch of forty sheep that was dipped in Zenoleum, one to 200, on November 18, was dipped again on December 1. This bunch, like the preceding, had a good number of cases of heavy scab.

No live scab was found in this pen until February 9, when the sheep were all examined and one was found with a small patch of fresh scab about one inch in diameter. On December 13, three sheep were put in this pen also, preparatory to a feeding experiment, and on the date that the scabby sheep above mentioned was found, these three sheep were also found to have some scab; one of them had a bad patch on its tail, which it was seen rubbing on a feeding trough. The three sheep were "spotted" and no scab has since appeared. It seems probable that the sheep put into the pen were the cause of the one sheep that had been dipped with Zenoleum getting scab again.

A Bunch of Sheep Dipped Twice in Zenoleum, Diluted 400 Times—On November 18, and again December 1, a bunch of forty sheep was dipped in Zenoleum diluted 400 times. No live scab appeared again until March 2, when one sheep with a small patch, less that an inch in diameter, was found. It is the only case that has appeared. This bunch had a good number of very scabby sheep when dipped.

EXPERIMENTS WITH CHLORO-NAPTHOLEUM.

Table Showing Results of Laboratory Experiments.

Date of Treatment.	Condition after 16 Hours		Condition after 44 Hours		Strength Used
	Dead	Alive	Dead	Alive	
November 14	All	0	----	----	$\frac{1}{10}$
November 26	30	0	----	----	
November 14	Many	2	----	----	$\frac{1}{200}$
November 16	14	0	----	----	
November 14	8	8	----	----	$\frac{1}{400}$
November 16	15	3	----	----	
November 14	0	All	----	----	$\frac{1}{800}$
November 16	----	----	3	4	

Applied to Sheep—On November 18, this dip was applied to forty sheep in the proportion recommended on the cans, which is three quarts in 200 gallons of water. There were a few cases of mild scab in this bunch, but no heavy scab. The treatment was not repeated and no scab has appeared since dipping. Further experiments are necessary before drawing definite conclusions regarding this dip.

EXPERIMENTS WITH QUIBELL'S LIQUID DIP.

Table Showing Results of Laboratory Experiments.

Date of Treatment	Condition after 16 Hours		Strength Used
	Dead	Alive	
February 26	14	0	$\frac{1}{100}$
January 5	10	0	$\frac{1}{200}$
February 26	19	0	$\frac{1}{200}$
February 27	16	0	$\frac{1}{200}$
January 12	12	0	$\frac{1}{200}$
January 5	14	0	$\frac{1}{400}$
January 12	9	3	$\frac{1}{400}$
February 26	27	0	$\frac{1}{400}$
February 27	15	1	$\frac{1}{400}$
January 12	8	0	$\frac{1}{800}$
February 27	14	0	$\frac{1}{800}$

Experiments on Sheep—On December 12 six sheep were treated with this dip as follows: Two sheep in a mixture of one part of dip to 200 parts of water; two sheep in a mixture of one part of dip to 400 parts of water; two sheep in a mixture of one part of dip to 600 parts of water. One of the sheep, dipped in the strongest preparation, had a large patch of heavy scab along the back, while the other had only a very small patch of light scab. In each of the weaker mixtures one sheep was dipped having a small but moderately heavy live scab, and one having one or two patches of very light scab. The sheep with heavy scab, dipped in the strongest mixture, was not cured, the mites continuing both on and about the old scabby spot. The one having very light scab was cured.

The two sheep dipped in the one to 200 strength were both cured.

The sheep with the heavier scab, dipped in the one to 600 strength, was not cured, while the one with incipient scab has shown no signs of scab since dipping.

LABORATORY EXPERIMENTS ONLY.

SULPHO-NAPTHOLEUM.

This dip was not obtained in time to enable me to do much with it. A lock of wool containing thirty-seven mites was dipped in this substance, diluted 200 times, and at the end of sixteen hours all were dead. Another application in one-half the above strength, in which forty-two mites were used, resulted in the death of all within the sixteen hours.

QUIBELL'S DRY DIP.

Three different lots of mites on wool were dipped in the proportions recommended on the packages. Sixty-six mites were included in the experiments, about one-third of which were alive at the end of sixteen hours. In one case the mites were examined after sixty-four hours and several found active. The indications are that this will not prove a very effectual dip.

CARBOLIC ACID.

One part to 100 parts of water. One lot of six mites were all dead after sixteen hours. One lot of fourteen mites gave nine dead and five living after twelve hours.

One part to 200 of water. A lot of fifteen mites treated in this strength all seemed dead at the end of sixteen hours. Another lot of a good number, but not counted, were about half dead at the end of twelve hours.

One part to 400 parts of water. One lot treated, and about half were active at the end of sixteen hours. Also used in proportions of 1 to 500, 1 to 1,000 and 1 to 2,000, but in no case did the treatment seem to kill any mites inside of sixteen hours. As carbolic acid is a dangerous substance to put animals into, it seems as though it is very doubtful if it can be employed safely in sufficient strength to kill the mites.

ARSENITE OF SODA.

Table Showing Results of Laboratory Experiments.

Date of Treatment	Condition After 16 Hours		Condition After 44 Hours		Strength Used
	Dead	Alive	Dead	Alive	
November 5	12	0	----	----	Full Strength
November 6	10	4	7	7	½ Full Strength
November 11	10	0	----	----	⅔ Full Strength
November 11	12	0	----	----	⅓ Full Strength
November 12	3	3	4	2	⅓ Full Strength
November 13	16	9	----	Few	⅓ Full Strength
December 6	10	6	10	6	¼ Full Strength
December 6	6	10	4	12	⅛ Full Strength

Full strength, as given in the above table, would be one ounce of arsenic and the same of carbonate of soda to one gallon of water. The experiments would indicate that, if used much weaker than this, it would not be very effectual. I believe this dip too poisonous to be used with safety.

AUSTRALIAN DIP.

Laboratory experiments with this dip were not satisfactory, as the solution on drying became a hard lump that inclosed the mites. On crushing this it became a mass of dry powder. Most of the mites that could be found after sixteen hours were dead, but in nearly every case a few living were found also.

There is no doubt but what this would be a very effectual lime and sulphur dip, but I believe it too strong to use on the sheep, and stronger than is necessary to kill scab.

COPPERAS DIP (GREEN VITRIOL).

Two tests were made in the laboratory of copperas as a dip. In one, the proportions were three pounds of the crystals to ten gallons of water, and in the other three pounds of the crystals to twenty gallons of water. In the former strength, about one-third of the mites were quiet at the end of sixteen hours, and in the latter strength only one mite in eight seemed dead at the end of the same time. At the end of forty-four hours one-half of those treated with the weaker solution were still active.

FLOUR OF SULPHUR (DRY).

Dry sulphur was thoroughly dusted into a lock of wool containing scab mites. At the end of sixteen hours four dead and five living mites were found, the latter having all left the wool. At the end of forty hours two mites were still crawling about covered with sulphur.

FLOUR OF SULPHUR IN WATER,

Used in the proportion of one pound to eight gallons, and one pound to twelve gallons of water. In the former case there were four dead and five active ones at the end of sixteen hours. At the end of forty hours one mite covered with sulphur was still active. In the weaker strength all the mites were active at the end of twelve hours.

CURTICE DIP.

Only one laboratory test was made with this dip. After sixteen hours there were many active and few, if any, dead mites. At the end of five days two active mites were found.

A very similar dip, prepared in the proportions of four pounds of strong tobacco and one pound of sulphur to ten gallons of water, was also used. At the end of sixteen hours the mites seemed uninjured. Only one test.

MILK OF LIME.

Wool treated with this dip became a hard lump on drying. After crushing the lump, at the end of sixteen hours, three living mites were found. Probably there were dead ones present, but, being quiet, were not seen. It would seem that lime has but little effect on the mites.

TOBACCO DECOCTION.

The first lot dipped was kept under for only one minute, and then the wool was dried by laying it on blotting paper. Nearly all the mites were lively at the end of four days. The decoction was also used in one-half, one-fourth and one-eighth the above strength in the same manner, and with the same result in each case.

Very strong tobacco leaves, from tobacco raised by the horticultural department, were also used in the same proportion (two pounds to a gallon of water), but the dipping was for two minutes, and the drying of the wool was in the usual manner. At the end of forty-four hours twelve dead and eight active mites were found.

These experiments seemed so unfavorable for tobacco that I concluded not to experiment with it farther. It is very possible that tobacco has a cumulative effect not shown in these experiments.

CARBOLIC ACID AND CORROSIVE SUBLIMATE.

Only one lot treated. At the end of twenty-four hours there were twelve active mites and few, if any, that were dead.

KEROSENE EMULSION.

Having found kerosene emulsion very effectual in destroying lice that infest cattle and hogs, I expected it would be an effectual remedy for scab in sheep. My laboratory experiments were so disappointing that I did not test the emulsion farther. It might have proven more effectual on sheep.

The mites were first dipped for one-half minute in full and one-half strengths. At the end of sixteen hours the mites were all lively, though wet with kerosene. The experiment was repeated in both of the above strengths, and at the end of forty-four hours all the mites were lively.

KEROSENE.

Failing with kerosene emulsion, I made one test with pure kerosene to see if it would kill. A lock of wool containing mites was dipped for one minute. At the end of two hours all the mites were active. At the end of sixteen hours four semed dead and five were still active. All were wet with the oil. At the end of forty-eight hours all were dead. Kerosene, either pure or in the form of an emulsion, may be a sure destroyer of the mites, but it is certainly not rapid in its action.

ALCOHOL.

Finding that kerosene had so little effect, I thought I would see what 95 per cent. alcohol would do. A quantity of mites was dipped for one minute in this substance. At the end of sixteen hours all were still active, and at the end of forty-eight hours only a few had died.

WHALE-OIL SOAP.

Used in the proportions of one pound to two gallons of water, and in one-half and one-fourth of this strength, and with no apparent effect in any case. In the strongest preparation many mites were alive at the end of sixty-four hours.

EXPERIMENTS WITH THE EGGS.

There is a prevailing opinion that the eggs are not killed by the applications that destroy the mites, and that, as a consequence, a second dipping is made necessary to destroy the young mites hatching from the eggs that survived the first treatment. It is commonly recommended to dip a second time from ten to fourteen days after the first treatment, but I can not find that anyone has actually determined the time required for the eggs to hatch. There is also the greatest difference of opinion as to the length of time the eggs may survive when off the sheep, some thinking they may live for years, and others that they can not survive more than a few weeks. These are all matters of very great importance, and the experiments tabulated below were conducted for the purpose of throwing light upon them. The eggs are difficult to obtain in sufficient numbers for experimental purposes, and it is not a very easy matter to keep them under a very close approach to natural conditions. The method that I adopted was to use small glass tubes supplied with corks. The cork, in each case, was removed, moistened with saliva on the inner end, the eggs for the particular experiment placed upon it, where they adhered without trouble after the cork was replaced. The tubes were then carried in an inside vest pocket during the day and kept in a warm place during the night. Any ordinary low temperature seemed to have no effect upon the eggs except to lengthen the period of incubation.

Tabulated Experiments with Eggs of Sheep Scab-Mite.

Date of Application	Date of Notes	Number of Eggs		Treated With	Strength of Dip
		Hatched	Unhatched		
Nov. 27	Dec. 11	0	9	Black Leaf	1 to 40
Nov. 7	Nov. 12	10	0	Black Leaf	1 to 42
Nov. 19	Nov. 27	1	0	Black Leaf	1 to 50
Nov. 17	Nov. 26	2	7	Phenyl Hydrazine	Full strength
Nov. 17	Dec. 9	0	7	Crude Aniline	Full strength
Nov. 17	Dec. 9	0	2	Crude Aniline	One-half strength
Nov. 7	Dec. 9	0	2	Zenoleum Dip	1 to 100
Nov. 27	Dec. 11	0	5	Zenoleum Dip	1 to 200
Dec. 13	Dec. 24	0	1	Zenoleum Dip	1 to 200
Feb. 7	Feb. 24	0	4	Zenoleum Dip	1 to 200
Feb. 7	Feb. 27	0	12	Zenoleum Dip	1 to 200
Nov. 13	Nov. 26	0	6	Zenoleum Dip	1 to 400

Date of Application	Date of Notes	Number of Eggs		Treated With	Strength of Dip
		Hatched	Unhatched		
Nov. 20	Nov. 26	0	13	Zenoleum Dip	1 to 400
Nov. 20	Dec. 9	0	13	Zenoleum Dip	1 to 400
Dec. 13	Dec. 24	2	4	Zenoleum Dip	1 to 400
Feb. 7	Feb. 27	0	12	Zenoleum Dip	1 to 400
Feb. 7	Feb. 24	0	7	Zenoleum Dip	1 to 400
Nov. 13	Nov. 14	1	0	Zenoleum Dip	1 to 800
Nov. 13	Nov. 17	3	0	Zenoleum Dip	1 to 800
Feb. 7	Feb. 27	0	10	Sulpho-Naptholeum	1 to 200
Feb. 10	Feb. 24	0	9	Sulpho-Naptholeum	1 to 200
Nov. 20	Dec. 10	0	1	Cooper Dip	
Nov. 27	Dec. 11	0	5	Chloro-Naptholeum	1 to 100
Nov. 17	Dec. 1	0	4	Chloro-Naptholeum	1 to 200
Nov. 17	Dec. 1	0	8	Chloro-Naptholeum	1 to 400
Nov. 27	Dec. 1	0	6	Quibell's Liquid Dip	1 to 100
Nov. 27	Dec. 14	2	5	Quibell's Liquid Dip	1 to 200
Nov. 28	Dec. 14	0	9	Quibell's Liquid Dip	1 to 200
Dec. 13	Dec. 24	0	13	Quibell's Liquid Dip	1 to 200
Nov. 27	Dec. 14	0	4	Quibell's Liquid Dip	1 to 400
Nov. 28	Dec. 14	0	14	Quibell's Liquid Dip	1 to 400
Dec. 13	Dec. 24	0	4	Quibell's Liquid Dip	1 to 400
Nov. 27	Dec. 11	1	10	Quibell's Liquid Dip	1 to 800
Nov. 6	Nov. 12	1	0	Potassium Sulphide Dip	1 pound to 5 gallons
Nov. 27	Dec. 11	0	4	Potassium Sulphide Dip	1 pound to 5 gallons
Nov. 7	Nov. 12	1	0	Arsenite of Soda	1 ounce to 1 gallon
Nov. 13	Nov. 19	2	0	Arsenite of Soda	1 ounce to 4 gallons
Nov. 27	Dec. 11	1	19	Quibell's Dry Dip	According to direct'ns
Nov. 27	Dec. 9	0	5	Quibell's Dry Dip	According to direct'ns
					Minimum Temperatures
*Nov. 19	Dec. 30	2	1	Out of Doors	8.3°
Nov. 27	Dec. 14	0	6	Out of Doors	—9.8°
Nov. 23	Dec. 9	0	6	Out of Doors	5.1°
Nov. 19	Dec. 24	0	5	Out of Doors	3.2°
Nov. 30	Dec. 11	0	1	Out of Doors	1.5°
Feb. 6	Mar. 13	0	2	Out of Doors	—5.3°
Feb. 6	Feb. 24	5	8	Out of Doors	11.8°
Feb. 9	Mar. 13	0	7	Out of Doors	—5.3°
Feb. 9	Mar. 7	0	2	Out of Doors	.1°
Feb. 11	Feb. 24	0	4	Out of Doors	11.8°
Feb. 20	Feb. 27	0	25	Out of Doors	.1°

An examination of the preceding table will show that the eggs are nearly, if not quite as easily killed, as the mites. It is possible that the eggs are more protected by the scabs than the mites, but in all the above experiments mites and eggs were treated alike on the wool and seem to have been killed about equally well.

It seems strange that in the use of Black Leaf all of the eggs should have hatched that were taken from a sheep twenty-four hours after dipping, and nearly all should have been killed that were treated in the laboratory.

* This lot was kept on an outer window sill.

The tar dips all did splendidly in destroying eggs. Zenoleum was most used. In dilutions of one to 100 and one to 200 it killed all. When diluted 400 times, only two hatched out of fifty-seven. In the proportion of one to 800, all hatched.

Out of a total of sixty-eight eggs treated with Quibell's Liquid Dip, only three hatched. Smaller numbers were dipped in Chloro-Naptholeum and Sulpho-Napthol and none hatched.

Effects of Exposure on Hatching the Eggs—The effects of exposure on the hatching of the eggs may be summarized as follows:

Four eggs were out five days with the minimum temperatures ranging between 11.8 degrees and 24.8 degrees. None hatched.

Thirteen eggs were out three days when the minimum temperatures ranged between 11.8 degrees and 24.5 degrees. Five hatched.

Twenty-five eggs were out fourteen days, when the minimum temperature ranged between .1 degree and 34 degrees. None hatched.

Six eggs were out twenty-one days when the minimum temperatures ranged between 12 degrees and 37 degrees. None hatched.

Two eggs were out thirty-two days when the minimum temperatures ranged between —5 degrees and 34 degrees. None hatched.

Seven eggs were out thirty-five days when the minimum temperatures ranged between —5 degrees and 34 degrees. None hatched.

Six eggs were out one night when the temperature went down to —9.8 degrees. None hatched.

One egg out one night when the temperature went down to 15 degrees. Did not hatch.

Five eggs were out eight nights when the temperature went to a minimum of —11.8 degrees. None hatched.

Three eggs were out a few nights (dates lost) when the temperature went to a minimum of 8.3 degrees. Two hatched.

Four eggs were out a few nights (dates lost) when the minimum temperature went down to —5.3 degrees. None hatched.

Do not understand that any of the eggs hatched while exposed to the cold. As soon as brought in the eggs were carried in a warm pocket, as before described.

These experiments show that the eggs may be subjected to a temperature of 8.3 degrees and still hatch. Those subjected to a temperature of 5 degrees or lower did not hatch in any case. It seems probable that the eggs will not bear a temperature as low as 0 and live.

Whether or not exposure will kill one of these eggs probably depends upon, at least, three things, viz., the degree of cold, the duration of the exposure and the stage of incubation of the egg when exposed.

Period of Incubation—When carried in the pocket, the longest time that eggs have lived and hatched after being removed from a sheep has been nine days. One egg known to have been laid November 3, was kept in a warm pocket and the mite emerged on November 8. Time of incubation evidently depends much on temperature. In their natural position on the skin of the sheep and protected from the cold by a heavy coat of wool, it is probable that the eggs hatch in from three to five days.

Where the Eggs are Placed—The eggs of these mites are not glued to the fibers of the wool, neither are they inserted beneath the surface of the skin, but are placed directly upon the moist skin or upon light scab.

EFFECT OF EXPOSURE ON THE MITES.

It is also a matter of much importance to know how long the mites can live off the sheep. How soon after scabby sheep have been turned out of a corral or field will it be safe to put healthy sheep in them without danger of their becoming diseased? The following experiments bear upon this point, but it must be remembered that I have been able to study the conditions during cold weather only.

EXPERIMENTS IN WHICH THE MITES WERE KEPT WARM.

In these experiments the mites were placed on wool in small vials and carried in an inside pocket during the day and were kept at a temperature of about 60 degrees during the night.

Lot 1—Fourteen mites of different ages, taken November 3.

November 4, all seemed active; November 5, five were active and nine quiet; November 6, only two were active; November 7, there were no signs of life.

Lot 2—Thirty-six mites of all ages, taken October 31.

November 2, eighteen seemed dead and eighteen were active; not examined again.

Lot 3—Fifteen mites taken November 5.

November 6, seven appeared dead and eight alive; November 7, only two showed any signs of life.

Lot 4—Seventeen mites taken November 6.

November 7, two seemed dead and the remainder alive; November 9, a few were still active, no count made; November 11, all were dead.

Lot 5—Eighteen mites taken November 12.

November 13, only fourteen were active; November 14, only four were active; not examined again.

Lot 6—Thirteen females taken November 13.

November 19, all were dead and no eggs had been laid.

Lot 7—A large number (not counted) of mites taken November 19.

November 27, one very sluggish mite was all that showed any signs of life; November 28, all were dead.

Lot 8—A large number of mites taken November 27.

Not examined till December 2, when all were dead.

The longest time that a mite lived in any of the above experiments was eight days. As a rule, all were dead at the end of five days.

EXPERIMENTS IN WHICH MITES WERE KEPT OUT OF DOORS.

In these experiments, mites were exposed for a greater or less time on wool, in vials, out of doors, then they were brought in and warmed to see if they would become active. If the mites were still alive they always became active in a very few minutes when the vials were warmed in the hand or with the breath.

Lot 1—A quantity of mites taken and put out November 3.

November 5 and 6, all seemed lively on warming; on the 6th, 7th and 8th, a few of the mites failed to revive, but no counts were made; on the 9th, only four seemed alive; on the 10th, only three, and on the 12th, two; on the 14th, two, and on the 17th, none. So that two mites in this case lived at least eleven days. Minimum temperature during the time was 13 degrees.

Lot 2—A good number of mites put out along with the preceding.

Examined for first time November 23, when all the mites became active on being warmed. Minimum temperature during the time, 13 degrees.

Lot 3—A quantity of mites put out November 19.

Examined for the first time November 28, when all were found to be dead. Minimum temperature while out, —11.3 degrees.

Lot 4—A large number of mites put out November 27.

Examined November 28, when all were dead. Minimum temperature during the night, —9.8 degrees.

Lot 5—Like the preceding, except that they were kept on an outer window sill where, according to tests made later, the temperature was probably about 7 degrees higher than upon the ground, or —2.8 degrees.

November 28, all the mites were dead.

Lot 6—Ten mites put out January 29.

February 1, on warming the mites, six, none of which were adults, became active; four, all adults, did not revive. Those that did revive seemed very sluggish. The minimum temperatures for the three nights were 10.7 degrees, 7.8 degrees and 8 degrees respectively.

Lot 7—A number of mites put out November 23.

When first examined, January 3, all were dead. Minimum temperature during this time, 11.3 degrees.

Lot 8—Mites put out November 30.

Examined January 3, when all were dead. Minimum temperature for this time, 5 degrees.

Lot 9—Mites put out February 6.

Examined February 9, when all became active on warming. They were kept in but a few minutes and then put back. The minimum temperature to which these mites was subjected was 11.8 degrees.

Examined again March 9, when all were dead. Minimum temperature during this time, 5.3 degrees.

Lots 10 and *11*—Put out February 6 and February 9, respectively.

Both lots were examined for the first time March 24, when all the mites were found dead. The minimum temperature during the exposure was 5.3 degrees.

Lot 12—Put out February 23.

Taken in and warmed February 24, when all became active. The lowest temperature during the night, 5 degrees.

Lot 13—Mites put out February 6.

First examined March 9, when all were found to be dead. Minimum temperature during this time, — 5.3 degrees.

The conclusions that may be drawn from the foregoing experiments are the following:

First—That the mites can not endure a temperature much below zero and survive, even for a single day.

Second—That the mites can endure a temperature of 5 degrees and live.

Third—That the immature mites can endure as low, if not a lower, temperature than the adults.

Fourth—That the mites may live very much longer in a temperature low enough to keep them dormant than in a warm temperature that will keep them active, provided the temperature is not low enough to kill them and that they are not supplied with food.

Fifth—That they will live longer in a moderately low temperature if the temperature is kept steadily below that point which will make them active. In other words, a steady low temperature is not as destructive to them as alternating low and high temperatures.

The longest that mites were kept alive with above experiments was twenty days.

The results with the preceding experiments, both with eggs and mites exposed to out-door temperatures, make it almost certain that the infection can not be carried over winter off the sheep, and it also makes it highly improbable that the mites or their eggs will live for more than a very few weeks at any time of the year unless upon sheep or some other animal that can serve as food.

DOES DIPPING GIVE THE SHEEP A "SET-BACK?"

Sheep feeders are quite unanimous in the opinion that dipping gives the sheep a set-back. Some think it will take one, others that it will take two or three weeks of feeding to get the sheep back to the weight at the time of dipping. The following weights were made for the purpose of determining the loss occasioned by dipping in these experiments:

Table Showing Loss of Weight Caused by Dipping.

Lot	†Dates of Weighing									Dips Used
	Nov. 17	Nov. 20	Nov. 23	Nov. 25	Nov. 27	Dec. 3	Dec. 5	Dec. 8	Dec. 22	
1	51	50	50	52	50	55	53	56	59	Zenoleum, Nov. 18th.
2	52	50	51	53	51	55	55	55	58	Zenoleum, Nov. 18th and Dec. 1st.
3	52	49	50	53	50	52	48	56	58	Zenoleum, Nov. 18th and Dec. 1st.
4	53	51	51	53	51	54	56	57	59	Potassium Sulphide, Nov. 18th and Dec. 1st.
5	43	44	47	48	46	51	51	53	54	Ft. Collins Lime and Su. Dip, Nov. 18th and Dec. 1st.
6	43	43	47	47	47	48	49	50	53	Chloro-Naptholeum, Nov. 18th only.
7	42	43	46	45	43	46	47	48	50	Cooper Dip, Nov. 18th and Dec. 1st.
8	44	45	47	46	44	48	50	50	52	Black Leaf, Nov. 18th and Dec. 1st.
9	44	45	48	47	44	47	49	49	52	Black Leaf, Nov 18th and Dec. 1st.
10	43	44	47	46	44	46	49	49	51	Black Leaf, Nov. 18th and Dec. 1st.
11	47	47	49	49	47	51	51	52	53	Not dipped.

†These weights were made by F. L. Watrous, of the Agricultural Department.

In the above table, lots 1 and 6 were dipped once, lot 11 was not dipped at all, and all others were dipped twice.

Each lot contained about forty sheep, except lot 11, which had but twenty.

Lots 1, 2, 3, 4 and 11 were all treated alike in feed, and are suitable for comparison. Lot 5, unlike any of the others, was fed on ensilage. Lots 6 to 10 were all fed grain, but differently, so that they are not suitable for comparison to determine loss from dipping. Lots 5 to 10 are included in the table only for the purpose of showing whether or not the dips seemed to have any particular injurious or beneficial effects.

The mid-day temperature for November 18, the first date of dipping, was 33 degrees, and the minimum temperatures for the three nights following were 8.8 degrees, 8.3 degrees and 13.7 degrees respectively.

COMPARISON OF LOTS ONE TO FOUR WITH LOT ELEVEN.

On November 20 the dipped lots averaged just two pounds per sheep less than on the day before dipping, while the check lot in pen 11 just held their own.

On November 23 the dipped lots averaged one and one-half pounds per sheep less than before dipping, while the check lot had made a gain of two pounds per sheep.

On November 25 the dipped sheep had gained three-quarters of a pound each to a gain of two pounds each in lot 11.

On November 27, the last weighing before the second dipping, the dipped sheep averaged three-quarters of a pound less than on the day before dipping, while the undipped lot showed neither gain nor loss.*

This would indicate a loss of three-quarters of a pound per sheep as a result of dipping and as indicated by weighing nine days after.

COMPARISON OF LOTS TWO, THREE AND FOUR WITH LOT ONE.

These four lots were as near alike in every respect as they could be made, including numbers. Lots 2, 3 and 4 were dipped December 1. The mid-day temperature was 38.5 degrees in the shade, and the minimum temperatures for the three nights following were 13.6 degrees, 28.7 degrees and 28 degrees.

On December 3 the dipped lots showed an average gain per sheep, since the last weighing, of three pounds, while lot 1 showed a gain of five pounds per sheep. This would indicate a set-back of two pounds per head as the result of dipping.

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*The sudden fluctuations in weights were due to sudden changes in temperature. On the night of November 25 the temperature went down to 20.3 degrees, and on the night of November 26 it went to 11.3 degrees.

I will omit the weighings of December 5, because of the unaccountable falling-off in lot 3, probably due to an error in weighing.

On December 8 the dipped lots had made an average gain of five and one-third pounds to an average gain of six pounds in the check lot.

On December 22 we find an average gain of seven and two-thirds pounds in the dipped lot against a gain of nine pounds by the checks, indicating a set-back of one and one-third pounds in consequence of the dipping.

It is a question concerning which there might be a difference of opinion as to whether the real set-back is better indicated within a very few days after the dipping, or after two or three weeks. It is my opinion that it is best indicated in a very few days. However we may think in regard to this, the weights given above show two-thirds of a pound as the least set-back and three and one-half pounds as the largest set-back. If the least loss indicated were the real loss, it would indicate a tax of about three cents per head for dipping at the temperatures above indicated. If the sheep are worth four cents, live weight, the heaviest loss, three and one-half pounds per sheep, would mean a loss of fourteen cents for each sheep dipped.

The amount of loss will, of course, depend largely upon the degree of cold, the distance the sheep are driven, and the manner in which they are handled, but I am fully convinced from the above experiments that when the temperature is approximately what it was in the above experiments, the loss of weight from dipping will cost the owner of the sheep fully five cents per head, and this must be added to the expense of dipping to get at the total cost. It is therefore very important that the most effectual dips be used, even though they may cost more, and the dipping should be done at such time and in such manner as to do the least possible injury to the sheep. This applies more particularly, of course, to sheep or lambs that are being fed for the market.

DO DIFFERENT DIPS HAVE DIFFERENT EFFECTS?

Patent dips are often recommended as having some tonic or other beneficial effect upon the sheep, aside from killing scab, which will more than pay for its use, while such dips as lime and sulphur are sure to have some bad effect. A study of the above table does not indicate anything of that kind. It will be noticed that the bunch dipped with lime and sulphur made the largest gain of any. To be sure, this bunch was fed upon ensilage, while the others had dry food, but the rapid gain argues strongly against any specially bad effect of this dip.

The next best gain, ten pounds, was in lot 6, but these were only dipped once. The others that were fed grain, lots 7 to 10, were dipped twice and made a gain of eight pounds each.

GENERAL DIRECTIONS FOR PREVENTING AND CURING SCAB.

A little prevention will often save many dollars of expense and much trouble in dealing with this disease.

If one has sheep that are free from scab, he should not allow sheep that may have the disease to be put with them. Suspicious sheep should be kept in a yard by themselves until it is quite certain that they are free from the infection.

Persons who are purchasing lambs or sheep from a locality where scab is known to be present should not put them at once into the yards where they are to be fed for the market. They should, if possible, be kept out of these yards until dipped, at least once, and it would be better if they could be dipped twice. The experiments to determine how long the mites may live off the sheep prove that they may live at least twenty days. There is no certainty then of eradicating the disease with the best dip, even in two dippings, fourteen days apart if the sheep are put back in the old yards. A single surviving female would be sufficient, if she could find her way back on the sheep, to start the disease afresh.

Where sheep are kept the year around it will be much cheaper to dip soon after shearing when the wool is short, as it will take less material.

If lime and sulphur, or potash and sulphur are used, boil thoroughly before using in order to get a more perfect combination of the ingredients. Also, do not use more than one pound of lime to three or four pounds of sulphur, as it is the excess of lime that does the injury to the wool.

Do not get the idea that the disease may be spontaneous under any possible conditions, for it is not. As well think of horses or jack rabbits coming into existence without parents. Every sheep that contracts scab does so by getting the mites or their eggs directly or indirectly from other animals.

I wish to acknowledge the assistance received from the farm department in carrying on these experiments.

Prof. Cooke has taken much interest in the work, has helped with good suggestions, and by putting at my disposal the dipping vat belonging to the farm department and such of the farm help as was needed in carrying on the work.

A FEW INSECT ENEMIES OF THE ORCHARD.

Clarence P. Gillette, M. S.

SCALE LICE.

Colorado fruit growers may well congratulate themselves that no serious outbreak of scale insects has ever occurred in the orchards of the state, and also, that the San Jose scale has not yet been found in Colorado. But, while congratulating ourselves thus, we must not fail to take care of the few species of scale lice that are known to be present in limited localities and to take every precaution against introducing others from abroad.

HABITS AND APPEARANCE OF SCALE LICE IN GENERAL.

Scale lice are so called because they secrete over themselves, for protection, a thin, horny covering or scale. If one examines these scales in the fall or winter he usually finds them filled with minute eggs. These eggs hatch early in the spring, and the minute, wingless lice that come from them crawl about over the tree for a few days and then insert their beaks into the bark, fruit or leaves and begin to draw the sap and to grow. Once located, the lice of most species never move again. The scale soon begins to form for protection and increases in size with the growth of the louse underneath.

These scales usually imitate the bark of the tree very closely in color, so that they are often unnoticed until the tree is nearly or quite dead. A close observer will notice, however, that the bark of the tree appears rough and scaly, and that the tree lacks vigor.

HOW THE LICE ARE SPREAD.

It may seem strange that so minute a creature without wings, and one that is able to run only for a few days, can distribute itself so rapidly and be so difficult to exterminate.

These insects are scattered for the most part by being carried upon nursery stock or grafts, or even upon fruit, from place to place. They are also carried by winds and are undoubtedly carried long distances in many cases upon the feet of birds.

A FEW SCALE LICE FOUND OR REPORTED IN COLORADO.

THE SAN JOSE SCALE (*Aspidiotus perniciosus*).

This, the most destructive of all the scale lice that infest deciduous fruit trees, has been reported on a few occasions in

Fig. 2.

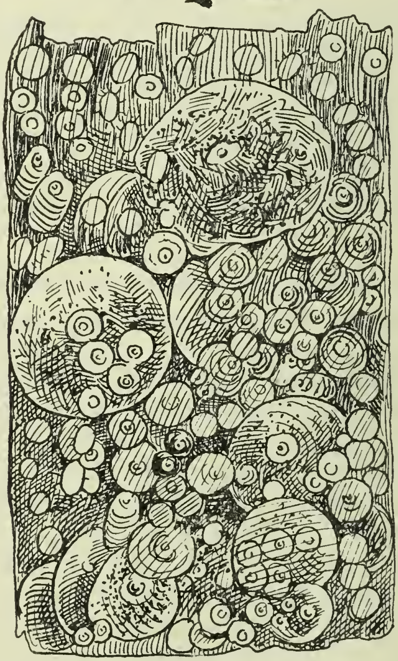

Figure II.—Piece of bark covered with San Jose scale, greatly magnified. (From United States Department of Agriculture, Division of Entomology, copied.)

Colorado, but I wish to assure the readers of this article that none of these reports have been corroborated. The recent reports of this scale in Mesa county were all a mistake, the scale in question being Putnam's scale, which is mentioned below.

After determining this to be Putnam's scale, I sent samples to Prof. Cockerell, of New Mexico, and to Dr. Howard, of the department of agriculture, at Washington, and both assured me that my determination was correct and that the species in question could not be San Jose scale.

This scale has been reported in no less than twenty states and territories, and is scattered from the Atlantic to the Pacific.

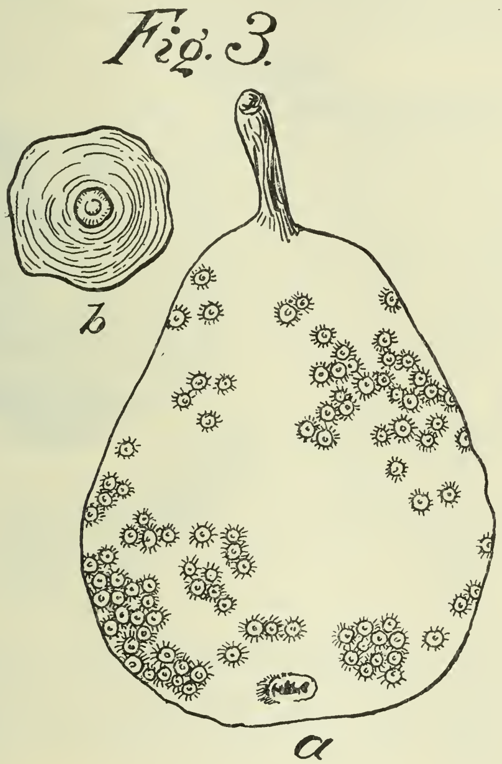

Figure III.—a, Pear infested with San Jose scales, natural size; b, a single scale greatly enlarged, showing the rust-colored spot at the center. (From the United States Department of Agriculture, Division of Entomology, copied.)

Our nearest neighbors reported as having it are New Mexico, Arizona, Idaho, Indiana and California.

The scales attack all parts of the tree above ground—bark, leaf and fruit. They are seldom over one-twenty-fifth of an inch in diameter, but may attain twice this size where there are only scattering individuals. Figure II. shows the appearance of scales and young lice upon bark greatly magnified, and figure III. shows the scales on a pear, where they are represented of natural size.

PUTNAM'S SCALE (*Aspidiotus ancylus*).

This scale resembles the preceding very closely, but can usually be told from it by its darker color and the brighter or deeper rust-colored spots on the center of the scales. These two scales can only be distinguished with certainty by the use of

Fig. 4.

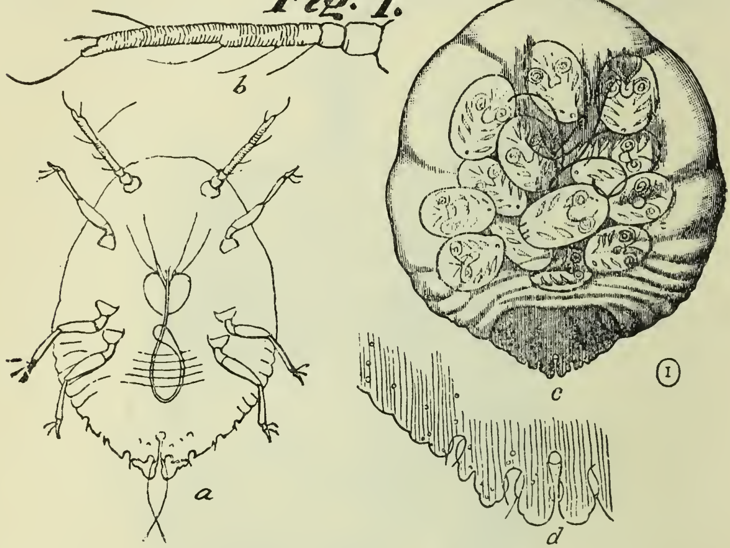

Figure IV.—a, Immature San Jose scale louse removed from the scale and greatly enlarged; b, its antenna, or feeler, still more enlarged; c, gravid female, showing young within her body; d, outline of the anal plate, greatly enlarged. (Copied from bulletin of United States Department of Agriculture, Division of Entomology.)

a compound microscope in the hands of a specialist. It is important, therefore, if either of these scales are suspected, that samples be forwarded at once to the experiment station for determination. So far as I can learn, Putnam's scale has never been a very serious pest in any part of the United States, but there is always a possibility that an insect that has formerly attracted little attention may suddenly become very abundant and injurious when introduced into a new locality. This has been known to be present in a few places in Colorado for several years. I know of one small plum orchard in Cañon City where this scale is very abundant and is probably the cause of several trees dying. Mr. Oyler, of Grand Junction, has sent me twigs from pear and plum trees in Mesa county containing this scale in large numbers. He reports the scale to be scattered over a large territory and in many orchards, but seemingly doing but little harm, except to a single plum tree. Prof. Cockerell, of New Mexico, tells me that this scale is found in that state on oak, box-elder and cottonwood, as well as on various fruit trees. It probably occurs in many orchards in this state where it is not suspected at present.

HOWARD'S SCALE (*Aspidiotus howardi*).

This scale is a comparatively new species and was first discovered by the writer upon native plum trees at Cañon City, Colo. The scales infest both the tender bark of the twigs and the fruit. The scales are of about the same size as those of the two preceding species, but they are almost white in color and lack almost wholly the reddish center. This species seems to have decreased rather than increased since it was first discovered. If it occurs in any abundance it will probably be found conspicuous on the fruit of plum trees.

A SCALE UPON PEACH TREES (*Lecanium persicae*).

I have just recently received from Mr. A. F. Reeves, of Montrose, Colo., peach twigs from his locality infested with a large rust-colored scale about three-sixteenths of an inch long by about one-eighth of an inch broad. The scales are prominent and stand out like little galls on the bark. The scales were very abundant on the twigs sent, and, when received, March 28, the young lice had hatched and were thickly scattered over the twigs. From their size, it seems probable that they hatched last fall. Mr. Reeves reports the scales on about forty trees, so far as he can determine. As the young of this species appear all within a short time, it is probable that this scale can be easily kept in check by the use of a strong kerosene emulsion, or a strong solution of fish-oil soap soon after hatching. It will be comparatively easy to treat them while the foliage is off the trees.

Whale-oil or fish-oil soap, lime, sulphur and salt washes, resin washes and kerosene emulsion are the most common remedies used against the scale insects.

THE BROWN OR CLOVER MITE (*Bryobia pratensis*).

This is one of the worst pests on fruit trees, especially pear, apple, plum and cherry, in the mountainous districts of Colorado.

Its presence in the summer time is best noticed by the pale, sickly appearance of the foliage of the trees, by the whitish, scurvy appearance on the under side of the limbs and about the small crotches of the trees, and by the minute spider-like objects, of a dark color running about upon the bark. On examination, it will be seen that the scurvy appearance of the limbs is due to the cast skins and empty egg shells of the mites.

Although the injury to the trees is chiefly manifested in the bleached foliage, the mites will seldom be found on the leaves.

REMEDIES.

The following are the results of experiments for the destruction of both eggs and mites that were conducted by myself one year ago. During the fall, the mites deposit enormous numbers of reddish eggs upon the limbs of the trees, chiefly about the crotches. The eggs are massed together, and are plainly seen as reddish or rusty patches upon the bark:

A number of small limbs of a pear tree that were almost covered with eggs were procured from Cañon City and set out in moist earth for the experiments. Some of these I took while in Cañon City, and others were sent me by Judge W. B. Felton:

Whale-Oil Soap, in the proportions of one pound to a gallon of water, and in one-half and one-fourth this strength, killed perfectly all the eggs that were treated with it, but in the proportion of one pound to eight gallons it did little good. The newly hatched mites were killed by whale-oil soap in all strengths down to one pound to eight gallons.

Kerosene Emulsion, used without diluting (in which the kerosene was two-thirds of the mixture) and diluted with water to one-half and one-fourth this strength, killed perfectly in every case. When diluted so that the kerosene was one-sixteenth of the mixture (or one-half of the last named strength) a very few of the mites hatched. This last strength did kill, perfectly, mites in all stages when thoroughly treated with it.

Leggett's Potash Lye, in the proportion of one pound to one gallon of water, did very little good in preventing the hatching of the eggs. As near as I could estimate, it killed one-third of the eggs.

Tobacco Decoction, made by steeping one pound of tobacco in three gallons of water, had no perceptible effect upon the eggs, all hatching perfectly.

Sulphur Spray, prepared by combining three pounds of sulphur and two pounds of caustic soda and diluting to 200 gallons in water, was also used against the eggs, but without effect.

The whale-oil soap and the kerosene emulsion, being entirely efficient, one or the other should be used against this pest. As it is much easier and cheaper to make the application during the winter season, while the foliage is off the trees, this is the season that should be chosen to destroy the brown mites.

THE CODLING MOTH, OR APPLE WORM (*Carpocapsa pomonella*).

This pest causes heavier annual loss to the apple crop than any other insect. It is found in nearly every part of the world where apples are grown. In the orchards of Delta county, Colorado, it was for a number of years unknown. It is now present in all the orchard regions of the state, unless it be in some very limited and isolated places. It is not a pest that we can hope to exterminate, and orchardists can not afford to let it go unchecked.

Life Habits of the Insect—There are two, and perhaps a partial third, brood of this insect in Colorado each year. The moths of the first brood begin to appear early in the spring, and are ready to deposit their eggs in the blossom ends of the small apples as soon as the blossoms fall. The moths do not all appear at once, so that the eggs of the first brood are distributed through several weeks. If the weather is warm, the eggs will hatch in about four or five days, and the young larvæ will begin to eat in the blossom end of the apple and to burrow their way to the core, about which they feed until mature. When mature, the larvæ or worms eat a large hole to the outside, and escape to go in search of a suitable place to spin a silken cocoon and change to a chrysalis, and, a little later, to come forth as moths. This second brood of moths begins to appear about the first week in July, and in a few days, like the first brood, fly to apples or other suitable fruit to deposit their eggs. This time the eggs are often laid in the stem end of the apple or upon any rough spot where they will readily adhere. The habits of this brood are like those of the first. The later individuals do not leave the apples until they have been barreled or put in winter quarters. The winter is spent in the worm state in some protected spot, as between barrel staves, under barrel hoops, under scales of bark on apple trees, etc. Early in the spring these worms change to chrysalids, and a little later appear as moths.

REMEDIES.

On account of the habit of the larva in feeding for a little time in the blossom of the apple before burrowing to the core, it has been found that a thorough spraying with London purple or Paris green at the correct time will destroy about 70 per cent. of them.

The proper time for spraying is immediately after the blossoms fall and *never before.* To spray before the blossoms fall is not only waste of time and material, but will also be liable to poison honey bees that visit the flowers for honey and pollen. If the spraying is much delayed, many of the worms will have already eaten their way into the fruit and be out of the reach of the poison. A second application should be made in a week or ten days after the first. If heavy rains fall, it is well to make the second application as soon as possible afterward. Should there be much rain-fall following the first or second treatment within a few days, it would pay to make a third treatment, but otherwise not. Care should be taken to throw the spray so that it will strike the blossom ends of the apples, and the treatment should be thorough. It is best to stop as soon as the leaves begin to drip.

In the eastern states, it is usually recommended to make the application in the proportion of one pound of poison to 200 gallons of water. In the dry atmosphere of Colorado I have found it very safe to apply in the proportion of one pound to 160 gallons the first time. The weaker mixture will do for the second or third applications.

A great many worms may be caught and destroyed by tying bandages of burlap or other cheap cloth about the trunks of the trees, and removing these once in a week or ten days to kill the worms that collect beneath them. This work should begin about the last week in June, and be continued until fall.

Where apples are kept in cellars, the windows and doors should have screens to prevent the escape of the moths that hatch in the cellars. Care should be taken not to take fruit barrels or boxes from storehouses or fruit dealers to the farm unless they have been thoroughly disinfected, as they often contain the larvæ of the codling moth in great numbers.

THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 39.

A STUDY OF ALFALFA AND SOME OTHER HAYS.

Approved by the Station Council,
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

SEPTEMBER, 1897.

Bulletins will be sent to all residents of Colorado, interested in any branch of Agriculture, free of charge. Non-residents, upon application, can secure copies not needed for distribution within the State. The editors of newspapers to whom the Station publications are sent are respectfully requested to make mention of the same in their columns. Address all communications to the

DIRECTOR OF THE EXPERIMENT STATION,
Fort Collins, Colorado.

EXPRESS, FORT COLLINS

THE AGRICULTURAL EXPERIMENT STATION,

FORT COLLINS, COLORADO.

A STUDY OF ALFALFA AND SOME OTHER HAYS.

Wm. P. HEADDEN, A.M., Ph.D.

The following pages are not intended as a continuation of Bulletin No. 35, although in a certain sense they form a part of that study. The work done on Bulletin No. 35, was undertaken with the view of examining the changes produced in the soil by continuous cropping to alfalfa, and, as published, claims to be a record of the work done on the plant—a study preliminary to that of the soil proper. We have been compelled, so far, to content ourselves with that work as published. There arose some questions in connection with that study which could not be discussed at the time, because our observations had not been extended enough, and we could not draw upon the results of observations still to be made. We shall, therefore, be compelled to connect portions of this bulletin rather closely with portions of Bulletin No. 35. The object of this bulletin, however, is to present a study of hays, more especially, hays made from leguminous plants—alfalfa, clover, and pease—though we shall discuss other hays to some extent.

We have attempted in this study to go beyond the routine methods of such investigations and to contribute to a better interpretation of the data obtained by the old methods in terms of much narrower and more definitely studied groups whose chemical composition, at least, if not their feeding value, is either already better known or susceptible of determination. In regard to their feeding value, too, we gain a more rational basis for evaluation than has been possible under our old methods and conventionalities.

There are many things in this bulletin which are only tentative, but they are the best results which we have obtained, and we give them as such without any apology except that we regret that our investigations have not been pushed so far as we have desired to push them.

I have no doubt but that some intelligent critic, with strongly utilitarian proclivities, will ask what value such work may be to the farmer; and possibly add, to any one else? There may also be a goodly number, other than the farmers and critics, who have but little sympathy with the class of effort recorded in these pages. I am aware that cattle will feed upon hay just as in the past and that the feeders will probably pay little heed to questions of composition as given in the fuller analyses; possibly but little more than the average man does to the same questions expressed in the terms of the analyses now in vogue. In spite of this, there is a satisfaction in finding out, with some degree of definiteness, what we mean by the old terms, such as nitrogen-free extract, crude fiber, etc. These have been useful terms, very convenient ones, under which to include much that we did not know about a fodder. If this line of work has no other commendation, it is an attempt to find out how much we do not know, and to which we have made no pretense of knowledge, and also some of our misconceptions.

In the closing paragraphs of Bulletin No. 35, I called attention to the variations in the composition of alfalfa hay grown in different localities, and the analyses given cover a period of about ten years—1886-1896. It would seem that the analyses recorded in this period ought to represent with a fair degree of accuracy the composition of the plant as grown in this country; but there is such a wide range in its composition that the suggestion is near at hand that the variation in composition is due to climatic conditions, and not to differences in the soils. We have extended our observations to observe these effects, and not simply to increase the number of analyses of alfalfa, which seems to us altogether useless.

It is true that there are variations in the climate of a locality from year to year; still the climatic conditions of a given locality are, in the main, quite constant in their general character, and we reduce the climatic effects to this minimum by making observations upon the plant grown in the same locality, and, contrariwise, we gain information on this very point by taking our samples from the same plot of ground.

Our samples of alfalfa hay showed, in comparison with samples from other states, a great uniformity in composition. The crude protein in the first cutting hay had a range of less than two per cent.—from 14 to 15.9 per cent. These samples represented hay made from alfalfa grown with and also without irrigation; also such as had been grown upon high land as well as that which had been grown upon low land. The crude fiber in these samples had a very much greater range in percentage—from 32 to 40 per cent.—than the crude proteids. This may have been partly due to a less degree of sharpness in the method of determination, but we judge it to be due to an actual difference in the samples. These are narrow limits when compared with those shown by analyses representing different states, in which we have, for the crude protein, a range of 14.6 per cent.—from 11.1 to 25.7 per cent.; and for the crude fiber, a range of 24.5 per cent., or from 15.4 to 39.97 per cent.

In the second cutting again we find a narrow range, but wider than in the first cutting. The extreme range for the crude protein is 5.6 per cent., and, excluding an exceptional sample with 18.47 per cent., this range becomes 3.5 per cent. The crude fiber for this cutting has a range of about 12 per cent.—from 26.16 to 38.08 per cent.

The range for the proteids in the third cutting is 3.5 per cent., and for the crude fiber, 10 per cent. These samples were all of hay as put into the mow or stack.

A study of the analyses published up to 1896, fails to furnish any general composition for this fodder, and we cannot discern any patent and adequate reason for this. In the New Jersey Experiment Station Report, for 1886, the lowest amount given for crude protein was 16 per cent., and the highest for crude fiber was 35 per cent.; as given in the Report for 1888, eight samples are recorded; the lowest of these in proteids has 15.24 per cent., and the highest in crude fiber has only 24.34 per cent. The same observations are true of the Texas samples, except that we find a greater difference between the highest and lowest in the case of both of these constituents; for the proteids, from 15.31 to 25.75 per cent., and for the crude fiber, from 16.64 to 34.23 per cent. If we take the published analyses of Colorado samples we shall find a like variation.

Even the most unfriendly critic of the methods or the operators using them, cannot possibly explain these differences by the weaknesses of either or both of these. In order to obtain light upon this point, we have studied the three cuttings of 1894, the first cutting of 1895, and the three cuttings of 1896. The methods employed in the analyses and the operators during the period of these experiments were the same, so the results are comparable, and are free from divers personal equations. There is, it is evident, much even in these results which would be more satisfactory if more uniform; still they show that this fodder, as grown in this State, has a pretty uniform value. The season of 1896 was not a very favorable one, and we judge that we have as great a variation, due to seasonal differences, as we have reason to expect. The samples for 1896 were all taken from the same piece of land with one exception, and this one differs so slightly from the others in composition that it is fortunate, rather than otherwise, that it was obtained from another locality.

Some of the samples of previous years were taken from nearly the same ground as those of 1896, so that they also have value indicative of how much alfalfa hay cut from the same land may vary in chemical qualities from year to year.

Three samples of each cutting were taken, representing different stages of maturity, regard being had to their respective influences upon the quality of hay produced.

The results of the analyses are as follows:

Cutting.	Condition of the Plants.	Air Dried Hay.							Thoroughly Dried Hay.					
		Moisture.	Ash.	Ether Extract.	Crude Protein.	Crude Fiber.	Nitrogen-Free Extract.	Total Nitrogen.	Ash.	Ether Extract.	Crude Protein.	Crude Fiber.	Nitrogen-Free Extract.	Total Nitrogen.
1	Coming in bloom.	7.22	9.81	1.15	15.16	36.49	30.17	2.426	10.57	1.24	16.47	39.43	32.29	2.624
1	In half bloom	7.92	11.89	1.26	14.46	32.80	31.67	2.310	12.92	1.36	15.70	35.62	34.41	2.508
1	In full bioom....	6.38	10.57	1.31	15 73	34.91	31.11	2.516	11.29	1.40	16.80	37.29	33.23	2.687
	Average..	**7.17**	**10.76**	**1.24**	**15.12**	**34.73**	**30.98**	**2.417**	**11.44**	**1.33**	**16.32**	**37.44**	**33.31**	**2.606**
2	Coming in bloom.	4.43	12.70	1.71	17.68	27.47	36.01	2.858	13.28	1.78	18.50	28.75	37.69	2.990
2	In half bloom....	9.48	11.34	1.50	17.14	24.27	36.27	2.743	12.53	1.65	18.94	26.81	40.08	3.032
2	In full bloom....	8.56	9.91	1.78	16.41	27.11	36.24	2.625	10.84	1.95	17.94	29.64	39.64	2.880
	Average..	**7.49**	**11.32**	**1 66**	**17.08**	**26.28**	**36 17**	**2.742**	**12.22**	**1.79**	**18.46**	**28.38**	**39.13**	**2.967**
3	Coming in bloom.	8.64	12.24	1.72	16.53	24.30	36.57	2.645	13.39	1.88	18.09	26.59	40.04	2.894
3	In half bloom....	7.43	11.07	1.52	15.51	30.55	33.92	2.482	11,96	1.64	16.76	33.00	36.65	2.681
3	In full bloom	8.36	10.66	1.83	15.59	30.18	33.38	2.495	11.63	2.00	17.01	32.94	36.42	2.722
	Average..	**8.14**	**11.32**	**1.69**	**15.88**	**28.34**	**34.62**	**2.540**	**12.33**	**1.84**	**17.29**	**30.84**	**37.70**	**2.766**

The analyses of the first cutting agree with those of preceding years, but the series representing the second cutting is not concordant with previously obtained results. The most marked deviations are in the higher amounts of crude protein and in the lower percentages of crude fiber. The third cutting is far more representative of the plants than the samples of the previous years, because this set of samples of the third cutting is complete in itself. The samples, too, represent the whole plant, without loss of leaves and stems, cut in the very best condition. The third cutting of 1894, the only previous year in which samples of this cutting were analyzed, was represented by samples of hay as it was taken from the field.

There is, in the 1896 samples, a superiority in quality over the samples of 1894. This is most marked in the third cutting, but, as has just been stated, a portion of this difference may be attributed to the fact that the samples were more nearly comparable to those of the other cuttings. The crude protein is higher for each of the three cuttings and the crude fiber is lower, while the nitrogen-free extract is slightly higher, though not so much so as one, at first glance, would think.

The season of 1894 was favorable for the making of heavy crops. The first cutting was very heavy, the stems were exceptionally stout, and the growing period was long. These conditions were reversed in 1896, and I am inclined to attribute the differences observed almost wholly to this cause. The second crop of 1896 grew quickly and resembles in composition samples of the first cutting, cut on May 5th, 1895, rather than the other second cutting samples. Both samples matured rapidly; they were both high in ash, high in crude protein, and low in crude fiber. The first cutting of 1895 (May 5th), is even higher in protein than the second cutting of 1896, and quite as low in crude fiber. This seems to me to indicate that the rate of maturing which, of course, depends upon the seasonal influences, determines, very largely, the composition of the hay produced. It is quite evident that a quickly maturing crop will probably be less in quantity than a more slowly maturing one of the same kind. In 1894 we collected samples from a variety of soils to see whether any differences in the quality of the hay were to be attributed to this cause. The results are in favor of an affirmative answer, but in no very marked degree. I speak of soils which have received no fertilizers. It is a demonstrated fact that these have an effect upon the quality of the hay, and I have elsewhere noted the susceptibility of the alfalfa plant to the direct application of manures. A fertilized soil, or one naturally rich, which, under ordinary conditions, is equivalent to a vigorous growth extended over a longer period, tends to increase the percentages of ash, protein, and crude fiber. In the second cutting of 1896, the ash and protein are high, but the crude fiber is low and the crop was light.

The conditions obtaining later in the season of 1896, were more nearly normal for our locality and the third cutting grew for a longer period, matured more slowly, and, while the proteids are high, we have an increase of about six per cent. in the crude fiber of the later sample. There is no such increase in the other series for this or for preceding years. While there is in general an increase in the percentage of woody fiber, with the development of the plant, we have found it neither so great nor so regular as is shown in Bulletin No. 8, of this station, and also by others. We speak of the plant during the period in which it is fit for making hay. In this instance, however, we have a decided increase which, I believe, is fully accounted for by the explanation offered, i. e., the season conditions which determine the rate at which the plant matures. If this view be correct, it follows that the same piece of ground will produce hays of different qualities in different years even when we take hays of the same cutting, and the total of these seasonal influences is correctly indicated by the differences in the composition of the respective samples. This influence seems to be large enough to determine the relative desirableness of the different cuttings which, under ordinary conditions, stand pretty close together. In speaking of the crop of 1894, we state that the first and second cuttings are about equal in value, so far as the proteids are concerned, and subsequently we call attention to the fact that, if we reject an entirely green sample because of its immaturity, the results are then in favor of the second cutting. The seasonal effects do not have to be very great to determine which of the cuttings shall have the more desirable composition.

The following table, presenting the averages for the respective cuttings for the years 1894, 1895, and 1896, will serve to make these differences plain and show that for a given district there is a comparative constancy in the composition of this fodder.

These averages, to which is appended averages for the usual three cuttings, taken from Bulletin No. 48 of the Utah Agricultural Experiment Station, which I have recalculated to a common water content of 7.5 per cent., instead of 12 per cent., to facilitate their comparison with our Colorado samples, are as follows:

Cutting.	Year Collected.	Source of Sample.	Number of Samples.	Moisture.	Ash.	Ether Extract.	Crude Protein.	Crude Fiber.	Nitrogen-free Extract.
1	1894	Laboratory samples..............	9	6.21	10.03	1.55	14.85	36.28	31.08
1	1894	Farm department................	3	7.59	11.19	*3.59	14.92	28.10	34.61
1	1895	Laboratory samples	4	6.49	10.61	1.50	15.13	34.03	32.24
1	1896	Laboratory samples..............	3	7.17	10.76	1.57	15.12	34.73	30.65
1	1896(?)	Utah †..........................	3	7.50	9.78	2.59	14.29	28.41	37.43
		Average	22	6.99	10.47	1.80	14.86	32.31	33.57
2	1894	Laboratory samples	5	5.94	10.24	1.41	14.43	34.15	33.73
2	1894	Farm department................	3	8.05	10.48	1.53	13.99	31.97	33.98
2	1896	Laboratory samples..............	3	7.49	11.32	1.66	17.08	26.28	35.25
2	1896(?)	Utah............	3	7.50	8.78	2.13	15.23	31.18	35.28
		Average	14	7.24	10.21	1.68	15.18	30.90	34 79
3	1894	Laboratory samples..............	2	5.93	9.83	1.46	13.01	37.01	32.74
3	1894	Farm department................	3	5.63	10.07	1.43	13.47	33.70	35.70
3	1896	Laboratory samples....	3	8.14	11.32	1.69	15.88	28.34	34.62
3	1896(?)	Utah............................	3	7.50	8.58	1.73	11.95	32.79	37.45
		Average	11	6.80	9.95	1.58	13.81	32.98	34.90

* Not included in the average.
† Taken from Bulletin No. 48, Utah Expt. Sta., and recalculated to a basis of 7.5 per cent. moisture.

We see from the preceding table that, for the first cutting, representing three years and four soils, the composition is practically constant, the greatest variation being in the percentage of crude fiber. This difference, however, is no greater than may be found in different samples collected from the same field on the same date. The results for the second cuttings are not so uniform, and I think that we have here exhibited the maximum variation, which may reasonably be attributed to differences in the seasons, amounting to three per cent. for the protein, and eight per cent. for the crude fiber.

The averages for the third cuttings show the same irregularities that are observed in the second cuttings. My samples for the season for 1896 are consonant with the general results in showing the second cutting to be, in point of composition, the preferable one. While these samples are the farthest removed from the general averages, they differ from these less than samples of the same cutting in any year may differ from one another. I am convinced that the variation in the different cuttings from year to year is dependent mostly upon the seasons, and is in no case very large, very much smaller in fact, than I had supposed.

CHANGES IN COMPOSITION OF OLD HAY.

That fresh hay, i. e., hay which has been in the mow or stack from one to nine months, is preferable to hay which has been there for a longer time, is generally conceded, whether there is any good ground for the general belief or not. The samples which we have used to study this question were prepared for analysis, put in glass bottles, and from one to two years allowed to elapse between the two determinations. These samples were stored in a dark cupboard in a dry room which was as close an imitation of the conditions prevailing in a mow as we could produce. The samples were air dried when put away, but they evidently changed in the amount of moisture present, as it was found necessary to redetermine the moisture in all of the samples. I expected that the crude protein would be most susceptible to changes, and therefore determined upon making a series of nitrogen determinations from which to judge of the amount of deterioration. We found that we were wholly wrong in our idea that the nitrogen would be the most sensitive measure of any changes, at least for the conditions under which our samples were preserved. It may be noticed here that every sample had increased in the amount of moisture contained; only one remained unchanged and this was the only sample which showed a diminution in the amount of nitrogen present. The changes, with this one exception, were all in the same direction—to an increase in the percentage of nitrogen. We examined seventeen samples and found but one exception to this rule. The bottles containing these samples were stoppered and sealed with paraffin, so it would seem very improbable that the whole seventeen should fail to keep out the atmospheric moisture. We give the moisture determinations to show how marked this increase was and how general the rule, there being only one pronounced exception to it. The first column contains the figures representing the hay in 1894, and the second in 1896.

	1894. Per cent.	1896. Per cent.
1	4.49	8.68
2	4.17	8.12
3	7.86	7.81
4	6.29	8.84
5	6.30	8.54
6	5.29	6.91
7	4.70	7.27
8	4.31	6.68
9	4.40	7.61
10	6.61	7.17
11	5.81	7.94
12	6.06	6.52
13	8.87	8.26
14	7.14	8.17
15	7.46	8.72
16	3.77	4.41
17	7.60	8.62

If this increase of moisture had not been accompanied by an increase in the percentage of nitrogen in the dry matter, I would have attributed it, in spite of the fact that the bottles were sealed, to the absorption of moisture.

NITROGEN IN NEW AND OLD HAY.

	1894. Per cent.	1896. Per cent.
1	2.422	2.989
2	2.604	2.878
3	2.740	2.132
4	2.459	2.514
5	2.181	2.770
6	2.205	2.382
7	2.037	2.500
8	2.149	2.627
9	3.013	3.037
10	2.572	2.657
11	2.005	2.912
12	2.401	3.051
13	2.366	2.588
14	2.047	2.426
15	2.522	2.702
16	2.562	2.680
17	2.638	2.657

In the above table the percentages are calculated on the dry material. The two series, of course, represent the same samples. There is no regularity in the amount of the increase in case of either the water or the nitrogen. This study is not sufficiently extended to justify fuller discussion, but a study of my notes indicates that the samples cut in early bloom have suffered the least change; also that the change is less in one year than in two years. The last three samples were only one year old at the time the analyses were made.

The increase in the percentage of water in the sample and the increased percentage of nitrogen in the dry matter seem to me to point to a transformation in the constituents included under the term nitrogen-free extract. It is certainly beyond question that the nitrogen cannot be increased by absorption, and it is improbable that the material which we class as crude fiber will break down rapidly enough to account for the formation of so much water, in some instances four per cent., especially when we remember its ability to resist the action of dilute acids and alkalies.

Our experiments indicate that there is no loss of the proteids, but that chemical changes take place to a considerable extent in some of the other constituents, probably in those complex and less stable compounds grouped under the head of nitrogen-free extract and frequently spoken of as carbohydrates. The apparent increase of nitrogen is easily accounted for by the elimination of water and probably of other compounds also, as oxides or hydrides of carbon.

We have in the above explanation of our facts, I think, a full and satisfactory explanation of such facts as have been observed relative to the saving of hay, for instance, by putting it in a mow, in which case the loss of weight is much less than when the hay is kept in the stack. Our application of the observed facts would be, that, other things being equal, hay preserved in the stack is more freely exposed to influences which promote these changes in the less stable constituents of the hay; and the loss due to these changes becomes noticeable.

I understand that it is found almost impossible, in practice, to feed out anywhere near the amount of hay for a ton put in a stack, that is usual to feed out when the same weight is put into a mow. It is evident that some hays may age very much faster than others, due to kind of hay—alfalfa, clover, timothy, etc.—also due to development at time of cutting, manner of storing, and other conditions.

There is, perhaps, a suggestion in the figures representing the percentages of water found in 1896, that the samples in 1894 did not really represent air dried hay and that in the course of the intervening year and a half, or more, they had really become such. This receives support from those samples prepared in 1896, which have about the same percentage of water. But this compels us to assert that the sealing of the bottles was of no avail at all and disregards the increase in the percentage of nitrogen in the dry matter, which seems to us fully established. The differences cannot be attributed to the different methods of determination, nor yet to the operator, as the same person, my assistant, Mr. Ryan, made the two series of determinations by the same method and always in duplicate.

While this subject may be more interesting to the investigator in the domain of agricultural science than to the practical agriculturist, we regret having been unable to pursue it to no greater extent.

ARTIFICIAL DIGESTION OF ALFALFA HAY.

It is not our purpose to discuss the relative merits of artificial compared with animal digestion, but if we confine ourselves to the question of the pepsin digestion of the albuminoids, it is certainly more agreeable, more satisfactory in that it can readily be applied to a much larger range of samples in a short time, and has the further advantage that the different samples can be subjected to the same conditions. The commercial pepsin preparations may vary in quality very greatly, but the pepsin can be tested before it is used quite as easily as any other chemical reagent.

We undertook the investigation to discover whether there is any difference in the digestibility of the three cuttings of alfalfa hay or in alfalfa hay of different ages. The samples employed in this work were new hay, one-year-old hay, and two-year-old hay. These terms, new hay, one-year-old hay, and two-year-old hay, are to be understood in their ordinary sense, and not that a sample of alfalfa was made into hay and its digestibility determined forthwith, for such was not the case. The samples were taken in the years of 1894, 1895, and 1896, and the determinations were made in the last year.

THE METHOD.

We followed the method in general use—digestion with a dilute hydric chlorid solution of pepsin. After an extended series of experiments with coagulated egg albumen, we adopted the following method as giving the best results. We dissolved five grams of scale pepsin in one litre of two-tenths per cent. hydric chlorid and to five grams of alfalfa, ground as fine as possible, we added 150 cc. of the pepsin solution, and digested it for eight hours at forty degrees C., adding, during the eight hours, .7 grams of hydric chlorid.

After the digestion was completed, the alfalfa remaining was filtered off, washed free from chlorid, and the residual nitrogen determined by Kjeldahl's method.

The period of eight hours was decided upon, because we found in experimenting with the egg albumen that we obtained a complete solution in this time and seldom in a shorter period, and if we allowed it to stand longer a precipitate began to form which was not very readily gotten into solution again. This method contains an error in that it shows any soluble amids which may not be assimilated by the animal as digestible. As the amount of amids is quite large in some of the samples, this may give rise to comparatively large errors. This error is not wholly eliminated in the case of animal digestion. The amount of amids had been previously determined in the samples of 1894 and 1895. They amounted to 10.85 per cent., for the first cutting, 19.93 per cent., for the second cutting, and 5.03 per cent. (one sample only) for the third cutting. The amids were not determined in the samples for 1896. The co-efficients of digestion obtained do not show any variation corresponding with the amids found. The sample of second cutting in half bloom shows a lower digestion co-efficient than the one following it in full bloom, and still lower than the one preceding it in half bloom, and yet it contains amid nitrogen corresponding to 29.47 per cent. of its crude protein. The others contained much less nitrogen in this form, the amount corresponding to 18.84 per cent., and 17.82 per cent. of the crude protein in the respective samples.

The co-efficients of digestion for the proteids in alfalfa, as determined by animal digestion, are as follows:

In green alfalfa, 78-83; mean of six trials, 81.

Carefully dried alfalfa, 70-83; mean of six trials, 80.

Alfalfa hay, early bloom, best quality, 71-83; mean of twenty-six trials, 76.

Alfalfa hay, full bloom, 66-73; mean of ten trials, 68.

Alfalfa hay, carefully dried, 78; mean of two trials, 78.

Alfalfa hay as given in Colorado Bulletin No. 8, 77.

Alfalfa hay as given by N. Y. Exp. Sta., 69.

Considering these seven averages, we observe that five of them fall between 76 and 81 per cent.

The only statements that I recall to have seen concerning the relative efficiency of animal and pepsin digestion is to the effect that the pepsin is rather higher, usually dissolving from 2 to 6 per cent. more of the crude protein than is taken up by the animal. If we take the average of the five most nearly agreeing means, given above, we obtain 78.4

for the co-efficient of digestibility for crude protein in alfalfa hay, or 75.6, if we include all the means given. It seems probable that the five closely agreeing ones are nearer to the truth than the two whose average is ten per cent. below the average of the five, and I take it that the 75.6 is a less representative co-efficient than the 78.4.

We record in the following table the results obtained by pepsin, or artificial digestion, of the first, second, and third cuttings of the year 1894; the first cutting of 1895, and the three cuttings of 1896.

ARTIFICIAL DIGESTION OF PROTEIDS IN ALFALFA HAY.

Number.	Number of Cutting.	Condition at Time of Cutting.	Total Nitrogen.	Nitrogen not Digested.	Nitrogen Digested.	Co-efficient of Digestion.
		Samples gathered in 1894—				
1	1	Plants not in bloom	2.878	0.574	2.304	80.07
2	1	Plants not in bloom	2.132	0.420	1.712	80.30
3	1	Plants in half bloom	2.514	0.520	1.994	79.30
4	1	Plants in full bloom	2.989	0.590	2.399	80.26
5	1	Plants in full bloom	2.770	0.522	2.248	81.15
6	1	Plants in early seed	3.051	0.643	2.408	78.92
7	1	Plants in full seed	2.500	0.595	1.905	76.02
8	2	Plants coming in bloom	3.037	0.522	2.515	82.81
9	2	Plants in half bloom	2.657	0.542	2.115	79.60
10	2	Plants in full bloom	2.627	0.502	2.125	80.89
11	2	Plants in full bloom	2.382	0.495	1.887	79.18
12	3	Hay, College farm	2.912	0.514	2.398	82.69
		Samples gathered in 1895—				
13	1	Plants in full bloom	2.588	0.499	2.089	80.72
14	1	Plants in full bloom	2.702	0.508	2.194	81.20
15	1	Plants in full bloom	2.680	0.510	2.170	80.97
16	1	Plants in full bloom	2.657	0.540	2.117	79.68
		Samples gathered in 1896—				
17	1	Plants coming in bloom	2.624	0.580	2.044	77.89
18	1	Plants in half bloom	2.514	0.512	2.002	79.60
19	1	Plants in full bloom	2.687	0.498	2.189	81.69
20	2	Plants coming in bloom	2.990	0.664	2.326	77.79
21	2	Plants in half bloom	3.032	0.664	2.368	78.10
22	2	Plants in full bloom	2.870	0.559	2.311	80.87
23	3	Plants coming in bloom	2.894	0.635	2.259	78.06
24	3	Plants in half bloom	2.681	0.567	2.114	78.85
25	3	Plants in full bloom	2.722	0.596	2.126	78.15

It is observable throughout the series that the samples in full bloom have a slightly higher co-efficient than the other cuttings with only one exception, which is in favor of a very early cutting. The third cutting hay (No. 12) is not an exception, as the plants were near or at full bloom when cut.

We have already given the average co-efficient of alfalfa hay of all kinds, determined by animal digestion, as 78.4. The highest and lowest individual results in the experiments which we have accepted as most representative are far apart, ranging from 70 to 83, a maximum difference of 13 per cent. of the proteids. The maximum difference in our series, debarring No. 7, because it was too ripe for hay, is five per cent. of the proteids, or, including all samples, it is approximately ten per cent. of the proteids. The co-efficients given by cuttings are as follows: For 1894, first cutting, 79.43; second cutting, 80.62; third cutting, 82.69; for 1895, first cutting, 80.64; for 1896, first cutting, 80.14; second cutting, 78.81; third cutting, 78.85. The average for all the cuttings, made in the three years, is 79.79, which is in excellent agreement with the results obtained by animal digestion.

The results taken by years are as follows: For 1894, hay two years old, 80.91; for 1895, hay one year old, 80.64; for 1896, new hay, 79.27, from which it is clearly apparent that the proteids have not lost any of their digestibility, and from this standpoint hay which is one or even two years old, is quite as good as new hay. The nitrogen determinations given on page 11 show a relative increase of nitrogen, so that whatever changes take place in hay in the mow, during the course of one or two years, they do not cause any deterioration in either the amount or digestibility of the proteids. The importance of this will be more apparent to the average feeder when he considers that the proteids make up between 1-7 and 1-6 of the total weight of the hay, and that in value it is equal to over one-third of the hay. This is based upon two and three-tenths cents per pound for proteids, one and fourteen-hundreths cents per pound for fats, and ninety-four hundreths cent per pound for crude fiber and nitrogen-free extract. (Conn. Exp. Sta., 1893.)

PENTOSANS.

It has been customary until very recently, and is still the general practice, to divide the food elements of plants into the four groups, fats, crude fiber, nitrogen-free extract, and crude protein. We have known how to divide the protein into two classes of nitrogen compounds, which are probably of very unequal value as food constituents, and, while we have been accustomed to speak of nitrogen-free extract, as though it had some definite individual character, we have done so with the understanding that it included gums, starch, sugar, etc., etc., and the same has been the case with the term crude fiber. We know that it contains cellulose and other allied compounds which differ from one another in composition, and probably to even a greater extent in their physiological value. Several of these compounds give, under similar treatment, a characteristic product which becomes the measure of the amount of them present. While it is exceedingly improbable that there is in the hays, to be mentioned later, only one furfurol-yielding complex, I have, for the sake of greater simplicity, calculated the results obtained in terms of xylan, as this is probably the predominating group yielding the furfurol. These substances are given in the present prevailing method of stating fodder analyses, partly as crude fiber and partly as nitrogen-free extract. The former, according to our results, contains from one-half to three-fourths of them and the latter the rest. We frequently speak of the nitrogen-free extract as almost equivalent to carbohydrates soluble in water; this custom has the merit of easy expression and convenience. It is not our province to determine the relation of these constituents to the economy of the plant, and it does not effect our object in the least to determine this, but simply to determine the quantity of them present. It seems highly probable that, as they are more reactive than the celluloses proper, they play a more important part in the nutrition of animals than these, but are inferior to the carbohydrates proper.

We have followed in our furfurol determinations the method as laid down by the Association of Official Agricultural Chemists, except that we dissolved the hydrazone in ether alcohol.

The samples of alfalfa hay used in these determinations were the same samples of which fodder analyses have been given in Bulletin No. 35 and in the early part of this bulletin. The results in the following table are calculated on dry matter. The crude fiber found in these samples is also given.

XYLAN IN ALFALFA HAY.

No.	Cutting.	Condition of Plants.	Xylan.	Crude Fiber.
		Samples gathered in 1894—		
1	1	Plants not in bloom	9.44	37.04
2	1	Plants in full bloom	9.86	38.50
3	1	Plants in full bloom	10.94	42.77
4	1	Plants in early seed	13.77	40.13
5	1	Plants in full seed	14.42	48.38
6	2	Plants coming in bloom	14.03	34.13
7	2	Plants in half bloom	12.43	39.19
8	2	Plants in half bloom	14.50	39.88
9	2	Plants in full bloom	12.48	39.64
10	3	Hay, from College farm	10.54	39.36
11	3	Hay, from Rocky Ford	12.34	34.27
		Samples gathered in 1896—		
12	1	Plants coming in bloom	14.24	39.43
13	1	Plants in half bloom	11.09	35.61
14	1	Plants in full bloom	9.12	37.29
15	2	Plants coming in bloom	8.88	28.75
16	2	Plants in half bloom	9.10	26.81
17	2	Plants in full bloom	11.01	29.64
18	3	Plants coming in bloom	10.11	26.59
19	3	Plants in half bloom	11.76	33.00
20	3	Plants in full bloom	12.91	32.94
		Parts of Plants—		
21	3	Leaves	9.29	13.00
22	3	Upper part of stems	13.32	....
23	3	Lower part of stems	11.25	....
		Crude Fiber—		
24	3	From the leaves	12.73	....
25	3	From the upper part of the stems	13.46	....
26	3	From the lower part of the stems	15.41	33.07

The percentage of crude fiber is given in the first twenty analyses to show that there is no constant relation between it and the xylan in the whole hay. This becomes more apparent when we examine the results of 24, 25, and 26. If we calculate the xylan found in 24, to percentage of the total xylan in the original sample, assuming thirteen per cent., as the average for crude fiber in leaves, we find it corresponding to 17.69 per cent. And in like manner for 25 and 26, assuming 33.07 per cent., as the percentage of crude fiber in the stems, we find the xylan in 25 corresponding to 33.33 per cent. of the xylan in their original sample, and in 26 it amounts to 45.29 per cent. The method of preparation of the crude fiber was not the same in each case and these samples are not strictly comparable as far as the method affects the question.

If we express these results in the more direct manner of stating the percentage of the total xylan removed by the successive digestions with sulphuric acid and caustic soda, we find that in the case of the leaves 82.31 per cent. of the xylan was removed; in the upper part of the stems, the small ends, we have 66.66 per cent. removed, and in the lower and more woody part we find that 54.71 per cent. has been removed. While it may not be rigorously correct that the amount of those substances which yield the furfurol are proportional to the furfurol obtained, it may be assumed to be true for the aggregate which we have in hay, and an examination of the percentages of xylan shows that they, like the proteids, depend probably not so much upon differences of soil, as upon seasonal differences. Taking the three cuttings of 1896, the second and third show an increase in the xylan as the plant matures, but the first cutting shows the opposite. The samples collected in 1894 are equally indefinite. We are, however, justified by analyses 21 to 26, in concluding that there are several complexes present which yield furfurol, and they offer different degrees of resistance to the alternate action of acids and alkalies. The complexes yielding more readily to the action of these agents predominate in the leaves, forming nearly nine-tenths of the whole amount, whereas in the stems they form only about one-half.

Analyses to be given subsequently indicate that there is still another distinction, for some of them are removed by extraction with alcohol and water, while others are not. The conditions, under which the work recorded in these paragraphs was made, were as uniform as possible, for it is evident that this is necessary in order that our results shall have the same significance.

COMPARISON OF LEGUMINOUS HAYS BY NEW METHODS.

It has long been felt that our methods of fodder analysis leave much to be desired, and, while they are very helpful in forming a judgment of the value of a hay, they have not been conclusive. I do not claim that the present effort leads to much more satisfactory conclusions, but it is an effort to get a more definite and detailed view of the components of hay. Heretofore we have been accustomed to speak of carbohydrates and water soluble substances as though starch, sugar, etc., were present in abundance. We may not be able to show what the substances are which we have been calling by these names, but we can show how much sugar and starch are present and that we must find some other names for the rest. As an example of the inadequacy of a fodder analysis to enable us to judge of the value of a grass as a fodder plant, I may cite the case of *Stipa viridula var. robusta.* My attention was called to this grass by Professor C. S. Crandall, who requested me to analyze it. The grass is one familiar to people of the West, growing in bunches among the foothills. For comparison we give an analysis of a hay taken from the Year Book of the Department of Agriculture for 1894:

	Hay, mixed grasses, and clover. Per cent.	Stipa viridula. Per cent.
Water	13.20	5.53
Ash	4.40	5.76
Protein	5.90	8.91
Fiber	29.00	39.60
Nitrogen-free extract	45.00	38.24
Fat	2.50	1.96

The analysis of the hay is an average analysis, while that of the Stipa is a single analysis of a small sample; but it suffices to show that hay made from this grass ought to be preferable to a mixed hay, that is the average article, but cattle will not eat the Stipa, and horses feed on it with great moderation. The analysis is correct in regard to the composition of the fodder, but stock do not like it, and hay which animals will not eat, except when driven to it by excessive hunger, does not answer the purposes of a first-class fodder, however good an analysis may show it to be. We have a parallel in the composition of our native hays and of alfalfa. All stock, so far as I know, eat alfalfa greedily, and its analysis shows it to be an excellent fodder for general purposes, and yet it possesses qualities which make it, in general estimation, a poor fodder for work or road horses, and it sells in the market at about one-half the price of native hay.

It is not probable that chemical analyses will ever be able to discover these properties which are, partly at least, physiological; still we may yet learn more about the subject and become able to form a better judgment than we can at present.

In the following I have endeavored to obtain a better knowledge of the hays made from alfalfa, clover, the field pea, and native hay.

For the methods followed I am indebted mostly to the work of Cross and Bevan, but I have also drawn upon whatever literature has been accessible to me.

The process of analysis is almost identical with that proposed by Professor Stone, i. e., successive extraction with boiling alcohol, cold water, diastase, boiling dilute acid, boiling dilute alkali, and treatment of the residual fiber with chlorin. The reducing power of the products of hydrolysis were determined by means of Fehling's solution and estimation of the copper by means of potassic cyanid solution. The chief difficulties arose from the large amounts of coloring compounds presents in some of the extracts. The reducing power of some of these solutions was diminished by treating them with basic lead acetate, though I could find no sugar in the precipitate.

The preparation of the sample of hay for this process is of considerable importance. If there are larger pieces of stems, it is difficult to free the cellulose from lignones and the cellulose will give the phloroglucin-hydrochloric acid reaction. I found this markedly the case with alfalfa, clover, and the pea vines, but not so with the native hay. If the sample is ground to a uniformly fine powder this is not the case, and the cellulose will not react with the phloroglucin solution. That this is the correct explanation of the cause of the reaction, and that it is not due to the inability of the chlorin to remove the lignone groups, is clearly observable when the reaction is watched under the microscope. The small pieces will remain uncolored, and the large ones will be observed to have an outer uncolored portion inclosing a colored nucleus.

The alfalfa selected for this analysis was a sample of new hay made from plants coming into bloom.

The following are the results obtained:

	Per cent.
Invert sugar	none
Sugar	trace
Dextrin	trace
Starch	1.11
Xylan, inverted by dilute acid	3.76
Xylan, soluble in alkali solution	0.15
Lignones, rendered soluble by chlorin	6.66
Cellulose	25.59
Moisture	7.21
Ash	9.81
Ether extract	1.15
Proteids	15.16
Soluble in alcohol	13.87
Soluble in water (starch, etc., deducted)	11.88
Not determined	3.65
	100.00

The substances dissolved by water are only partly precipitated upon the addition of a large excess of alcohol. The amount precipitated was 8.2 per cent. of the sample. It did not prove to be dextrin. This caused me some trouble and I increased the amount of hydric chlorid used in inverting and increased the time of heating, at the temperature of boiling water, to one and a half and even to two hours. I did the same with the starch solution.

A portion of the sample was extracted successively with 95 per cent. alcohol and cold water—two grams of the sample, 24 c. c. alcohol, and subsequently 40 c. c. cold water—the residue was washed with cold water and the remaining nitrogen determined. We found 1.554 per cent., calculated on the air dried substance; whereas the total nitrogen was equal to 2.426 per cent., a difference of .672 per cent., which is over 27 per cent. of the total nitrogen. This is rather more than we have found in any sample in the form of amid nitrogen; but inasmuch as some samples have furnished nearly as much as this, we are led to believe that it is the amids, principally if not wholly, which are soluble in water. There is in this no oxidation and fermentation such as take place in the weathering of hay, and the two processes are not equivalent, though they may be similar to some extent.

The crude fiber contained, in this instance, .33 per cent. nitrogen, or, roughly calculated on air dried hay, about .11 per cent. This was neglected in the further calculations. Of the crude fiber itself 78.96 per cent. was cellulose, and 21.04 per cent. was lignones.

The sample of clover hay was two years old. The plants were cut when the heads were half turned, and the whole plant was cured without the loss of any leaves or stems. The sample, as judged by physical properties, is somewhat above the average of clover hay in quality. The ordinary fodder analysis of this sample was, for the dry matter:

	Per cent.
Ash	10.63
Ether extract	2.07
Crude protein	14.18
Crude fiber	30.52
Nitrogen-free extract	42.60
Total	100.00

The average percentage of nitrogen, as determined in the fresh sample, was 2.268, and two years later it was 2.287. There is no apparent change in the nitrogen content caused by its aging.

The co-efficient of digestion, as determined by pepsin solution, was found to be 76.43 per cent., which is rather higher than the maximum for red clover hay, 71, and even higher than that of the green clover, 76. This hay was going on three years old at the time the determination was made.

The amount of xylan found was 16.54 per cent., which is materially more than the maximum found in alfalfa hay. The average nitrogen-free extract in alfalfa hay is close to 32 per cent., while the clover has 43 per cent.; and it seems probable that the excessive xylan found in the clover, owes its origin to the non-fibrous celluloses included in the nitrogen free extract. The fuller analysis of the sample was as follows:

	Per cent.
Invert sugar	1.33
Sugar	0.21
Dextrin	4.03
Starch	0.76
Xylan, inverted by dilute acid	4.03
Xylan, soluble in alkali solution	0.72
Lignones, soluble by chlorin	4.99
Cellulose	18.70
Moisture	5.36
Ash	10.17
Ether extract	1.88
Proteids	13.43
Soluble in alcohol, sugar, etc., deducted; Soluble in water, dextrin, etc., deducted	29.59
Not determined	4.80
	100.00

The total loss upon successive extraction with 95 per cent. alcohol, cold water, and then hot water, was 37.8 per cent. The amount extracted from alfalfa hay was, in round numbers, 28 per cent. I did not in this case determine the amount of nitrogen removed by the extractions.

The crude fiber in this case contained 77.88 per cent. cellulose, and 22.12 per cent. of lignones; practically identical with the composition of the crude fiber prepared from alfalfa.

The nitrogen-free extract, however, differs both quantitatively and qualitatively from that of the alfalfa. To what extent this difference is due to the difference in the development of the plants at the time the samples were cut, would be interesting to know. The absence of the sugars in the alfalfa sample and their presence in the clover may be wholly attributable to this. Alfalfa is our principal honey plant and yet this sample which was just coming into bloom yields only traces of the sugars. That they are subquently present cannot be doubted; but whether they are ever present in sufficient quantity to constitute more than a fraction of one per cent. of the hay is a question.

PEA-VINE HAY.

As the quantity of pea-vine hay made in this state aggregates a large amount, I shall, at the risk of digressing too much, give a brief presentation of it in comparison with the other hays, particularly in comparison with alfalfa and clover hays. The variety of pease here dealt with, is what is designated the Mexican pea. It is a strong grower and quite prolific. I am indebted to Mr. James A. Kelley, of Monte Vista, Colorado, for one of the samples of hay and to Mr. R. E. Trimble for the other. Both samples are from the San Luis valley, where the pea-vine hay, to a certain extent, takes the place of alfalfa and clover hay of this portion of the state.

I am informed by Mr. Kelley that experiments in feeding pea-vine hay to horses, steers, and sheep have given very satisfactory results, especially so with sheep. Mr. Kelley's statements of its effects upon horses indicate that they are similar to those of alfalfa, but are much milder and he makes no mention of its producing any cough or the heaves. This hay even when cut, after many of the pease have ripened, is an acceptable fodder to cattle and one on which they do well.

The sample furnished by Mr. Kelley was in perfect condition; the plants were almost at full bloom at the time of cutting, and the pods had merely formed in the older bloom. The leaves were well preserved. The sample obtained for me, by Mr. Trimble, was of hay cut when the plants were quite mature and a goodly number of the pease were ripe. The hay, however, was in good condition. The samples were ground to a coarse powder, from which smaller samples were prepared for analysis.

COMPOSITION OF PEA-VINE HAY.

Condition at time of Cutting.	Moisture.	Ash.	Ether Extract.	Crude Protein.	Crude Fiber.	Nitrogen-Free Extract.	Total Nitrogen.
Cut at time of full bloom	5.871	11.273	3.200	20.200	29.428	30.028	3.232
Water free	....	11.977	3.398	21.460	31.264	31.901	3.434
Cut when in full pod	6.028	7.135	1.839	16.581	30.013	38.404	2.653
Water free	....	7.592	1.957	17.645	31.938	40.888	2.723

We give, in the subjoined table, analyses of pea-vine ensilage, first cutting alfalfa, and clover hay. The analyses of the ensilage and clover hay are reproduced from Bulletin No. 35.

	Moisture.	Ash.	Ether Extract.	Crude Protein.	Crude Fiber.	Nitrogen-Free Extract.	Total Nitrogen.
Pea-vine ensilage	4.710	14.910	3.240	10.950	30.060	36.130	1.752
Water free	....	15.630	3.400	11.300	31.390	38.540	1.839
Alfalfa, average of first cutting	6.210	10.030	1.550	14.850	36.280	31.080	2.376
Water free	....	10.694	1.653	15.833	38.682	33.138	2.533
Clover hay, water free	....	10.630	2.070	14.180	30.520	42.600	....

The analyses show the pea-vine hay to be richer than either clover or alfalfa in proteids, the alfalfa containing 297 pounds, while the pea-vine hay, cut in full bloom, contains 404 pounds per ton ; and it is only a little higher than the clover hay in crude fiber. We also observe a decrease in the ash constituents and the proteids with the ripening of the plant, so that the pea-vine hay forms no exception to this rule

It will be noticed that it removes a large amount of ash, the hay containing an average of 9.204 per cent. of ash or mineral matter.

These ashes were submitted to analysis and the results are given below, together with an analysis of an alfalfa ash, made from plants of first cutting, full bloom.

The composition of these ashes is as follows:

	Pea Vines in full bloom.	Pea Vines in full pod.	Alfalfa in full bloom.
Carbon	Trace	Trace	0.112
Sand	5.033	4.524	0.829
Silicic acid	2.620	3.293	0.881
Phosphoric acid	6.726	7.070	5.234
Sulphuric acid	4.767	2.620	5.608
Carbonic acid	18.325	21.455	23.730
Chlorin	6.231	3.765	8.500
Calcic oxid	11.614	16.650	27.620
Magnesic oxid	3.669	4.192	3.798
Ferric oxid	0.659	0.560	0.269
Aluminic oxid	0.366	0.548	0.089
Manganic oxid, brown	0.262	0.560	0.168
Potassic oxid, potash	36.164	30.917	24.240
Sodic oxid, soda	1.366	3.629	0.943
Moisture	Not det'd	0.856	0.000
Sum	100.802	100.939	102.021
Less oxygen, equivalent to chlorin	1.188	0.855	1.920
Total	99.614	100.084	100.101

These results show that the pea is a still heavier feeder, particularly upon phosphoric acid and potash, than the alfalfa plant, which, in the aggregate, removes very large quantities of these substances. The phosphoric acid in the alfalfa ash is quite the maximum found in fifteen samples prepared from alfalfa hay, but is less than that in the ashes of the pea vines. On the other hand, the sum of the lime and magnesia in the ashes of the pea vines is only from one-half to two-thirds of the amount found in the various samples of alfalfa ashes. The ashes of the pea vines compare with those of red clover in the same sense and almost in the same degree as with those of the alfalfa. In regard to the total nitrogen in the plant, it will be observed that the pea vines contain materially more of it than alfalfa does. For the purposes of green manuring, they are easily and quickly enough grown to deserve the attention of our ranchmen. They will serve admirably to add organic matter and nitrogen to the soil and to render other plant food more available.

CRUDE FIBER AND NITROGEN-FREE EXTRACT.

Our subsequent analyses of these samples, of pea-vine hay, with the object of getting more definite information concerning the composition of the crude fiber and the nitrogen-free extract, resulted as follows:

	In full bloom. Per cent.	In full pod. Per cent.
Invert sugar	0.000	0.000
Cane sugar	0.000	3.050*
Dextrin	0.738	0.705
Starch	0.000	2.530
Xylan, inverted by dilute acid	3.157	7.237
Xylan, soluble in alkali solut'n	0.816	0.659
Lignones, soluble by chlorin	6.466	10.296
Cellulose	18.646	18.199
Moisture	5.871	6.028
Ash	11.273	7.135
Ether extract	3.200	1.839
Proteids	20.200	16.581
Soluble in alcohol / Soluble in water	28.345	25.841†
Not determined	1.258	.000
	100.000	100.100

I was quite surprised at the absence of starch in the sample in full bloom, but no more so than at the small amount of this substance in the alfalfa and the very small amount in the clover hay. The result for the alfalfa is entirely consonant with the results of the following experiment: A portion of the alfalfa was digested with alcohol and subsequently with cold water, to remove as much of the coloring matter and extractives as possible and then examined under the microscope, at last with the addition of a solution of iodin in potassic iodid, the reaction with the lignocelluloses was very strong, and if there was any reaction for starch it was entirely masked. I at no time succeeding in obtaining a satisfactory test for starch in this manner, though some of the tests might have been interpreted as showing its presence, and I think this interpretation is correct; but it was not clear enough at any time to indicate a large percentage of starch, even after boiling

* A second determination gave 2.94 per cent. † Sugar, dextrin, etc., deducted.

the sample with water. The extract of this sample of pea vines obtained by first boiling it, after having previously freed it from gums and fats, with fifty times its weight of water for an hour and a half, subsequently digesting with diastase for two hours at 55-60 degrees and inverting with 10 c. c. of concentrated hydric chlorid at a temperature of 90-95 degrees, failed to give any more sugar than was added with the diastase though tested three times.

That starch should be found in the other sample is in accord with the condition of the plant at the time of cutting, i. e., in full pod with many ripe pease. The large percentage of lignones in the crude fiber of the hay made from the maturer vines may be due to the relatively large quantity of pods in the sample and suggests a great difference in the quality of the samples.

The pea-vine hay made from the less mature vines resembles the alfalfa samples not only in the amount of lignones present in the crude fiber, but also in the amount of xylan yielded upon distillation, 11.17 per cent. The amount of the lignocelluloses present varies with the maturity of the plant, especially those which are not susceptible to hydrolysis by dilute acids and alkalies increasing with maturity, while the cellulose remains nearly constant.

The furfurol yielding complexes, expressed as xylan, are less abundant in the mature plants than in the younger, but the difference is probably within the limits of error due to the method, and not conclusive as regards their variation in the plant. The sample made from plants in full bloom yielded 11.17 per cent. xylan, and the one cut, when the plants were in full pod, gave 10.23 per cent. The range in the percentage of xylan found in our alfalfa samples is from 8.9 to 14.50 per cent., but fluctuates so irregularly that no evident relation can be discovered between the development of the plant and the amount of xylan found and the same would probably be the case with the pea-vine hay if our series of samples were only slightly extended. It is true, too, that our method is not very sharp and small differences in percentages have so slight a significance that the range of only about six per cent. may be taken as establishing the xylan content of alfalfa and pea-vine hays at about ten or twelve per cent. The relation of the lignones to the xylan found is not made apparent by our results, if any exists at all; the ratios obtained are approximately as follows: for clover, 0.30:1; for alfalfa, 0.47:1; for pea-vine hay, cut when the plants were in full bloom, 0.42:1; but for pea-vine hay cut when the plants were in seed, the ratio found is 1:1. There is evidently no approximation to a uniform ratio shown by these figures.

The residue obtained from the mature sample by successive extractions with alcohol and cold water yielded, upon distillation with hydric chlorid, xylan equivalent to 8.01 per cent. of the air dried hay, or 78.2 per cent. of the total xylan. This seems to indicate a greater difference between the pea-vine hays, in regard to the character of the lignocelluloses present, than in regard to the other constituents. The deportment of the hay from the vines in pod toward heat, i. e., the readiness with which it browns, is probably due to the large amount of these lignocelluloses present. I have not observed so great a sensitivness in any sample of fodder which I have analyzed. The roots of alfalfa alone have exceded it in this respect.

Accepting the phloroglucin reaction as indicative of the amount of these lignocelluloses, I began a series of observations on samples of alfalfa taken from the same root, at intervals of seven days, the first sample being taken when the stems were only four or five inches high. The intention was to continue the taking of samples from this plant at the stated intervals until the plant was fully ripe, and to study the development of the lignocelluloses in thin sections under the microscope for each internode of stems throughout the whole period of growth. An accident to my chosen plant, it having been cut up, brought this experiment to a sudden end. My observations indicated the absence of these in the very young joints, and their subsequent development in two rings, the first continuous with the fibrovascular ring whose outer margin was fluted, while the second one lay outside of this and was composed of individual bundles, sometimes, but not always, coalescing so that the ring was broken.

The co-efficient of digestion of the proteids in these pea-vine hays, as determined by artificial digestion, are rather higher than, but not very different from, those found for the proteids in alfalfa hay. They are, for the pea-vine hay, cut when the plants were in full bloom, 84.71; and, cut when the plants were in full pod, 81.61.

I can not find that the co-efficient of digestion of such hay has been determined by experiments with animals, though such experiments have been made with pea straw, the proteids of which have a digestion co-efficient of 61; also with pease in which the co-efficient is, for ruminants, 89; for horses, 86; and for swine, 88, from which it would appear that the proteids in such pea-vine hays are of nearly as much value as the proteids in the pease themselves. In this statement, the amount of amids which may be present in the pea vine is not considered.

The crude fiber of the pea-vine hay, sample in full bloom, was composed of 74.25 per cent. of cellulose, and 25.75 per cent. of lignones. This is quite close to the composition of the crude fiber from the alfalfa and clover hays in which the cellulose was 79.96 and 77.88 respectively.

Whatever the value of the lignones may be, this seems to be true of these three leguminous hays, cut when the plants are in full bloom or earlier, i. e., that there is about six or seven per cent. of them present which resist the action of dilute acids and alkalies, even when the soluble portions of the hay have been removed by previous extractions with alcohol and water. In the sample of pea-vine hay in pod these lignones increased and the cellulose in the crude fiber amounted to 63.82 per cent. I have already suggested the presence of a large percentage of pods as a possible explanation. This, however, only means a particular stage in the development of the plant.

UPLAND AND MEADOW HAY.

These names are applied to hay made from grasses growing for the most part on level grounds along streams or where water courses have been.

The grasses making up this class of hay are numerous. Prof. C. S. Crandall, of the Department of Botany, kindly determined those present in the sample analyzed. The first two in the list made up the major portion of the sample. They were as follows: *Andropogon scoparius, Mich.*; *Carex marcida, Booth.*; *Elymus canadensis, L.*; *Panicum virgatum, L.*; *Sporobolus asperifolius, Thurb.*; *Sporobolus cryptandrus, Gray*; *Poa tenuifolia, var. rigida, Vasey*; *Andropogon furcatus, Muhl.*; *Chrysopogon avenaceus, Benth.*; *Calamovilfa longifolia, Hack.*; *Agropyrum tenerum, Vasey*; *Bouteloua oligostachya, Torr.*

This hay was made in the latter part of August, 1896; it was cut from land belonging to Mr. J. J. Ryan, and lying close to the Big Thompson river, near the town of Loveland, this county.

This hay was considered to be a good quality of this class which is in large demand, at all seasons. The market value of such hay is always greatly in excess of that of alfalfa, usually a little less than twice that of alfalfa hay, and often fully twice. I am, myself, not in position to express an opinion as to what extent this difference in price is due to the difference in the supply of the respective hays, but persons who keep horses for road purposes, liverymen and others, will not use alfalfa hay. On the other hand, feeders of cattle and sheep use alfalfa principally, if not exclusively, in this section. I do not know how this matter stands relative to pea-vine hay, but the pea-vine silage has been fed with very satisfactory results.

It would seem that the low esteem in which alfalfa is held as feed for horses, is mostly due to its action upon the kidneys and bowels of the animal and also to the fact that the loss in feeding horses alfalfa hay is very large, due to their not eating the leaves readily, and lastly, because the alfalfa is sometimes dusty. It may be that this is in part a practical recognition of the fact that the nutritive ratio of the whole hay is rather a narrower one than is desirable. Be this as it may, an average alfalfa hay has a much larger percentage of proteids than the upland hay, also less crude fiber, and the proteids in the alfalfa have a higher co-efficient of digestion. The same is in a measure true of clover hay, but the upland hay is preferred for feeding animals at work.

The composition of the upland hay was as follows:

	Per cent.
Moisture	3.047
Ash	7.886
Ether extract	2.219
Proteids	6.131
Crude fiber	40.372
Nitrogen-free extract	40.351
Total	100.000

The co-efficient of digestion for the proteids found by artificial digestion was 45.77, about equal to that given for the proteids in late cut timothy. I gave on a preceding page an analysis of hay made from Stipa viridula, in comparison with an analysis of a mixed hay. In that analysis the proteids are given as 8.91 per cent. We see that it is richer also in this constituent than our native hays, which are in great demand at all times. Not only is the amount of the proteids larger in the Stipa, but their co-efficient of digestibility is also higher, being 64.71. It would have been interesting to have studied the Stipa hay still further to see if we could solve the question why this grass is not eaten, but we were compelled to drop the comparative study at this point, and all that we are justified in stating is that, in spite of the fact that cattle do not eat it, it has, according to analysis, the composition of a good fodder, better in some respects than mixed hay, and that the co-efficient of digestion for its proteids is higher than that of our native hay, which is considered a very desirable one.

The native hay yields, when analyzed according to our method, exceedingly different results from the leguminous hays.

While the following analysis may not be so exact as one might wish, it is not far from the truth, and shows that there is a very great difference between the two classes of hay—hay made from leguminous plants and hay made from the grasses. Subsequent investigation may, it is true, modify these results somewhat, but we think that this difference exists and that it is fully as great as appears from the results of our analysis. I know of no analysis of hay made in a similar manner; a single determination of sugar—sucrose—in a sample of timothy hay, by Professor Stone, is all that I can find. He gives the sugar in his sample of timothy hay as 2.53 per cent.

ANALYSIS OF UPLAND HAY.

	Per cent.
Invert sugar	0.00
Cane sugar	0.98
Dextrin	0.00
Starch	0.40
Xylan, inverted by dilute acid	1.77
Xylan, soluble in dilute alkali	0.79
Lignones, dissolved by chlorin	3.12
Cellulose	27.93
Moisture	3.05
Ash	7.89
Ether extract	2.22
Proteids	6.13
Soluble in alcohol, sugar, etc., deducted / Soluble in water, dextrine, etc., deducted	19.75
Not determined	35.97
	100.00

The reaction of the original sample and also the crude fiber prepared from it with phloroglucin is very much fainter than that given by the leguminous hays. I regret that we did not determine the total xylan by distillation, as that might have added something to our knowledge of the thirty-six per cent. which is missing. But the comparative faintness of the phloroglucin reaction indicates that the pentaglucoses are not present to the same extent as in the alfalfa and other leguminous hays.

In the usual fodder analysis the two most striking points are the high percentages of crude fiber and nitrogen-free extract. In the second analysis the most remarkable percentages given are for the cellulose and those things embraced under the term "not determined," which includes substances soluble in dilute acid and dilute alkali, but insoluble in alcohol and water. The portion soluble in alcohol and water is low and a large portion of the 40.3 per cent. nitrogen-free extract is included in the 36 per cent. "not determined."

In order that the comparison of these analyses may be facilitated, we bring them together in the following table:

	Alfalfa Hay, coming in bloom.	Clover Hay Heads, half turned.	Pea-vine Hay in full bloom.	Pea-vine Hay in full pod.	Upland Hay.
Invert sugar	0.00	1.33	0.00	0.00	0.00
Cane sugar	Trace	0.21	0.00	3.05	0.98
Dextrin	Trace	4.03	0.74	0.71	0.00
Starch	1.11	0.76	0.00	2.53	0.40
Xylan, by acid	3.76	4.03	3.16	7.24	1.77
Xylan, by alkali	0.15	0.72	0.82	0.66	0.79
Lignones	6.66	4.99	6.47	10 30	3.12
Cellulose	25.59	18.70	18.65	18.20	27.93
Soluble in alcohol, sugar, etc., deduted	13.87	29.59	28.35	25.84	19.75
Soluble in water, dextrin, etc., deducted	11.88				
Moisture	7.21	5.36	5.87	6.03	3.05
Ash	9.81	10.17	11.27	7.14	7.89
Ether extract	1.15	1.88	3.20	1.84	2.22
Proteids	15.16	13.43	20.20	16.58	6.13
Not determined	3.65	4.80	1.25	0.00	35.97
	100.00	100.00	100.00	100.10	100.00
Co-efficient of digestion for the proteids	79.15	76.43	84.71	81.61	45.77

This shows the pea-vine hay to contain the largest percentage of proteids, with the highest co-efficient of digestion, with the alfalfa next in both respects. The pea-vine hay has the lowest percentage of cellulose and the upland hay the highest; in this respect the pea-vine and clover hays stand quite apart from both the alfalfa and upland hays. The sugars and starch, which we have for the most part understood by carbohydrates, are present in small quantities. The sample showing starch to be present in the largest quantity contained some mature seeds, which contain from 48 to 50 per cent. of starch. The sugar found in the same sample may be correct, but I think it admits of a doubt.

CONCLUSIONS.

First.—That the composition of alfalfa hay grown under the same climatic conditions does not vary from year to year, more than samples of the same year, which is within fairly narrow limits.

Second.—That climatic or seasonal differences do affect the composition of the hay. This, however, affects the different cuttings of the same year, rather than the crops for a whole year, but this effect is comparatively small and expresses itself most pronouncedly in the percentage of crude fiber.

Third.—That the amount of the proteids in alfalfa hay does not decrease with, but rather increases, with age, if the hay is kept in a close mow.

Fourth.—That the changes in the hay probably affect the amount and character of the nitrogen-free extract.

Fifth.—That the proteids of the different cuttings are about equally digestible, as determined by means of pepsin-hydrochloric acid. There is, however, a slight difference in favor of the hay cut when the plants were in full bloom.

Sixth.—The digestibility of the proteids does not vary materially from year to year, nor is it affected by the age of the hay, if well kept.

Seventh.—That the lignocelluloses in alfalfa increase with the age of the plant, but there are exceptions which can not be justly attributed to methods of determination.

Eighth.—That the presence and amount of sugar,starch, etc. depend upon the development of the plant at the time of cutting, and is at all times comparatively small.

Ninth.—That the lignocelluloses are more abundant in the leguminous hays than in those made from our native grasses, but that the cellulose is much more abundant in the latter.

Tenth.—That the soluble portion of leguminous hay, is greater than that of the little hay made from the grasses which accounts for their susceptibility to weathering

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THE AGRICULTURAL EXPERIMENT STATION

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BARLEY

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ALSTON ELLIS, President

FORT COLLINS, COLORADO

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BARLEY.

BY W. W. COOKE.

The barley plant is not properly appreciated in Colorado. There are but about 15,000 acres grown in the State, and they are credited with producing, in 1896, 450,000 bushels or 21,600,000 pounds of barley, an average of 30 bushels or 1,440 pounds per acre.

This yield compares well in value with the returns made by wheat the same year. There is quite a general belief that barley does not do well in Colorado, and this deters many from giving it a fair trial. Barley has been grown on the College Farm for many years, and all of the common varieties have been tested for longer or shorter periods. The yields have always been satisfactory, and during the later years have been highly successful. When these results are considered in connection with the fact that the College farm is by nature, both in the lay of the land and the character of the soil, below the average, it is fair to presume that, if properly handled, barley will give bounteous yields on other farms of the State.

One of the commonest mistakes in raising barley, is not to give it water enough. Barley will grow and make a crop on a small amount of water. Even at Fort Collins, which is in the arid region, a crop of barley can be raised one year in three, without irrigation. Because of these facts, farmers are inclined to slight the crop, and when water is short, give it to the other crops. Another peculiarity of barley is, that it does not show to the eye the need of water, until it has suffered beyond redemption. When barley grows with a shortage of water, it retains its natural color, but fails to grow long straws and stools but little. It throws all its strength into forming the heads, and these begin to show at scarcely eight inches above the ground. Water applied at this stage, will carry these heads on to ripeness, but will not produce much more growth of straw, no more stooling, and the heads will have but few kernels.

Barley prefers an open, warm soil, tending to clay rather than sand, with good drainage and not much alkali. It does better on rich land, and thrives well on land the first year after treating with stable manure. But, of course, in this latter case, it requires much more care in the irrigating and considerably more water. When well fed and watered, the growth is enormous and the probability is, that some of it will lodge. Our experience on the College Farm is, that lodging does but little damage. The heaviest yields we have ever secured have been from fields that were badly lodged. One in particular, lodged quite badly and went down flat. But the last few inches of the stalk turned up enough to keep the head off of the ground, and, though hard to cut and bind, the grains were plump, well filled out, and the yield enormous.

The treatment of the subject of barley in the following pages will be from the standpoint of the feeder. Colorado can grow first-class malting barley, can obtain as many bushels per acre as Iowa or any other of the barley growing states, and usually has dry weather at the time of barley harvest, so that the crop is secured without discoloration and in the best condition for use. There is a moderate local demand for malting barley, and, up to the point where this demand is supplied, barley is a more profitable crop than wheat.

There is, however, almost an unlimited demand for barley as a stock feed, to take the place of part of the corn that is now imported from Kansas and Nebraska.

It is with reference to its growth for this purpose, and the methods and results of feeding it to stock, that the remainder of this bulletin will be devoted.

VARIETIES.

The barleys can be separated into two classes: the common hulled varieties and the hulless, or naked varieties. These latter are often called "bald barley." The common hulled varieties are well known everywhere. The hulless varieties have no beards; they lose the hull in threshing, the same as wheat, and the cleaned grain closely resembles wheat; but the sides are more rounded and the upper end more pointed.

The common barleys can be divided into malting and non-malting, while the principal varieties of the hulless are the black and white.

The hulless barleys are not much raised in Colorado, but within the past few years, one variety known as the "Success" barley, has gained a good reputation as a profitable crop in the foothills and mountain parks from 7,000 to 8,500 feet altitude. At 7,000 it matures a crop of grain. Up to 8,500 feet it will make a heavy crop of hay, if cut just after blossoming, that takes the place of both hay and grain. Many teams do heavy work, in lumbering all winter long, with nothing to eat but this barley hay.

On the plains, under irrigation, some varieties of the common barley give so much larger yields than the hulless that the latter is not much grown. It is probable that even there the hulless barley could be grown at a profit, mixed with oats as a stock food. When sown together at the rate of thirty pounds of hulless barley and seventy-five pounds of oats per acre, the barley seems at first the leading crop. It shoots up above the oats, soon heads out and has the appearance of a barley crop. The heads ripen and turn downward, while the straw remains upright. Later the oats shoot far above the barley and make a crop that is apparently not lessened by the presence of the barley. The double crop is harvested when the oats are fully matured. A large field grown to hulless barley in 1893 and sown to oats in 1894 without additional seeding of barley, yielded 48 bushels per acre of the mixed grain, weighing 47 pounds per bushel or 2,256 pounds of grain per acre. Treated in this way, some of the barley shells out and reseeds the ground. These grains live over winter, and, if the land is to be kept in oats for several years in succession, once seeding with barley is sufficient. On account of this fact, wheat should never be grown after hulless barley, if it is expected to use the wheat for flour. Hulless barley can be gotten rid of by planting the land to a hoed crop or to alfalfa. The seeds of hulless barley are so heavy that they do not spread in ditch water as do those of wild oats.

TESTS OF VARIETIES.

TESTS OF 1887.

Small plots, hand-planted, selected seed, in drills 22 inches apart, four pounds of seed per acre.

Name of Variety.	Per cent of seed germinating.	Yield of grain per acre in bushels.	Number of days ripening.
Smooth Hulless	84	30	114
Winnepeg No. 1	83	35	114
Winnepeg No. 2	80	35	123
New Zealand	82	35	121
Chevalier	84	55	112
Zealand	84	47½	112
Winter 6-rowed	73	62½	126
Purple	72	37½	116
Melon	99	40	117
Del Norte	76	47½	116
Triumph	67	47½	116
India	88	47½	116
Kilima	93	50	117
Scotch Amat	93	35	116
Black	96	60	116
Palestine	71	37½	117
Amat	93	35	127
Guy Malye	82	47¼	116
Manchurian	66	37½	
Frick's	79	50	
Spring 4-rowed	75	47½	
Erfurt	93	47½	
Nepaul	79	47½	
Winter 4-rowed	76	47½	
Phœnix	77	47½	
Sibley's Improved	78	55	
Manshury	72	50	
Adams's Heavy	94	55	
Sibley's Pearl	92	27½	
Sibley's Purple	95	50	
Battledore	76	35	

TESTS OF 1888.

Small plots, selected seeds, 7 pounds per acre, hand planted in drills 13 inches apart.

Name of Variety.	Per cent of seed germinating.	Yield of grain per acre in bushels.	Yield of straw per acre in pounds.	Number of days ripening.
Smooth Hulless	90	25	720	89
Winnipeg No. 1	94	18.3	1040	89
Winnipeg No. 2	90	21.7	96	90
New Zealand	97	28.3	880	89
Chevalier	90	25	1360	94
Zealand	94	31.7	880	90
Winter 6-rowed	92	18.8	640	97
Purple	84	33.3	800	90
Melon	100	19	1120	92
Del Norte	94	33.3	1760	90
Triumph	81	33.3	120	92
Indian No. 4	92	28.3	1280	92
Kilma	97	33.3	1200	90
Scotch Amat	97	33.3	912	90
Black	95	33.3	1040	90
Palestine	91	26.6	1200	92
Animate	93	31.7	896	92
Guy Malye	94	36.6	960	90
Manchurian	96	18.5	800	90
Frick's	97	33.3	1280	90
Spring 4-rowed	92	19	1360	90
Erfurt	90	28.3	1120	92
Nepaul	83	26.6	104	90
Winter 4-rowed	95	18.6	904	90
Phœnix	94	18.3	960	92
Sibley's Improved	91	18.5	1280	90
Manshury	96	18.8	104	90
Adams's Heavy	95	31.7	1040	92
Sibley's Pearl	98	35	1520	92
Sibley's Purple	94	18.6	880	97
Wales	94	18.3	1440	107
Berkley	94	2.3	88	90
Zeochrit	79	28.3	912	100
Perlgerste	84	2.3	880	112

TESTS OF 1889.

San Luis Valley Sub-Station.

Small plots, 50 pounds of seed per acre, in drills six inches apart, sown with a hand drill.

Name of Variety.	Length of straw in inches.	Date of ripening.	Number of days ripening.	Yield of grain per acre in bushels.
Black	22	August 22	114	16.3
Hulless	20	" 22	114	10.2
Nepaul	22	" 22	114	14.9
Melon	23	" 30	122	21.1
Phœnix	21	" 22	114	14.6

Arkansas Valley Sub-Station.

Small plots, 26 pounds of seed per acre, in drills 18 inches apart, sown with hand drill.

Name of Variety.	Number of days ripening.	Yield of grain per acre in bushels.
Black	91	16.2
Hulless	91	15.7
Melon	91	18.5
Phœnix	91	14.8

TESTS OF 1890.

Drilled.

Small plots, 5 pounds of seed per acre, in drills 18 inches apart, sown with a hand drill. Sown March 28.

Name of Variety.	Date of cutting.	Height in inches.	Yield of grain per acre in bu.
Smooth Hulless	July 22	34	38.5
Winnipeg	" 22	32	37
Winter 6-rowed	" 25	28	30.1
Purple	" 21	35	41
Guy Malye	" 21	31	55.6
Frick's	" 22	37	30.1
Berkley	" 22	35	38.1
Unknown	" 25	32	21
Unknown	" 26	32	21.6
Algerian No. 1		29	22.6
Algerian No. 2	" 23	24	13.1
Algerian No. 3	" 23	30	33.1

Hand Planted.

Small plots, one seed each six inches, in drills 18 inches apart or about 5 pounds of seed per acre. Sown March 28.

Name of Variety.	Date of cutting.	Height in inches	Yield of grain per acre in bu.
Smooth Hulless	July 24	31	32.6
Winnipeg	" 23	29	31.1
Winter 6-rowed		23	27.6
Purple	" 23	31	26.1
Guy Malye	" 23	31	29.5
Frick's	" 24	35	25.6
Berkley	" 26	34	17.1
Unknown	" 26	32	19.1
Unknown	" 28	32	20.1
Algerian No. 1	" 26	28	22.6
Algerian No. 2	" 26	24	23.1
Algerian No. 3	" 26	29	30.1

Arkansas Valley Sub-Station.

Small plots, 26 pounds of seed per acre, in drills 18 inches apart, sown with hand drill. Sown April 22.

Name of Variety.	Number of days ripening.	Yield of grain per acre in bushels.
Black	84	31.4
Hulless	84	30.3
Melon	84	30.1
Phœnix	84	21.5

TESTS OF 1891.

Field plots, 90 pounds of seed per acre, sown with machine drill. Sown April 27.

Name of Variety.	Date harvested.	No. of days ripening.	Yield of grain per acre in bu.
Purple	July 22	86	42
Guy Malye	" 20	84	54
Palestine	" 25	89	40.5
Frick's	" 28	92	44
Smooth Hulless	" 28	92	41.8
Winnipeg No. 1	" 21	85	44.5
Algerian No. 3	" 30	97	57.5

TESTS OF 1892.

Field plots, 90 pounds of seed per acre, sown with machine drill.

Name of Variety,	Date of harvesting.	Yield of grain per acre in bushels.
Purple	July 28	20
Guy Malye	" 29	30
Smooth Hulless	August 2	25
Frick's	" 8	30
Smooth Hulless	" 2	40
Winnipeg	" 8	33.3
Sonora	" 2	9.5

San Luis Valley Sub-Station.

Planting the same as above.

Guy Malye	August 1	24.2
Frick's	" 26	28
Palestine	" 26	28
Sonora	September 10	11

TESTS OF 1893.

Field plots, 90 pounds of seed per acre, sown with machine drill.

Name of Variety.	Date of planting.	Date of harvesting.	Yield of grain per acre in bu.
Guy Malye	May 15	August 8	24
Success	" 11	" 8	21

TESTS OF 1894.

Field plots, 90 pounds of seed per acre, sown with machine drill.

Name of Variety.	Yield of grain per acre in bushels.
Champion	51
Nepaul	27
Black	24
Mansbury	34
New Zealand	51
California	50
Italie	23
Celeste Petite	23

TESTS OF 1895.

Field plots, 90 pounds of seed per acre sown with machine drill.

Name of Variety.	Date of planting.	Date of harvesting.	Yield of grain per acre in bu.
New Zealand	April 3	July 31	22.5
Black	" 3	" 28	25.6
California (Volunteer)		August 1	49
California	" 4	" 1	83
Chevalier	" 4	" 8	79

TESTS OF 1896.

Field plots, 90 pounds of seed per acre, sown with machine drill.

Name of Variety.	Date of planting.	Date of harvesting.	Yield of grain per acre in bu.
California	April 7	July 21	33.8

From the above records it will be seen that many varieties of barley have been grown on the College Farm and Sub-Stations for several years. For the past three years, a large number of varieties of foreign barleys have been grown on small plats, but as none of them have seemed to be an improvement on the kinds usually grown, their records are not here given.

Without going into any extended discussion of the merits of the different varieties, it may be said in general, that the white varieties of hulless barley have usually produced better than the black or purple, though some individual yields of small plats of the purple have been very high. It should be remembered in comparing the yields of the common and the hulless barleys, that the latter weighs fully sixty pounds to the bushel, and hence represents a quarter more value per bushel than the hulled varieties.

Among malting varieties the Chevalier has given by far the best results. It is, however, to the results obtained with common barley for feeding purposes that special attention is desired. The California has given the largest yields and we have finally settled on it as being the best for raising for sheep feeding. This variety has been tested at the Home Station at Fort Collins, and at the Sub-Stations at Cheyenne Wells, Rocky Ford, and Monte Vista. At Cheyenne Wells it was the only cereal that withstood the severe drouth of 1895. At Rocky Ford it produced 200 bushels from a field of five acres, in spite of a hard hailstorm, while even at the high altitude of the San Luis Valley, at Monte Vista, it produced 38 bushels per acre on a large field.

Its record at Fort Collins has already been given. In 1896, with but one light irrigation, it yielded 33.8 bushels per acre. In 1894, the yield was 50 bushels per acre with a fair season, and not much shortage of water. The banner year was 1895. That season the barley was put on a piece of bottom land that had been drained and cultivated for several years until it showed signs of impoverishment. It was covered with a very heavy coat of stable manure during the winter of 1893–4. The summer of 1894, it was planted to corn and in 1895 to barley. The growth of straw was enormous and the heading out perfect. Although lodged flat by a hard wind, it ripened its crop. From this field of about three acres, there were gathered by the self-binder, 83 bushels per acre, of well cleaned, solid grain. A few days later when the straw had somewhat straightened, it was cut close to the ground with a mower, and produced two large loads of straw that was thrown to the hogs, and contained grain enough to give them full feed for about three weeks. A heavy crop of volunteer barley showed that much had shattered out in addition to the enormous quantity gathered.

The same year this variety was sown on more than twenty farms between Fort Collins and Greeley. The results were uniformly satisfactory, the yields ranging from 50 to 80 bushels to the acre.

FEEDING VALUE OF BARLEY.

The value of any material as a food can be tested in two ways: first, by submitting it to chemical analysis to ascertain the amount of food constituents it contains; second, by feeding it to stock and noting the results. Our study of barley includes both of these methods.

The method by chemical analysis is the easier and quicker, but it is not certain yet that we know how to interpret the figures obtained by the analysis. The work has been confined to two representative varieties: the California as the best of the non-malting common barleys, and the Smooth Hulless as representing the bald barleys. For the remainder of this bulletin the terms "common barley" and "bald barley" will be understood as referring to these varieties. Both kinds were analyzed and the analyses are given herewith, in comparison with those of corn, wheat, oats, and bran, since these are the feeds with which barley comes most in competition. The analyses are of the material in the air dry condition in which it is usually fed.

	Water	Ash	Crude Protein	Fat	Nitrogen Free Extract.	Crude Fiber.
Common Barley*	10.09	1.87	8.66	2.47	73.82	3.09
Bald Barley*	9.44	3.34	13.21	2.69	68.55	2.77
Wheat	10.52	1.83	11.87	2.09	71.90	1.79
Corn	10.56	1.53	10.25	5.02	70.40	2.24
Oats	10.98	2.98	11.80	4.96	59.74	9.54
Bran	11.91	5.78	15.42	4.03	53.87	8.99
Common Barley†	10.80	2.44	10.69	2.13	69.89	4.05
Bald Barley†	10.00	2.44	11.97	2.50	70.08	2.83

*Used in the feeding experiments.

†Average composition as given in the reports of the United States Department of Agriculture.

The preceding figures show the amount of each material contained in a hundred pounds of the grain. Some of this is digestible and useful to the animal. Much of it is indigestible and worthless.

The next table gives the per cent. of each of these that is commonly considered as digestible.

	Crude Protein.	Fat.	Nitrogen Free Extract.	Crude Fiber.
Common Barley	75	74	90	34
Wheat	71	84	93	25
Corn	72	74	93	37
Oats	81	82	73	23
Bran	79	71	73	25

No figures are given in the above for bald barley. So far as the present writer is aware, no digestion experiments have been made with this grain. From its nature, it is fair to presume that it would be about as digestible as wheat, and the figures for wheat have been used in making the calculations of the following table.

	Digestible Protein.	Digestible Fat.	Digestible Nitrogen Free Extract.	Digestible Fiber.	Total Digestible Material.
Common Barley*	6.50	1.85	66.44	1.03	75.82
Bald Barley*	9.38	2.24	63.70	0.69	76.01
Wheat	8.43	1.76	66.87	0.45	77.51
Corn	7.38	3.71	65.47	0.83	77.39
Oats	9.56	4.08	43.61	2.19	59.44
Bran	12.18	2.86	39.32	2.25	56.61
Common Barley†	8.02	1.58	62.90	1.38	73.88
Bald Barley†	8.50	2.10	65.17	0.71	76.48

*Used in the feeding experiments. †Average composition.

This last table is obtained by combining the other two. Thus the first table gives a hundred pounds of common barley as containing 8.66 pounds of crude protein; the second table says that 75 per cent. of this is digestible. Hence 100 pounds of common barley contain 6.50 pounds of digestible protein.

In the tables given above the figures 75 and 71 were used to represent the per cent. of digestibility of the protein in the common and bald barleys. The Chemist of the Station who made the analyses of the barley already given, also made a special test of artificial digestion on both the barleys by the method already published in Bulletin No. 39, of this Station. The results are 77 per cent. for the common barley, and 75 per cent. for the bald barley.

Among feeding materials of the same general character, it is believed that the total digestible material offers a pretty fair measure of their comparative feeding value. From this standpoint it will be seen that barley belongs to the more highly concentrated and digestible grains, like wheat and corn, rather than the lighter feeds, oats and bran.

There is no great difference in the chemical composition or the digestibility of wheat, corn, and barley. Judged from the standpoint of the chemist, they have almost exactly the same feeding value.

FEEDING TESTS WITH BARLEY.

Barley has been fed experimentally on the College Farm to steers, sheep, and pigs. Most of the tests have been with the common barley, but during 1896–'97 the bald barley was extensively fed. The tests were designed to answer the following questions:—

1. How does common barley compare as a stock food, with wheat and corn?
2. Is it better to feed barley alone or with corn?
3. How does bald barley compare in feeding value with common barley and with corn?
4. Is anything gained by grinding either common or bald barley for feeding to stock?

The tests cover a period of three years and will first be given separately for each class of animals, and then a summary presented of the results

FEEDING TESTS WITH PIGS.

First Test. Fall Pigs of 1894.

There were eleven pigs in the test. Six pigs were put in a large pen and fed ground common barley. The other five were put in a similar pen and fed whole corn. The pens were not fed the same amount of grain, but each was fed all that would be eaten up clean.

Feed.	Average Weight at Beginning of Test.	Average Weight at End of Test.	Average Gain in Weight.	Grain eaten per Pig.	Grain eaten for each pound of Growth.
Barley	152	240	88	481	5.4
Corn	159	235	7	430	5.6

The results are slightly in favor of barley. The pigs getting barley, eat more grain and grow faster and require a trifle less grain to produce a pound of growth.

Second Test With Pigs. Spring Pigs of 1895.

A repetition of the preceding test with the same number of pigs, divided and fed in the same manner, but the pigs are smaller and younger at the beginning of the test.

Feed.	Average Weight at Beginning of Test.	Average Weight at End of Test.	Average Gain in Weight.	Grain eaten per Pig.	Grain eaten for each pound of Growth.
Barley	89	194	105	452	4.3
Corn	101	214	113	480	4.3

The results of the second test are just the reverse of the first, i. e., the pigs getting corn eat a little more grain per head and grow a little faster—just fast enough to balance the extra grain; so that the same amount of grain is eaten by each lot per pound of growth. Combining the figures of the two tests there is a substantial equivalence of the results, the pigs eating the same amount, growing at the same rate, and eating the same quantity of grain for each pound of growth. Thus, under the conditions of these experiments, barley and corn have shown equal feeding value.

One noteworthy feature of the two tests is, the smaller amount of grain the younger pigs required to make a pound of growth as compared with the other pigs. This difference would amount to half a cent a pound in the cost of raising the pork.

Third Test with Pigs. Winter of 1896-'97.

From November, 1896, to April, 1897, an extensive series of feeding tests was made with forty-four pigs divided into nine groups. The rate of growth, as will be seen from the results, is rather small and is due to the fact that the feeding was done in an open shed where the temperature was below freezing most of the time, and often below zero. As the conditions were the same for all the pigs, this does not affect the reliability of the comparisons and conclusions.

The feeds tested were corn, bald barley, and common barley, each fed whole and also ground; each fed with and without skimmilk. Each test was continued for about six weeks. There were several re-arrangements of the pigs, so as to make the conditions of each comparison as nearly equal as possible.

FEEDING RECORDS. WINTER OF 1896-'97.

Period.	Number of Pigs.	Average Weight at Beginning of Test.	Average Weight at End of Test.	Average Gain in Weight.	Average Daily Gain in Weight.	Average Daily Feed.		Food per lb. of Growth.	
						Grain lbs.	Skim-milk qts.	Grain lbs.	Skim-milk qts.
WHOLE CORN.									
1	5	25	30	5	0.10	1.2		11.8	
2	5	76	86	10	0.27	1.8		6.8	
3	5	77	91	14	0.33	2.2		6.7	
4	5	117	125	8	0.27	2.9		10.7	
GROUND CORN.									
1	5	32	44	12	0.24	1.8		6.6	
3	4	76	90	14	0.33	2.7		8	
4	5	92	104	12	0.40	2.9		7.3	
WHOLE CORN AND SKIMMILK.									
2	5	46	77	31	0.84	1.8	3	2.1	3.5
3	5	86	119	23	0.55	2.3	1.9	4.1	3.4
GROUND CORN AND SKIMMILK.									
2	4	42	76	34	0.92	1.8	3	2	3.3
4	5	57	84	27	0.90	2.7	2	3	2
WHOLE BALD BARLEY.									
1	5	30	46	16	0.32	1.6		5.0	
1	5	68	93	25	0.50	2.2		4.4	
2	4	106	116	10	0.27	1.8		6.8	
2	5	59	73	14	0.40	1.8		4.8	
4	4	186	199	13	0.43	3.7		8.5	
GROUND BALD BARLEY.									
1	5	31	50	19	0.38	1.6		4.3	
2	4	63	85	22	0.60	1.8		3.1	
4	5	92	110	18	0.60	2.9		4.9	

Period.	Number of Pigs.	Average Weight at Beginning of Test.	Average Weight at End of Test.	Average Gain in Weight.	Average Daily Gain in Weight.	Average Daily Feed.		Food per lb. of Growth.	
						Grain lbs.	Skim-milk qts.	Grain lbs.	Skim-milk qts,
WHOLE BALD BARLEY AND SKIMMILK.									
1	4	70	131	61	1.22	2.3	6.0	1.8	5.0
3	4	116	150	34	0.80	2.6	2.4	3.5	3.0
3	5	73	101	28	0.67	2.3	1.2	3.4	2.2
GROUND BALD BARLEY AND SKIMMILK,									
3	3	70	116	46	1.10	2.8	2.0	2.6	2.0
4	5	77	107	30	1.00	2.9	2.0	3.0	2.0
WHOLE COMMON BARLEY.									
1	5	30	44	14	0.28	1.6		5.7	
3	5	63	75	12	0.29	2.3		7.8	
4	4	144	162	18	0.60	3.6		6.0	
GROUND COMMON BARLEY.									
1	5	27	40	13	0.26	1.6		6.2	
3	5	65	82	17	1.40	2.3		5.6	
WHOLE COMMON BARLEY AND SKIMMILK.									
2	5	35	63	28	0.76	1.7	2.1	2.2	2.8
GROUND COMMON BARLEY AND SKIMMILK.									
2	5	37	65	28	0.76	1.7	2.1	2.2	2.8
4	3	59	100	41	1.37	4.2	2.3	3.1	1.7
GROUND COMMON BARLEY AND GROUND CORN.									
1	5	26	39	13	0.26	1.6		6.1	
2	5	41	51	10	0.24	1.7		6.1	
GROUND COMMON BARLEY, GROUND CORN AND SKIMMILK.									
3	5	51	88	37	0.90	2.3	1.9	2.6	2.1
4	5	83	133	50	1.67	2.9	2.0	2.9	2.0

Average Results of the Different Feeds.

	Number of Tests.	Average Weight at Beginning of Test.	Average Daily Gain.	Average Daily Feed.		Food per pound of Growth.	
				Grain lbs.	Skim-milk qts.	Grain lbs.	Skim-milk qts.
Whole Corn	6	71	0.39	2.0	0,7	7.0	1.1
Ground Corn	5	60	0.46	2.4	1.0	5.4	1.1
Whole Bald Barley	8	88	0.58	2.3	1.2	5.0	1.3
Ground Bald Barley	5	67	0.74	2.4	0.8	3.6	0.8
Whole Common Barley	4	68	0.49	2.3	0.5	5.4	0.7
Ground Common Barley	4	47	0.70	2.4	1.1	4.3	1.1
Ground Corn and Barley	4	50	0.77	2.1	1.0	4.1	0.8

VALUE OF GRINDING GRAIN FOR PIGS.

The preceding tests offer thirteen comparisons of whole and ground grain. In almost every case, the ground grain has given decidedly better results than the unground. This is most noticeable in the case of corn. The little pigs weighing only 25 pounds each, made but small headway eating whole corn, and gained but the tenth of a pound per day per head. The older pigs had no trouble in masticating the grain, but their growth is still somewhat slower than those fed on ground grain, and requires more food to produce a pound of growth.

Ground bald barley made a better growth than the unground. To one who watched the experiment, the wonder is that the results are not still more in favor of the ground grain. Bald barley is smooth and very hard; harder than the hardest wheat. A large part of it when fed unground, passed through the alimentary canal whole and undigested. In the course of the day, these grains would be again and again eaten from the floor of the pen. It is possible that the same grain passed through a pig from three to five times. Each time some of the grains would be cracked and digested. The small difference in the results of the ground and unground, would seem to indicate that eventually most of the grain was digested, but the pigs certainly earned all they ate.

Ground vs. Whole Grain.

	Number of Tests.	Average Weight at Beginning of Tests.	Average Daily Gain.	Average Daily Feed.		Food per pound of Growth.	
				Grain lbs.	Skim-milk qts.	Grain lbs.	Skim-milk qts.
Whole Corn	6	63	0.44	1.9	1.0	6.7	1.2
Ground Corn	6	62	0.52	2.4	0.8	5.8	0.9
Whole Bald Barley	4	58	0.65	2.0	1.8	3 7	1.8
Ground Bald Barley	4	60	0.77	2.3	1.0	3.2	1.0
Whole Common Barley	3	43	0.44	1.9	0.7	5.2	0.9
Ground Common Barley	3	43	0.47	1.9	0.7	4.7	0.9

Average Results of Ground vs. Whole Grain.

	Number of Tests.	Average Weight at Beginning of Test.	Average Daily Gain.	Average Daily Feed.		Food per lb. of Growth.	
				Grain lbs.	Skimmilk qts.	Grain lbs.	Skimmilk qts.
Average Whole Grain alone	8	59	0.28	1.9		7.4	
Average Ground Grain alone	8	66	0.37	2.2		8.1	
Average Whole Grain and Skimmilk	5	54	0.87	2.0	3.1	2.3	3.4
Average Ground Grain and Skimmilk	5	57	0.74	2.4	2.2	2.6	2.4
Average Whole Grain	13	57	0.55	2.0	1.2	5.5	1.3
Average Ground Grain	13	57	0.59	2.3	0.9	4.8	0.9

The gain for grinding is largest in the case of bald barley, and least with common barley. The gains amount to about one-half more in the case of bald barley, one-fifth more for corn, and about one-twelfth more for common barley. This means that two bushels of ground bald barley made as much gain in two weeks, as three bushels of whole bald barley did in three weeks. The grinding increased the rate of growth and decreased its cost.

There is no doubt but that the increased returns for grinding the bald barley more than paid the cost of grinding. It is equally certain that grinding the common barley did not pay for itself. In the case of the corn, circumstances would determine which was the more profitable. We bought this corn at fifty cents per hundred, with two cents per hundred added for grinding, the labor of hauling being the same in both cases. Then, if grinding added a fifth to its value, it would pay to have it ground. Had we raised this corn, it would have cost us five cents a hundred to get it ground, beside the labor of hauling from the farm to the mill and return. The addition of a fifth to its value, would not, under these conditions, pay for the labor and the expense.

Whole Corn versus Whole Bald Barley.

	Number of Tests.	Average Weight at Beginning of Test.	Average Daily Gain.	Average Daily Feed		Food per pound of Growth	
				Grain lbs.	Skmi-milk qts.	Grain lbs.	Skim-milk qts.
Whole Corn	5	66	0.30	1.9	0.4	7.3]	0.7
Whole Bald Barley	5	72	0.40	1.9	0.4	5.2	0.5

The whole bald barley does better than the whole corn. Indeed, the whole corn did the poorest of any feed. The young pigs did not seem to be able to grind it easily, and as is well known, corn is largely lacking in the elements necessary to make bone and muscle. Bald barley is especially rich in both these ingredients.

Whole Corn versus Whole Common Barley.

	Number of Tests	Average Weight at Beginning of Test	Average Daily Gain.	Average Daily Feed. Grain lbs.	Average Daily Feed. Skim-milk qts.	Food per pound of Growth. Grain lbs.	Food per pound of Growth. Skim-milk qts.
Whole Corn	5	68	0.36	2.0	0.6	7.6	0.7
Whole Common Barley	5	67	0.44	2.3	0.4	6.0	0.6

The whole common barley has given a quarter more growth per day than the whole corn and has produced this growth with a quarter less grain and a little less of the skimmilk. The differences in favor of the whole common barley are just about the same as those in favor of the whole bald barley.

Whole Corn versus Ground Corn and Ground Common Barley.

	No. of Tests.	Average Weight at Beginning of Test.	Average Daily Gain.	Average Daily Feed Grain lbs.	Food per lb. of Growth. Grain lbs.
Whole Corn	2	50	0.18	1.5	9.3
Common Barley	2	33	0.25	1.6	6.1

Since barley has given better results than corn, and ground grain than unground, it is natural to expect what these tests show, that ground corn and ground common barley have given considerably better returns in growth and the cost of that growth than the whole corn.

Ground Corn versus Ground Bald Barley.

	Number of Tests.	Average Weight at Beginning of Test.	Average Daily Gain.	Average Daily Feed. Grain lbs.	Average Daily Feed. Skimmilk qts.	Food per lb. of Growth. Grain lbs.	Food per lb. of Growth. Skimmilk qts.
Ground Corn	5	63	0.55	2.6	0.8	5.6	0.9
Ground Bald Barley	5	67	0.74	2.4	0.8	3.6	0.8

The results speak very highly in favor of the good qualities of ground bald barley as a food for young pigs. We paid fifty cents per hundred pounds for this grain, and, allowing twenty-five cents per hundred pounds for the skimmilk, makes a cost of 2.2 cents for the food used in producing a pound of growth. When it is remembered that this was in cold weather, with scant shelter, it will be seen how strong a testimonial this is in favor of bald barley.

Ground Corn versus Ground Common Barley.

	Number of Tests.	Average Weight at Beginning of Test.	Average Daily Gain.	Average Daily Feed.		Food per lb. of Growth.	
				Grain lbs.	Skimmilk qts.	Grain lbs.	Skimmilk qts.
Ground Corn	4	52	0.60	2.5	1.2	4.9	1.4
Ground Common Barley	4	47	0.70	2.4	1.1	4.3	1.1

In the tests the previous years of corn and ground barley, the results had been equivalent. These were tests with large and nearly grown pigs, the object being to fatten them. In the present tests with young pigs to produce growth, the barley shows its superiority to the corn. Both these results are in accordance with the chemical analysis of the grains already given. The two grains are closely alike in heat and fat-producing elements, while the common barley is better suited than corn to produce growth. It should be noted, however, that even here the results of the two grains are not greatly different.

Ground Corn versus Ground Corn and Ground Common Barley.

	Number of Tests.	Average Weight at Beginning of Test.	Average Daily Gain.	Average Daily Feed.		Food per lb. of Growth.	
				Grain lbs.	Skimmilk qts.	Grain lbs.	Skimmilk qts.
Ground Corn	3	44	0.69	2.1	1.7	3.7	1.8
Corn and Barley	3	53	0.94	2.3	1.3	3.5	1.5

The apparent results in favor of the mixed grain are due to the figures of only one of the three tests. The other two, give one slightly in favor of the corn, and the other slightly in favor of the mixture, the average being equivalent.

Whole Bald Barley versus Whole Common Barley.

	Number of Tests.	Average Weight at Beginning of Test.	Average Daily Gain.	Average Daily Feed.		Food per lb. of Growth.	
				Grain lbs.	Skimmilk qts.	Grain lbs.	Skimmilk qts.
Whole Bald Barley	5	82	0.41	2.2	------	5.5	------
Whole Common Barley	5	79	0.39	2.5	------	6.5	------

In spite of the hardness of the bald barley grains, the pigs received enough nourishment from them to produce as much growth as the common barley and from a fifth less grain.

Ground Bald Barley versus Ground Common Barley.

	Number of Tests.	Average Weight at Beginning of Test.	Average Daily Gain.	Average Daily Feed.		Food per lb. of Growth.	
				Grain lbs.	Skimmilk qts.	Grain lbs.	Skimmilk qts.
Ground Bald Barley	3	60	0.77	2.3	1.0	3.2	1.0
Ground Common Barley	3	50	0.68	2.7	0.8	5.0	0.6

This is the series of tests where both grains are at their best, and results confirm or are borne out by the chemical analyses, that bald barley is better adapted for producing growth than the common barley. Bald barley grew a pound of pork at a cost of 2.1 cents for the food eaten; while the common barley required 2.8 cents' worth of food.

Three more comparisons could be made between the mixture of ground corn and ground common barley, on the one side, and, on the other side, either ground bald barley or ground common barley, or the average of the results from ground corn and ground common barley fed separately.

Without going into the details of these comparisons, it may be said that the mixture of corn and barley has done better than ground common barley, and not so well as ground bald barley. Feeding corn and barley together has produced a quarter more growth on about a fifth less food than feeding the two grains separately.

FEEDING TESTS WITH STEERS.

During the winter of 1895–96 a test was made of feeding barley to steers, with and without beets, in comparison with corn and wheat. Some of the figures from this test have already been printed in Bulletin No. 34, of this Station. Only that part of the test will be mentioned here that refers to the feeding of barley.

There were four pens of steers. A weighed quantity of hay was given each day, and the amount left weighed. The column headed "hay" in the table means the amount actually eaten. All the barley fed was common barley, and all the grains were ground before feeding.

Record of Steer Feeding.

No. of Pen.	Hay.	Corn.	Wheat.	Barley.	Beets.	Gain in Weight per Head	Shrinkage in Shipping.
1	9,195	2,334		237	756	155	8
2	7,938	237	2,352		6,936	163	27
3	8,898			2,574		76	37
6	7,524		237	2,256	5,694	141	66

Corn versus Barley. A comparison of pens No. 1 and No. 3 is a test of corn and barley, each fed without beets. The two lots ate nearly the same amount of hay and much the same of grain. The extra grain eaten by pen No. 3 just about balances the extra hay and a few beets fed to pen No. 1. The amount of food eaten and the market value of that food are about equal. The growth is decidedly in favor of corn. Not only did the corn make a larger growth, amounting to 79 pounds per head, but this growth was so much firmer that it shrank less in shipment. The corn-fed steers weighed on the market 124 pounds more per head than the barley-fed. The barley-fed steers began to show soon after they were put on to the feed that they were not doing so well as those having corn. They ate their food up clean and with a fairly good appetite, but always looked worse than their neighbors on corn.

Wheat and Beets versus Barley and Beets. The amount of beets fed in each case is not so much different, when taken in connection with the difference of grain, but that the results may be considered as due to the difference in the feeding value of the wheat and the barley. The wheat and beets give considerable more growth than the barley and beets. Just as the steers fed on barley alone shrink more than those on corn alone, so those on barley and beets shrink more than those on wheat and beets. In both cases the barley does not seem to make so hard flesh and fat as the corn or wheat. Judged by the weights on the market, the wheat and beets have made almost double the gain in live weight of the barley and beets.

Barley versus Barley and Beets. The steers on barley alone had 450 pounds more of hay, and the others 1,646 pounds more of beets. To offset this thousand pounds of beets extra, the steers getting beets grew nearly twice as fast as those getting barley alone, gaining 141 pounds per head, while the barley-fed steers are gaining 76 pounds. The flesh made from beets is softer than that from grain. Those fed barley shrink 37 pounds in shipping; those having the beets in addition shrink 66 pounds. On the market the steers having barley and beets weighed 75 pounds each above their weight in December; while the steers eating barley alone had gained only 36 pounds. This extra growth upon the addition of the beets made a return of about three dollars per ton for the beets fed.

First Feeding Tests with Sheep.

Winter of 1895–'96.

The tests with lambs during the winter of 1895–'96 included barley, corn, wheat, beets, and a mixture of barley and corn. All the grains were fed ground. There were 220 lambs used in the experiments, divided into lots of about 35 head each.

There will be given here only those tests that relate more particularly to barley.

Feeding Record per Head--January 8 to April 13.

Pen.	Hay.	Barley.	Corn.	Wheat.	Beets.	Gain in Weight per Head.
1	300	86				27
2	294		86			28
3	321				375	22
4	227			77	218	26
5	181	32	56			26
6	191	32	56			26

The gain in weight of the pen eating barley is one pound less, and the hay eaten six pounds more than the pen eating corn. In other words, the barley and corn are very nearly equal in feeding value, with the advantage slightly in favor of corn. All these grains were ground and the barley used was the common barley.

Barley gives about the same results as wheat and beets. If the extra shrinkage in shipping the sheep fed on beets could be taken into account, the results in favor of the barley would show more plainly.

Barley does much better than beets alone. If a comparison is made of beets alone, and wheat with beets, and then the results worked back to a comparison of wheat and barley, it gives almost exactly the same feeding value to each. Barley and corn fed separately have given a little better results than the two fed together. In the case of pens 5 and 6, barley was fed the first third, then barley and corn the second third of the time, ending with corn alone. The results were entirely unexpected. Theoretically this feed should give better results than either fed alone. Moreover, for the purpose of another experiment, pens 5 and 6 received a much better quality of hay than either pens 1 and 2. Nevertheless, the pens on the poor hay and the grain separately did better than on the good hay and the mixture of grain.

The difference in the results is so slight as to show a substantial agreement in the feeding values of the three grains, barley, corn, and wheat.

Second Feeding Test with Sheep.

Winter of 1896–'97.

The largest trials we have made with sheep were those of 1896–'97. There were 440 lambs used, divided into ten pens of about 45 head each.

All the pens received alfalfa hay. The other feeds used were as follows:—

Pen No. 1. Ground corn, beginning January 5, reaching one pound per day per head March 3, 1¼ pounds April 17, and changed on April 27 to 1¼ pounds whole corn.

Pen No. 2. Same, using ground bald barley until April 27, after that whole corn; but the quantity scarcely raised above a pound per head per day.

Pen No. 3. Same quantities and dates as pen No. 1, using whole bald barley, changing April 27 to whole corn.

Pen No. 4. Beginning January 5 on ground bald barley, changing February 16 to half ground bald barley and half ground corn, on March 30 to all ground corn, and on April 72 to whole corn. Quantities the same as in Pen No. 1.

Pen No. 5. From November 19 to March 14, 4 pounds per head per day of corn ensilage. Beginning March 6, ground corn added, reaching one pound per head per day March 16, raised to 1¼ pounds by April 15, and changed April 27 to 1¼ pounds whole corn.

Pen No. 6. Began November 19 with whole corn, two ounces per day per head; raised gradually reaching one pound on March 3, to 1¼ pounds April 17, and continued at this amount to May 17.

Pen No. 7. Same as pen No. 6, using ground corn and changing April 27 to whole corn.

Pen No. 8. Same as pen No. 6, using whole common barley, changing April 27 to whole corn.

Pen No. 9. Same as pen No. 6, using ground common barley, changing April 27 to whole corn.

Pen No. 10. Same as pen No. 6, using ground bald barley, but scarcely going above one pound per day per head, and changing April 27 to one pound whole corn.

The experiment progressed nicely until March 31, when the grain fed began to be raised above one pound per day per head. Pens Nos. 2 and 10, on ground barley, soon lost their appetite and got badly off-fed. Several lambs were taken sick and two died, apparently from indigestion. The grain fed was at once lowered, and, in the course of two weeks, their appetite returned; but they would never take more than the pound of grain per head per day. Pen No. 9, on ground common barley, got off-fed when the quantity was raised, but after a few days came back all right and took their 1¼ pounds to the end of the test. The lambs on whole bald barley, whole common barley, and both whole corn and ground corn, came up easily to the 1¼ pounds and continued this to the end of the test. The explanation of these results seems to be that the bald barley contains so large an amount of gluten that, when ground, it gathered into a sticky mass; but, when fed whole, much of the grain passed the animal unbroken and undigested and what was cracked was so mixed with the hay as to make no trouble. About one pound per head per day seemed to be the limit of the digestive powers of these lambs on ground bald barley.

In the case of the ground common barley, analysis shows that it contained much less gluten than the bald barley, and in addition the hull would tend to keep the gluten grains from gathering into a mass.

On account of the changes in feed and the trouble with the bald barley, it seems best to divide the winter's test into four periods.

First Period. November 19 to January 5.

Pens 1 to 4 receive no grain.
Pens 5 to 10 receive a small amount of grain.

Second Period. January 5 to April 6.

All the pens receive grain up to one pound.

Third Period. April 6 to April 27.

Pens 2, 9, and 10 more or less off-fed.
Other pens raised to 1¼ pounds grain per day.

Fourth Period. April 27 to May 17.

All pens given whole corn.

The most reliable comparisons are those obtained from November 19 to April 6; but, in the case of the pens that had no trouble, the comparisons can be carried to April 27 or to May 17.

The amounts of feed eaten and the gains in live weight are given in the following tables. The results are all calculated to 40 sheep in each pen.

Feeding Records November 19, 1896, to May 17, 1897.

	Pen 1.			Pen 2.			Pen 3.		
	Hay.	Ground Corn.	Whole Corn.	Hay.	Ground Bald Barley.	Whole Corn.	Hay.	Whole Bald Barley.	Whole Corn.
Nov. 19—Jan. 5	4,730			4,889			4,930		
Jan. 5—Apr. 6	9,687	2,555		10,295	2,502		10,273	2,497	
Apr. 6—27	1,640	1,010		1,349	877		1,559	996	
Apr. 27—May 17	912		1,125	1,102		900	1,234		1,125
Total	16,969	3,565	1,125	17,635	3,379	900	17,996	3,493	1,125

	Pen 4.				Pen 5.				Pen 6.	
	Hay.	Ground Bald Barley.	Ground Corn.	Whole Corn.	Hay.	Ensilage.	Ground Corn.	Whole Corn.	Hay.	Whole Corn.
Nov. 19—Jan. 5	4,432				2,133	8,886			4,189	382
Jan. 5—Apr. 6	10,183	847	1,650		5,871	11,040	1,061		8,645	2,719
April 6—27	1,718		996		1,626		995		1,619	995
Apr. 27—May 17	1,119			1,125	1,390			1,125	1,117	1,124
Total	17,442	847	2,646	1,125	11,020	19,926	2,056	1,125	15,570	5,220

	Pen 7			Pen 8			Pen 9			Pen 10		
	Hay.	Ground Corn.	Whole Corn	Hay.	Whole Common Barley.	Whole Corn.	Hay.	Ground Common Barley.	Whole Corn.	Hay.	Ground Bald Barley.	Whole Corn.
Nov. 19—Jan. 5....	4,032	370		4,180	367		4,815	370		4,032	357	
Jan 5—April 6.....	8,366	2,682		8,731	2,685		8,363	2,635		7,258	2,685	
April 6—27........	1,580	996		1,911	996		1,273	917		1,472	825	
April 27—May 17..	1,238		1,125	2,034		1,125	1,186		1,125	1,196		900
Total........	15,216	4,048	1,125	16,856	4,048	1,125	15,637	3,922	1,125	13,958	3,867	900

Total Feed November 19, 1896, to May 17, 1897.

Pen	Principal Grain Feed.	Hay.	Grain.	Ensilage.	Gain in Live Weight.
1	Ground Corn.................	16,969	4,690		38
2	Ground Bald Barley..........	18,183	4,279		33
3	Whole Bald Barley	17,996	4,618		38
4	Ground Corn and Barley	17,442	4,618		37
5	Ensilage and Ground Corn..	8,946	3,181	19,926	40
6	Whole Corn.................	14,570	5,220		44
7	Ground Corn	15,216	5,176		42
8	Whole Common Barley......	16,856	5,173		40
9	Ground Common Barley	15,637	5,047		38
10	Ground Bald Barley.........	13,958	4,767		38

Gains in Weight.

Pen.	Live Weight.				Gains in Live Weight.							
	Nov. 19.	Jan. 5.	Apr. 6.	May 17.	Nov. 19—Jan 5.	Jan. 5—Apr. 6.	April 6—27.	Apr. 27—M'y 17	Nov. 19—Apr. 6	Nov. 19—Apr. 27	Apr. 6—May 17	Nov. 19—May 17
1	53	59	79	91	6	20	8	4	26	34	12	38
2	52	57	81	85	5	24	—1	5	29	28	4	33
3	51	57	81	89	6	24	2	6	30	32	8	38
4	52	58	81	89	6	23	6	2	29	35	8	37
5	43	56	71	83	13	15	9	3	28	37	12	40
6	43	55	79	87	12	24	4	4	36	40	8	44
7	42	51	74	84	9	23	7	3	32	39	10	42
8	44	52	75	84	8	23	6	3	31	37	9	40
9	44	52	73	82	8	21	5	4	29	34	9	38
10	43	52	74	81	9	22	2	5	31	33	7	38

Light versus Heavy Feeding of Grain.

Pens Nos. 1 to 4 were fed no grain during the first eight weeks of the winter, while pens Nos. 6 to 10 received no grain from the start. The amount of grain given was not large, only 9 pounds per lamb, but the growth made during these eight weeks shows the effect of even this small amount. Pens Nos. 1 to 4, average growing 6 pounds per head; while pens Nos. 6 to 10 grow 9 pounds each. Three pounds of growth as a result of nine pounds of grain is making mutton at a very cheap rate.

For the rest of the winter the grain feeding is not much different. Pens Nos. 1 to 4 receive 114 pounds of grain per head and pens Nos. 6 to 10 receive 116 pounds. Omitting pen No. 6 with a much greater gain, due to a different kind of feed, the two lots retain to the end this difference of three pounds' gain in live weight. In other words, feeding nine pounds of grain in November and December has given three pounds more of lamb to market in May. This represents a net profit of 15 cents per lamb, or nearly one-third of the profits of an ordinary winter's work.

Whole Grain versus Ground Grain.

Pens Nos. 7 and 9 received ground grain, while pens Nos. 6 and 8 received the same amount of the same kind of grain fed whole. From November 19 to April 6, while being fed these rations, pen No. 6 gains 4 pounds per head more than pen No. 7 and pen No. 8 gains 2 pounds more. For the whole season the average is 2 pounds per head in favor of the whole grain. Thus, the grinding of the grain was not only time and labor lost but was an actual detriment to the sheep.

What Grain is Best for Sheep.

In previous years when corn has been fed in comparison with wheat, the results have been the same. This year, in comparing corn with common barley and bald barley, the corn is far ahead. Whole corn fed to pen No. 6 makes 4 pounds more of growth than whole common barley with pen No. 8. Ground corn to pen No. 7 gives 4 pounds more weight than ground common barley to pen No. 9. Corn makes 4 pounds more of growth than common barley, whether weights are taken April 6 or May 17.

It may seem to some that this is attaching a great deal of importance to a small amount of growth; that only four pounds difference in a whole winter's feeding of 180 days, is scarcely enough to show much difference in the feeding value of the various grains used. It must be remembered, however, that these small differences in growth are what determine the profit or loss on the winter's work. Lambs are fed here on a rather narrow margin. If one could be sure of paying all expenses and netting 30 cents per lamb, above the market price of hay and grain fed, it would be considered worth trying, while 50 cents per head is counted as a good return. On this margin, the difference in the above results, between corn and common barley, represents half the net profits of the whole season.

The comparisons of bald barley with the other feeds are not so easy or satisfactory. Bald barley contains so large an amount of gluten that the lambs could not handle more than a pound per head per day. It is necessary to make all comparisons with this grain before April 6, as after that date the lambs were more or less off feed and did poorly.

From November 19 to April 6, pen No. 2, on bald barley, gains three pounds more than pen No. 1 on corn, and pen No. 10 on bald barley, gains one pound less than pen No. 7 on corn. The average results are, therefore, nearly even, with a slight advantage in favor of bald barley. It is well to notice here that, during this period, the larger and stronger lambs of pen No. 2 seemed better able to handle this rich bald barley than the smaller lambs of pen No. 10, gaining two pounds more on slightly less feed. The results indicate strongly the high feeding value of bald barley for lambs, but they just as strongly emphasize the great danger of overfeeding. It would be easy, from the figures already given, to construct a theory that the perfect feed would be bald barley at the beginning and corn at the end. But, unfortunately for the theory, this is just what was tried with pen No. 4. The results up to April 6 are satisfactory, but the lambs did not respond to heavy feeding afterwards as those did that had received nothing but corn.

It seems a fair conclusion from all the results that, while bald barley has as high a feeding value as corn, it is in no way superior to it. The comparison of bald barley and common barley is somewhat in favor of the bald barley. The whole bald barley did decidedly better than the ground bald barley, not because it really had any more feeding value, but because it could not gather into a sticky mass and clog digestion as did the ground grain. As a fact, a large amount of the bald barley fed whole passed through the lambs undigested, and still they did better on it than on the ground corn, or ground corn and ground bald barley.

SUMMARY.

Good crops of barley can be grown in Colorado if good land is used and attention given to proper irrigation.

Malting barley does well in Colorado, but most of the barley grown in the State is used for feeding purposes.

On the average, bald barleys have not yielded as many pounds of grain, i. e., as much animal food per acre as some of the common barleys.

California barley has given the best yields on the

College Farm, an average of over a ton of grain per acre.

Bald barley has proved the best to grow in the mountains for grain or hay.

Analysis of barley shows that both the common barley and the bald barley contain about the same amount of total animal food; that this amount is closely equivalent to the food material in wheat or corn, and more than in either bran or oats.

Barley contains about the same elements to produce growth of bones and muscles in young animals as wheat, and more than in corn.

Bald barley contains more bone and muscle producing food than common barley.

For the production of fat in fully grown animals, analysis shows bald barley, common barley, wheat and corn to be practically equivalent.

Barley has been tested at the College Farm as feed for pigs, steers, and sheep.

Ground common barley and whole corn, fed in moderate weather to pigs of a hundred pounds or more in weight, have produced the same amount of growth.

Fed to Young Growing Pigs in Winter in Open Pens:

1. Ground bald barley has done one-half better than whole bald barley.

2. Ground corn has done one-fifth better than whole corn.

3. Ground common barley has done one-twelfth better than whole common barley.

4. Whole bald barley gave better results than whole corn as did also whole common barley.

5. Ground bald barley made the most rapid growth of any of the feeds used and produced this growth on the least food. One pound of growth was made with 3.6 pounds of grain and 0.8 quarts of skimmilk at a cost of 2.2 cents for the food.

6. Ground corn required one-half more food than ground bald barley to make a pound of growth.

7. Ground corn and ground common barley had about the same feeding value, with the slight difference in favor of barley.

8. Ground common barley required one-third more food for each pound of growth than ground bald barley.

9. Ground common barley and ground corn fed together have produced better results than the same grains fed separately.

In the Feeding Tests With Steers

1. Ground corn made considerably more growth than ground common barley. This growth was also much firmer and shrank less in shipping. The difference between the two amounted to the entire profits of the feeding.

2. Ground wheat and beets surpassed ground barley and beets in about the same proportion that the corn excelled the barley.

3. Beets added to a ration of barley produced more growth, but only enough to return three dollars per ton for the beets fed.

In the Feeding Tests With Lambs, 1895-6.

1. Ground common barley and ground corn have given nearly equal results, with the slight advantage in favor of corn.

2. The results of ground wheat and ground common barley have been almost identical.

3. Barley and corn fed separately gave a little better results than the two fed together.

In the Feeding Tests With Lambs, 1896-7.

1. Giving grain from the start produced more and cheaper growth, than feeding six weeks on hay alone before giving grain.

2. Whole grain yielded more rapid and cheaper growth than ground grain.

3. Corn, whether ground or whole, gives more growth than common barley, the difference in favor of corn being greater than it was the year before.

4. Bald barley made slightly more growth than corn when given in moderate feeds; but when the amount was raised above a pound per day per head, the lambs were unable to digest it and went off feed.

5. Corn and bald barley mixed give no better results than corn alone.

THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 41.

BLIGHT AND OTHER PLANT DISEASES.

Approved by the Station Council,
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

FEBRUARY, 1898.

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FORT COLLINS, COLORADO.

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BLIGHT AND OTHER PLANT DISEASES.

BY C. S. CRANDALL.

BLIGHT OF APPLE AND PEAR TREES.

Discussion of the disease known as blight is approached with some trepidation, and is only undertaken in response to what seems to be a growing demand from fruit growers for information concerning the disease. It has been present in the state for ten years, but never before have letters of inquiry and appeals for aid been so numerous as during the past summer.

It should be remarked at the outset that I have nothing new to offer regarding the disease or its treatment, but shall simply attempt to bring together the main historical facts, and epitomize the work that has been done by those who have given the disease exhaustive study.

Pear-blight, apple-blight, fire-blight, twig-blight are all names for the same disease; a disease which has proven the most destructive of any of the plant maladies with which the horticulturist has ever had to deal. It is not a new disease; it has been known and dreaded for at least a hundred years. The early horticultural journals abound in articles on the subject, and horticultural societies, ever since their inception, have found it a constant subject for discussion. But writing about it and discussing it failed to eliminate the disease or to make plain its cause. Discussion became so barren of results that the Western New York Society resolved that the subject should not be broached unless some one had something entirely new concerning the disease to communicate.

As with all phenomena arising from causes unknown and therefore mysterious, pear-blight offered abundant opportunity for the theorist. Theory after theory was put forth; some based upon the observations of practical men, and some on pure conceptions of the mind. Every theory as to the cause prescribed a remedy based upon the theory. These remedies were put to trial and reported on; reports varied. Two men would report the use of a remedy under similar circumstances; one with favorable results, the other with adverse results. The next season the same men using the same remedy in the same way would reverse their reports. Success one year would be counterbalanced by failure the next, and the remedy would be laid aside as useless.

Many of the successes with various remedies as reported in the older journals, we can now see were simply successes reasoned from negative results. A man has a tree affected with blight, he cuts off the blighted limbs, applies a wash of copperas over the tree, the blight progresses no further, and he reports a cure effected by washing with copperas. His experiment is worthless; had he allowed the blighted branches to remain on the tree, and applied the copperas, with an arrest of the disease as a result, then his report would have been warranted. But as he reported, might not his accredited cure have been due to the complete removal of the disease with the infested branches which he cut off? And just so with a great number of experiments tried with other remedies. They were of no value because conclusions were hastily drawn from only a part of the attending circumstances.

THEORETICAL CAUSES.

Among the numerous assigned causes of pear-blight I may mention the following. 1–Electricity and atmostpheric influences. 2–A stroke of the sun. 3–Old age, or a long duration of varieties. 4–A sudden freezing of the bark. 5–The freezing of the roots wherby absorption is prevented, and, the supply of moisture being cut off, the evaporation from the branches caused blight. 6–Too high culture. 7–The absence of certain mineral matters in the soil. 8–Insects. 9-Fungi. 10–An epidemic transmitted from place to place by the air.

Each of the above theoretical causes had a following, but most of them were entertained for a brief period only, because observed facts made the theories untenable, and wherever any one of these theories was put to the test of actual experiment it was quickly shown to be fallacious.

DOWNING'S FROZEN-SAP THEORY.

The most widely accepted of the early theories was that advanced by A. J. Downing in the first edition of his "Fruits and Fruit Trees of America" which appeared in 1845. The name "Frozen-sap blight" was there applied to the disease. The theory being that the disease was due to freezing and thawing of the sap which thus lost its vitality, became dark and discolored, and poisonous to the plant. He says a damp warm autumn, followed by a sudden and early winter, always precedes a summer when blight is very prevalent.

In enumerating the symptoms of the disease, Mr. Downing gives just those characteristic features with which every one who has come in contact with the disease is familiar. The thick gummy exudation from diseased tissue, the dark, discolored areas of bark that follow attacks upon the trunk and branches, and the sudden blackening of growing extremities in early summer.

No fault can be found with all that Mr. Downing says of symptoms, and of circumstances attending the disease; but he was wrong in many of the conclusions drawn, and in the wide application he makes of conditions that prevailed only locally. Of remedies Mr. Downing says: "The *most successful remedies* for this disastrous blight, it is very evident, are chiefly preventive ones"........"As a remedy for blight actually existing in a tree, we know of no other but that of freely cutting out the diseased branches, at the earliest moment after it appears."

In July, 1846, Mr. Downing began the publication of the "Horticulturist," a monthly journal of "Rural Art and Rural Taste," and in the second, or August number of that journal he writes at length of the blight, repeating the theory as advanced in his work of the year previous.

OBJECTIONS TO THE FROZEN-SAP THEORY.

In the December number for the same year, place is given for an article by a correspondent from Terre Haute, Indiana, who signs himself S. B. G. This writer presents a number of observations which appear as valid objections to the frozen-sap theory, some of which I desire to quote. "If this theory be true, why have its effects manifested themselves so recently? Our climate has undergone no change. The vicissitudes of weather have never been less than now. I have resided upon the Wabash more than twenty-three years and have known no difference in this respect. I have known almost whole winters that the plow might have run, while others have been cold. Late spring frosts, and late, warm, humid fall weather, have always marked our fitful climate, yet was the pear blight never heard of until recently."

The prevalence of blight in 1845 was ascribed to a frost occurring on the tenth of May. This writer cites a much more severe frost on the same day of the year 1834, but there was no blight that year.

A further objection refers to the effect of frost upon sap. "The freezing of sap does not change its properties. That the freezing of vegetable matter in a certain state of development produces death, may be admitted."........"It may also be admitted that the freezing in winter may be so severe as to destroy the vital principle as well in vegetable as animal life."........"Death thus produced is not occasioned by deleterious properties imparted to the sap, but by the mechanical force of the frost upon the cellular and woody tissues." ...."All our trees are frozen, except their trunks and large branches, every winter, especially the young and tender wood of the past summer's growth, and if an elaboration of the sap injurious in its consequences were thereby produced, no vegetable matter would survive a single winter. The economy of the vegetable world rests not on so insecure a basis as this would indicate." This writer here speaks of the spread of the disease in the individual plant, and cites a case of the production of the disease in a healthy tree by inoculation from a diseased tree. Further he says: "There is no occasion to theorize upon this subject for the mere sake of theory, and I have none that I regard as certainly true; but I strongly incline to the belief that the pear blight is an *epidemic*, that it prevails like other epidemics, and will pass off like them. The atmosphere is, I believe, generally admitted to be the medium by which they prevail, and are carried from place to place. What that subtle principle may be, which pervades our atmosphere, by which infection is retained and transmitted, so that, like the Asiatic cholera, it makes the whole circuit of our earth, human science has not discovered, and perhaps never will; but that such a principle exists, is sufficiently obivious from its effects."

Looking back in the light of what "human science" in the modern times has discovered, to those days when the germ theory was little more than a suggestion, the statement above quoted is of interest.

CAUSES SOUGHT IN ATMOSPHERIC AND SOIL CONDITIONS.

The writers for the agricultural press of fifty years ago were much inclined to look for causes of the disease in the attendant atmospheric and soil conditions. One writer in 1851 says: * "A fruit tree planted on a well-drained poor

* Patent Office Report. Agriculture. 1851 page 403.

soil will seldom suffer from blight of any kind. Too much trimming, too much moisture, and too rich soils are, in my opinion, some of the causes of blights in apple and pear trees. I believe there are several varieties of blights in apple trees and probably in pear trees also. I think I am in posession of facts and observations which will explode all the blight theories which I have seen published." This gentleman certainly observed some of the conditions which may aggravate blight, but his was as far from the true cause as any of the blight theories he thought himself able to explode.

FUNGI.

The man who introduced the theory of a fungus origin of the disease was for a considerable time quite safe from contradiction. Many fungi are very small; to learn anything of them beyond the fact of their existence requires a microscope. They had then received little attention, little was known of them, and it was impossible to prove or disprove their casual connection with the disease.

An investigator in 1872 ascribes the disease to a local fungus fermentation of the genus Torula and he observes that * "Every condition that will prevent the bark and shoots from ripening will foster under high temperatures, in the presence of organic acid and vegetable nitrogenous matter, one or more species of Torulacei fungi." And he further infers that contamination may come about by the absorption of the fungus germs by the roots, and in this case the fermentation proceeds from the sap-wood to the exterior. Drainage, or the removal of the tree to a more favorable place is recommended. The writer speaks of another form of the disease where the fermentation proceeds from the surface to the interior. This he calls atmospheric blight. Now beyond the fact of the presence of fungi in the diseased tissues this was all theory.

In 1875 Thomas Meehan, editor of the Gardener's Monthly, in speaking of the researches of Dr. Hunt of Philadelphia, says he finds "That a very minute fungus germinates in the outer bark, enters the structure, destroying the cells as it goes, till it reaches the alburnum, and then it penetrates clear to the pith, by the way of the medulary rays, totally destroying the branch from center to circumference;" and he adds, "There is no other conclusion here than that arrived at by Dr. H., that in the true fire blight, fungi are the cause of the disease."

It was an easy matter to find fungi in the dead tissues

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* Department of Agriculture Report 1871, page 191.

of trees affected by blight, and their presence there was considered as sufficient evidence that they caused the disease. No crucial test was ever applied to prove that causal action. So in the absence of positive proof, all the claims of discovered cause made, up to this time were valueless.

DISCOVERY OF THE TRUE CAUSE.

The first light shed upon what has since been proved to be the true cause of pear blight was in 1878 when Professor Burrill of Illinois announced to the Illinois State Horticultural Society the discovery of bacteria apparently connected with the disease. The germ theory of disease had been under discussion for several years, and, previous to this time Pasteur had (in 1869–70) demonstrated that a microbe caused the terrible silk-worm disease, and later in 1876 that splenic fever and fowl cholera were also due to the action of specific microbes. Professor Burrill was the first to suggest that these low organisms might be connected with plant diseases. In his announcement in 1878 he made no positive assertion, but simply reported discoveries which were sufficient foundation for a very strong suspicion that these organisms did cause the disease. Continuing his investigations of the subject, in 1880 he had advanced far enough to announce before the American Association for the Advancement of Science that he had discovered the cause of pear blight. That the cause was a specific organism, for which he proposed the name Micrococcus amylovorus. Professor Burrill rested his claim upon the results obtained in a series of experiments. He inoculated healthy pear and apple trees with diseased tissue, and, in a large number of cases, blight followed the inoculation. The process of inoculation was both by the transfer of small pieces of diseased bark, and by pricking with a needle dipped in macerated diseased tissue. His results would seem to warrant his assertion that blight was caused by the organism which the microscope showed was present in large numbers. But in the light of modern methods of experiment, his proof could not be considered as absolute.

Investigators of the etiology of the contagious diseases of animals, agree, that in order to prove positively that any suspected organism is the specific cause of any particular disease, four steps are necessary. These steps which were first recognized, enumerated, and published by Professor Cohn, are as follows :

1. To demonstrate the habitual presence of the organism in cases of the disease in question.

2. To find some medium outside the animal body, in which this organism will live and multiply.

3. To cultivate the organism in this medium for a sufficient number of generations to insure the complete elimination of other organisms that may have been introduced into the first cultivation; in other words, to secure a pure cultivation of the organism.

4. To inoculate a healthy individual from the pure culture of the organism, and produce the original disease.

These steps carefully followed, afford a means of proof that, it seems to me must convince the most skeptical. This method of proof is just as applicable to plant diseases as to animal, and in the case of pear blight it remained for Professor Arthur, then of the New York experiment station at Geneva, to apply it. This he did during the seasons of 1884 and 1885.

WORK OF PROFESSOR ARTHUR.

Professor Arthur used as a culture medium a tea made by steeping corn meal in water and then filtering until a clear infusion was obtained. In this medium he cultivated the organism for a number of generations. Trees inoculated from his last culture, which contained Micrococcus amylovorus, and no other organism, developed the disease. Here was good proof that this specific organism caused pear blight; but there was one question that might be raised. Might not the liquid in which the organism lived be the exciting cause, instead of the organism? To prove this point a culture containing the organism was filtered through porcelain. The clear liquid, which upon examination by the microscope was shown to be free from germs, failed in every case to communicate the disease, but the residue of germs, left after filtering, when used to inoculate healthy trees, readily produced the disease. Thus by the method of experiment has every doubtful point been covered, and the fact established beyond controversy that this particular organism, Micrococcus amylovorus, is the true cause of pear blight, or apple blight.

This demonstration did not at once meet with universal acceptance. Various objections were raised to it. There were many men who refused to accept as the exciting cause something they could not readily see, something which could not readily be made evident to the senses. The observation and study of these low organisms, and of the tissue in which they live must be carried on under high powers of the microscope; they must be magnified at least

1,000 diameters. It is only men trained in the use of the microscope that can carry on observations under these conditions. The growth of an organism in a culture fluid is readily observed by the naked eye, by reason of its action on the fluid, and the results obtained by inoculation are easily seen. These two points must serve to inspire confidence in the statements of the microscopist regarding what takes place beyond the range of natural vision. The specific name, amylovorus, given by Professor Burrill, to this organism, means starch-devouring, and was given because the removal of starch from the cells appears to be the work they perform. In the process, which is a true fermentation, carbon-dioxide is given off, and butyric acid is formed.

EPIDEMIC NATURE OF THE DISEASE.

Like all diseases which have been traced to an origin in low forms of life, pear blight is epidemic in its character. During certain seasons it is very destructive; this extreme virulence may last two, three, or four years, then the disease will decrease, or possibly pass away entirely, to appear again after a long interval.

Charles Downing says, in speaking of his locality: "Pear blight has appeared at intervals of about twenty years, and the duration of each has been from three to five years. I have passed through three of these periods, and with each additional visit the attack is very much lighter ; and like many other diseases it may run itself out in time." Mr. Downing's statement was made before the true cause of the disease was known. There does seem to be a periodicity connected with the disease, and while we are likely to have intervals of immunity, I have no faith in its finally running out.

MEANS ON DISSEMINATION.

How does the disease get into the tree, and how is it carried from one tree to another? First as to its dissemination. Whether the germs of the disease are carried in the air or not has not yet been satisfactorily demonstrated, but it is well known that insects carry the disease, and that in them we have the chief means of its dissemination. The gummy exudation already alluded to, which is commonly present in cases of attack upon the trunk or larger branches, is shown by examination to consist of myriads of the living organisms, held together by the viscid secretion which seems so characteristic of their work. This exudation is most abundant in the spring after the tree has started into full activity. It is attractive to insects, and they by their frequent visits disseminates the organisms rapidly at a period when the opportunities for their easy access to healthy plants are best.

HOW THE GERMS GET INTO THE TREE.

Now as to the method of gaining access to the tree. The virus of the disease spread upon healthy bark will not communicate the disease; this has often been proved by experiment. The microbe is incapable of penetrating healthy bark; but prick the bark with a fine needle smeared with the virus and you can produce the disease. The puncture or wound, no matter how small, is large enough to afford access to the germs which at once find themselves under conditions that will promote their growth. Wounds in the bark then, afford one means of access to the disease. Most cases of blight on the body of the tree originate in this way, certainly all those that show only isolated diseased areas, and in many of these cases the fact that the disease has spread from a central point of infection is very apparent. Last season portions of the trunks of several trees, ranging from one and one-half inches to two and one-half inches in diameter were sent us from an orchard near Canon City. Each piece bore from one to four elliptical areas of bark dead from blight, and in each case it was very plain that the disease had spread from a center; the center being a point where a starting shoot had been rubbed off. This would point to a need for some application following the removal of adventitious shoots to prevent the access of the blight organisms.

During the winter season, fully formed bark envelops the whole tree, forming an impervious protective against the disease, so at this season the only means of access would be by wounds. But as the buds push in spring we have presented other vulnerable points. The young shoots are soft and succulent, they have no covering capable of resisting attack, as has been often demonstrated. When the flowers expand we find in the flower cup, parts that are even less protected than are the youngest shoots. The stigma and nectaries offer conditions most favorable to the development of the organism.

Insects are no doubt responsible for the first infection, and in their busy flight from one flower to another during the whole period of flowering they disseminate the disease from one tree to another, and from orchard to orchard. It has always been observed of the disease that the twig-blight form was most common shortly after the blooming period, and the reason seems apparent.

The points of access are then three in number. The flower, the young and growing shoots, and wounds in the bark.

CONDITIONS WHICH AGGRAVATE THE DISEASE.

It remains for us to consider briefly the conditions which may aggravate the disease and what may be done to check or prevent it. It is a matter of common observation that the disease varies greatly in different localities and in different seasons. It may progress slowly or with great rapidity. Knowing as we do now, the cause of the disease, and the conditions under which the organism most rapidly propagates, we can account for this variation by the different conditions prevailing. The old theory that rich soils, and moisture were the cause of the disease was a favorite one, and undoubtedly arose from the observation that on rich soil, and in moist seasons the disease was most virulent and destructive. Rich soils with accompanying moisture is conducive to rank, rapid growth. The tissues formed are gorged with sap, and are very succulent. In this condition of things, we find all that is necessary for a rapid growth of our microbe. On a soil of only moderate fertility the growth is slow, less succulent tissue is produced, and if the supply of moisture is small, we have conditions not advantageous to the organism, and its development is slow. In this matter of growth we find a reason for the various opinions regarding clean culture, or grass in the orchard. One man has no blight and attributes his escape to clean culture. Another has no blight and thinks it is because his orchard is in grass. Both may be right, though the reasons they give for the immunity are wrong. An orchard on rich soil may receive just the necessary check in growth to prevent too great succulency by having grass in the orchard. An orchard on poor soil may need the clean culture to keep it in healthy growth. Anything then, whether in the choice of soil or manner of treatment that gives the trees a slow growth which will thoroughly ripen and harden, will render them less liable to attack from blight. Close planting is objectionable, because the ground being too much shaded, moisture is retained, and moisture favors blight.

In irrigating, care should be taken not to apply an excessive amount of water. I believe the general tendency is toward the use of too much water, and that by this means that succulent growth so readily attacked by blight is induced.

Water should only be applied when needed, and the need is easily discovered by careful examination of trees and soil.

TREATMENT.

From the nature of the disease, it is evident that when it has once gained access to the tree, preventive applications are useless.

The organism is secure in the cell tissue beneath the outer bark; you cannot reach it with any germicide yet known. There is therefore, but one remedy, and that is to cut and burn the infested portion of the tree. If trees are closely watched and diseased portions removed as soon as discovered, the difficulty may be checked without serious injury to the tree, but if allowed to spread until the amputation of large limbs becomes necessary the tree will be deformed if not entirely ruined. In years when the disease is extremely virulent, this work of cutting out is discouraging, and this has led some to object to the practice. Objections have also arisen from those who were unsuccessful because of careless and imperfect work. There is, however, abundant testimony from many sources that it pays to follow the practice closely and persistently. There is no other way of holding the disease in check after it has once started.

In cutting out twig blight it is hardly practicable to protect the cut surfaces; but where branches one-half inch and upward in diameter are removed, and particularly where the bark is cut away from blighted areas on the trunk and larger limbs, the cut surfaces should be at once covered with some protective coat. Lead and oil paint, shellac wash, and various forms of grafting wax, have all been used. I prefer the paint because it is cheaper, and less liable to crack and fall away under the drying action of the sun.

In cutting out blighted portions there is one precaution that should always be observed, and that is the sterilization of the knife after each cut; if this is not done, germs may be left upon the cut surface of the branch and the disease will continue to spread.

The sterilization of the knife may be effected either by passing through a flame or by immersion in carbolic acid or other germicidal solution. In cutting, it should of course, be the aim to cut safely below the diseased part. The limit of the disease is not the well marked line of dead tissue. It is not in the dead tissue that we find active work going on. The very fact that the tissue is dead and discolored is evidence that the organism has sapped it of all nutriment and is through with it. The work of destruction goes on outside this line of dead tissue, and extends a variable distance, from only three or four, to twelve or fifteen inches. So in cutting be sure and make the cut sufficiently low to remove all the infested tissue. If the tree becomes very badly affected before receiving attention, it is best to grub it out and burn the entire tree.

VARIETAL DIFFERENCES.

There appear to be no varieties that are entirely free from attack, but, according to reports, there are wide differences in susceptibility and in resisting power. The testimony concerning pears, gathered from many sources, indicates that Anjou, Angouleme and Seckel resist attack better than do Bartlett, Clapp or Flemish Beauty, and when attacked the disease progresses less rapidly in the first three, than it does in the last three.

Among apples, the varieties of crabs seem everywhere more susceptible than do standard apples, but even here occasional exceptions are met with. A case illustrating this came under my notice at Eaton.

A three-acre garden was surrounded by a row of crabs, Martha and Whitney alternating. The Whitney trees were all either dead or dying of the disease, while not a Martha had been attacked. The difference between the two varieties was here so marked as to suggest security from attack on the part of the Martha, but in other localities the variety has succumbed. Reports concerning the standard varieties of apples vary greatly from different localities. Varieties apparently immune in one locality are badly attacked in another, and I am inclined to the belief that the differences in behavior toward the disease, with both pears and standard apples, are due more to varying local conditions than to varietal differences.

The crabs are so universally attacked that it seems undesirable to plant them at all. In choosing varieties of standard pears and apples, be governed by the best local experience, and by the fruit list as recommended by the Board of Horticulture. Then by rational treatment bring about those conditions of growth that make the trees least liable to attack. If trees are attacked follow the course outlined in the preceeding pages, and by persistence eradicate the disease, or at least hold it in check.

Of remedial preparations offered for sale I have nothing to say. Having stated the cause of the disease, and outlined its manner of work, I leave the probability of cure to the judgment of the intelligent reader.

MECHANICAL INJURIES

TO WHICH

FRUIT TREES ARE SUBJECT.

The disease we have attempted to discuss is only one of the many sources of injury to which our fruit plants are liable. Aside from the numerous insect pests which are demanding constant attention, we have a long list of parasitic fungi, and certain other mechanical injuries whith result from peculiarities of climate. Some of these deserve brief mention here.

The mechanical injuries referred to are commonly spoken of as "frost-crack" and "sun-scald," and both are referred to a combined action of sun and frost. Most of the cases of so-called sun-scald that have come under my observation have proved to be cases of blight upon the trunk or large branches. They are characterized by dark, discolored areas of dead bark, commonly circular or elliptical, but sometimes irregular in form, and most frequently, though not always on the side exposed to the sun. The dead bark as it dries shrinks and adheres closely to the wood.

Frost cracks occur upon the exposed side of the trunk, extending longitudinally. They are produced in winter and early spring under the influence of extreme low temperatures, and may, when growth starts close and entirely heal. The liability of trees to injury of this character depends mainly upon the amount of water contained within the tissues. Trees that grow late, and enter the winter with wood not thoroughly ripened, and hence containing more water, are more susceptible to injury than those that are enabled to ripen and harden the wood. Even well ripened wood contains normally about 40 per cent. of water. Trunks of apple trees cut on the fifteenth day of January 1897 when last weighed, on the eighth of January 1898 showed a loss of water by air drying of 39.36 per cent. and branches from the same trees lost in the same time 42.24 per cent. The weights are not yet quite constant, but the figures may be taken as an approximate showing of the moisture contained in normal tissues in midwinter. But this moisture is not in the easily freezable liquid form; it is distributed as a constituent of cell wall, and in the viscid or solid cell contents, and can only be withdrawn and crystalized under the prolonged action of extreme cold. Suppose a tree thus normally constituted to be subjected, during the winter or early spring, to a period of warm bright weather. The influence of the sun's rays penetrates the tissues, the cell contents become less viscid, water taken in by the roots still further liquifies these cell contents, there is movement within the cells and they become turgid with fluid sap. A sudden change marked by temperatures below zero occurs. There is a gradual shrinking of the tissues until the point of actual freezing, or crystalization is reached, and then comes that familiar and seemingly resistless expansion. If the sap-gorged tissues escaped rupture during the process of shrinking they are sure to yield to the expansive force accompanying congelation.

This form of injury is usually worse on plums, cherries, and peaches, than upon apples and pears. The cracks are less likely to heal; they more often increase in size, and the exudation of gum is followed by rot which leads to the death of the tree.

With all trees this trouble can be in large measure prevented by providing some protection against the sun. This protection is most needed when the trees are young; as they attain size they in a measure protect each other. Various devices have been used, but we find wrapping with burlap the cheapest and most effective. Burlap that has been used for baling was purchased at dry goods stores at two cents per pound. One pound supplies twelve strips four inches wide and three feet long, and one strip is sufficient for a reasonably low-headed tree three to five years in orchard. The burlap being cut, and strings of proper length at hand, one man will wrap the trees at the rate of 60 an hour. The cost is thus nominal and the protection afforded ample.

More serious than the the frost crack is that mechanical injury which is characterized by a separation of the bark from the wood. It has thus far been reported upon apple trees only, and most of the cases of which I have knowledge occurred in the southern portion of the state.

The separation between wood and bark in those cases examined occured near the ground, and was not noticeably confined to any particular side.

In most cases the bark appeared discolored over a portion of the separated area, and more or less ruptured as if from lateral tension in drying. Between the discolored portion and the limits of the affected areas the separated bark often appeared perfectly healthy, and in some cases new growth was protruding into the space between bark and wood. A few cases were found that gave no visible sign of injury beyond a slight change from the normal color of the bark. There was nothing to indicate the size of the affected areas; the bark was smooth and apparently healthy, but when struck emitted the hollow sound that proved a sure test of the extent of the injury. In cases of this kind it would seem that considerable time might elapse between the working of the cause and the discovery of its effect, and I apprehend that the first evidence of injury would be seen in a generally unhealthy appearance of the foliage of the tree. Of course, if the trunk was affected to the extent of girdling it, the tree would soon die. If the affected area was confined to one side the tree might endure for some years, but with vitality diminished in proportion to the extent of the injury.

Where small areas only are affected the tree may by the intrusion of newly formed tissue, completely cover the denuded wood and thus effect a cure. From the location of this trouble beneath the bark, and from the tardy appearance of any evidence of injury, it is clear that a practical demonstration of the cause would be difficult if not impossible. I am not aware that any actual demonstration of the working of the cause has ever been made. Since the trouble became known its origin has been assigned to the action of frost, but there was no tangible basis for the assumption until the matter was taken up and critically studied by Professor Burrill of Illinois. The results of his observations and the theoretical deductions from them were presented in a paper before the American Association for the Advancement of Science at the Ann Arbor meeting in 1885. After explaining frost cracks, and the phenomena attending the crystalization of liquids by frost, he says—"The second form of injury—especially prevalent in apple trees—is believed to be due to the *growth* of ice crystals studding in a close or dense layer, the surface upon which they form. Such miniature forests of crystals can be found in green plants even after slight freezing, as well as in ripened wood in severely low temperatures." The process of crystal growth is further explained as follows: "In the trunks of trees the crystalizations begin in any part where there is proportionally most pure water. The very process of solidification causes, by the law of equal diffusion, a movement of water from adjoining parts, toward the point from which the first liquid (as such) is removed. Hence the ice crystals first formed constantly grow, attracting as it were the water from neighboring parts of the tissue. This growth of the crystals, associated as they occur in close layers, pushes asunder the normally connected tissues." The theory here given being based upon careful observations, and being in perfect accord with physical laws has been accepted as the true explanation of the trouble under discussion. It will be noted that the operation of the theory depends upon the presence of fluid sap, and that the greater the water content of the tree the more liable it is to injury. It follows that the same conditions that protect against other frost injuries will protect against this. Fruit growers should therefore, use every endeavor to thoroughly ripen the wood of the trees before winter sets in and thus reduce the liability to injury from frost to the minimum.

FUNGOUS DISEASES.

Leaf Blight or Rust of the strawberry. This is a cosmopolitan disease due to the parasitic fungus known as Sphærella fragariæ. While our climatic conditions are in general unfavorable for the development of this disease, we do occasionally have periods during which it does injury. Moisture is necessary for the germination of the spores, and the fungus can spread to an injurious extent only during moist and warm weather. The month of June, 1895, was marked by prevailing high temperature and frequent showers, and during that time the disease did considerable damage to strawberry beds about Fort Collins. This past season the disease started under somewhat similar conditions toward the latter part of May, but showers becoming less frequent it did no serious damage.

All growers are familiar with the purple or red spots which mark the presence of this disease. These spots enlarge and become of a brown color; finally, by the growth of the spores beneath, the cuticle is ruptured and they then appear white at the center with a brownish ring outside. Affected leaves soon turn brown throughout and die.

This loss of foliage saps the vitality of the plant, and if the attack comes early in the season it prevents the development of a full crop of fruit. If the attack comes after the fruit has been harvested the plants are weakened so that the crop for the next year will amount to nothing, or at least be shortened, depending upon the severity of the attack. As the mycelial threads of the fungus are within the leaf tissues it is apparent that preventive, rather than curative measures must be resorted to. The fungus survives the winter within the leaf, both by spores and by its mycelium. It follows that the destruction of infested leaves in the fall is important as a means of holding the disease in check. The practice of mowing the old leaves after the fruit has been removed and then burning is not to be recommended because it sometimes results in injury. It is better to rake the leaves off the bed for burning and then by cultivation and the application of ferlilizer induce a vigorous new growth preparatory to fruiting the next season.

The simplest and most effective way of controlling the disease is, however, by spraying with any of the standard fungicides adapted for application to foliage. The following have been successfully used. Hyposulphite of soda, one pound to ten gallons of water, applied every ten days. Modified "Eau celeste" made as follows—Dissolve one pound copper sulphate in two gallons of water; in another vessel dissolve one pound of Sodium carbonate; mix these two solutions and when chemical action has ceased add one and one-half pints of ammonia. Dilute to 25 gallons. Ammoniacal copper carbonate made by dissolving three ounces copper carbonate in one quart of ammonia, and diluting to 25 gallons. Three or four applications of the copper solutions are usually sufficient.

ORANGE RUST OF BLACKBERRIES AND RASPBERRIES.

This disease has been reported from Arvada and other places near Denver, and has been present here in Fort Collins for the past three years. It has not been particularly destructive, but the damage done is sufficient to warrent a word of caution. Eastern growers have in many places suffered severely from the disease, and it would be well to profit by their experience and use every effort to exterminate it. The cause of this disease is a true fungus (*Cæoma nitens*) which has been known under various names since 1820.

Its presence has been reported from nearly every state east of the mountains: it is common in Canada, and is also known in Europe. Apparently it is confined in its work to plants of the one genus-Rubus, but has been observed on nearly every species of the genus. It works on wild as well as on cultivated plants, and appears to prefer some species to others. As between the dewberry and the blackberry it works most upon the dewberry: and between the black and red raspberries the blacks are more susceptible to attack. The disease also shows choice of varieties: thus the Kittatinny and the Erie blackberries seem much more susceptible to attack than do Snyder and Wilson.

The presence of the disease can be detected quite early in the spring in the tufted slender shoots which are produced, and in the glandular appearance given to some of the new leaves by an early and little understood spore form which the fungus produces. Later, about the first of June the Æcidium or cluster cup spore formation may be looked for. The cluster cups first appear as small raised spots covering the under surface of the leaves: soon the skin is ruptured, the cups containing the spore masses protrude, and then we have that characteristic appearance which suggested the name orange rust.

This, the fruiting stage of the fungus is conspicuous, and cannot fail to attract attention, but it is not all there is to the plant.

The vegetative portion consisting of very minute threads which ramify through the plant, and which must develope before spore formation can take place is not apparent to the naked eye: it gives no sign of its presence except by inducing the tufted growth of slender shoots.

It will readily be seen that this vegetative portion of the fungus is beyond the reach of any curative applications that might be made. It is secure within the tissues of the plant, and since it has been proved that the threads extend into the roots and are perennial, we are led to the conclusion that our only course is to completely destroy the infested plants Spraying has been recommended as a protection against the spreading of the fungus by the spores, but spraying will be unnecessary if the plants are carefully watched and the infested ones removed before the dissemination of spores begins.

ANTHRACNOSE OF THE RASPBERRY AND BLACKBERRY.

In 1896 canes of black-cap raspberry infested with this disease were sent us from near Denver. From the fact that nothing has been heard of the presence of the disease since, we regard this as an isolated case introduced, in all probability, on plants from some eastern nursery. The dryness of our climate is not favorable to the development of this disease and we apprehend no serious trouble from it; but as it is liable to appear at any time on introduced stock, it may be well to dwell briefly upon its characteristics. The cause of the disease is a fungus (Glœosporium venetum) and Professor Burrill of Illinois is credited with publishing the first account of it in 1882 under the name Raspberry Cane Rust. The disease appears to be confined to the blackberry and black-cap raspberry. As with the orange rust the vegetative threads of the fungus ramify within the plant and are perennial. The first evidence of the presence of the fungus is seen in small, purplish, circular or elliptical spot on the canes near the ground. As the canes grow the fungus ascends and the spots appear at intervals even to the tips of the canes. The spores are formed about the centers of these spots and as they push outward the bark is ruptured and curled back. The spots then appear grayish white with a purplish border. Often several spots may coalesce forming irregular patches. While the principal work of the fungus is on the canes, it is not wholly confined there, but may appear on the petioles and veins of the leaves. The nature of this fungus suggests the cutting out and burning of all canes seen to be affected. As a preventive measure it is recommended to spray, as soon as the canes are uncovered in the spring, with a solution of sulphate of iron, two pounds to five gallons of water, to be followed later, if the disease appears, by an application of the Bordeaux mixture.

THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 42.

SUGAR BEETS IN COLORADO IN 1897.

Approved by the Station Council,
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

FEBRUARY, 1898.

Bulletins will be sent to all residents of Colorado, interested in any branch of Agriculture, free of charge. Non-residents, upon application, can secure copies not needed for distribution within the State. The editors of newspapers to whom the Station publications are sent are respectfully requested to make mention of the same in their columns. Address all communications to the

DIRECTOR OF THE EXPERIMENT STATION,
Fort Collins, Colorado.

EXPRESS, FORT COLLINS

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FORT COLLINS, COLORADO.

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SUGAR BEETS IN COLORADO IN 1897.

W. W. COOKE AND WM. P. HEADDEN.

During the past few years the interest in the growth of sugar beets has largely increased. The Colorado Experiment Station has for many years been encouraging their growth in Colorado, but the work of 1897 was conducted on a larger scale than any previous year. The United States Department of Agriculture at Washington gave the Station five hundred pounds of beet seed for conducting the trials, and the Station also received two hundred pounds from A. Keilholz, Quedlinburg, Germany, through his United States agent, F. G. Zimpel, New York City. The government seed was the Kleinwanzlebener variety, imported by the Oxnard Beet Sugar Co. and sent to us from Norfolk, Nebraska. The seed from A. Keilholz was the Imperial White variety.

With this large amount of seed on hand, it was determined to extend the experiments over all the agricultural sections of Colorado. Notices were inserted in the newspapers of the State, to the effect that the station would send the seed to those that applied for it, and who would promise to take good care of the crop and report results in the fall. Applications were received from and seed sent to six hundred and eleven persons, representing forty-seven counties.

One pound of seed was sent to each person, accompanied with a copy of a bulletin giving full directions for the planting and care of the crop. How the directions were carried out will be noted in another place in this bulletin.

The seed was sent out in April and early May. About the middle of June a circular was sent to each one who had received seed, asking for information as to the planting of the crop. A copy of this circular is given later in this bulletin.

Of the six hundred circulars sent out, less than two hundred and fifty were ever returned, showing that not half of those who applied for the seed really desired to ascertain whether or not they could grow beets fit for sugar purposes.

When the time came in the fall for taking samples of the crop for analysis, it was deemed best that some at least of these samples should be taken by a representative of the Station so as to know better than it could be told on any blank, the exact circumstances under which the crop was grown and its condition at the time the samples were taken. With this object in view, the agriculturist of the Station visited about forty farms situated east of the range, secured samples of the beets, and made full notes of the conditions.

When the work of the season was planned it had been hoped that the new chemical laboratory of the college would be completed in season, so that most of the beets could be analyzed in Fort Collins. Owing to unavoidable delays, this building has not even yet been completed, and in the crowded condition of the old laboratory still in use, it was found impossible to make many more analyses than were required by the tests of beets grown on the college farm.

In this predicament, the Secretary of Agriculture at Washington came to the rescue, and through his kindness, nearly all the samples taken of beets grown outside of Fort Collins, were analyzed at Washington.

It was soon found that to get samples enough to fairly represent the different parts of the state would require more time than any representative of the Station had to spare, and therefore the first of October a circular was sent out asking those who had grown sugar beets to take samples and forward them direct to Washington.

At the same time there was sent to them from Washington, blanks for describing the samples and shipping tags, so that the beets could be sent by mail free of postage.

Below are given copies of the two papers sent from Washington.

UNITED STATES DEPARTMENT OF AGRICULTURE.

WASHINGTON, D. C., *August 15, 1897.*

Directions for Taking Samples of Sugar Beets for Analysis.

Prepared by H. W. WILEY, Chief of Division of Chemistry.

When the beets appear to be mature (September 15 to November 15, according to latitude and time of planting) and before any second growth can take place, select an average row or rows, and gather every plant along a distance which should vary as follows, according to the width between the rows:

From rows		16 inches apart,		length	75	feet.
"	"	18	"	"	" 66	"
"	"	20	"	"	" 59	"
"	"	22	"	"	" 54 and four-fifths feet.	
"	"	24	"	"	" 50	"
"	"	28	"	"	" 42 and nine-tenths	"

The beets growing in the row, of the length above mentioned, are counted. The tops are removed, leaving about an inch of the stems, the beets carefully washed free from all dirt and wiped with a towel. Where the row is not long enough to meet the conditions, take enough from the adjacent row or rows to make up the required length. Rows of average excellence must be selected; avoid the best or poorest. Throw the beets promiscuously in a pile and divide the pile into two parts. This subdivision, of one-half each time, is continued until there are about ten beets in a pile. From these ten select two of medium size. Be careful not to select the largest or smallest.

From all the rest of the beets, save these two, the necks are removed with a sharp knife at the point indicated by the dotted line in the figure. The beets, including the two saved as a sample, are then weighed.

The number of beets harvested multiplied by 435.6 will give the total number per acre. The total weight of beets harvested multiplied by 435.6 will give the yield per acre.

Wrap the two sample beets carefully in soft paper, and write your name legibly thereon. The beets must be perfectly dry. Fill out blank describing beets, enclose in the envelope, and sew up in bag with beets. Sew the beets up in a cotton bag, attach the inclosed shipping tag thereto, and send by mail.

No beets will be analyzed which are not sampled as described above and properly identified.

Miscellaneous analyses of samples without accurate description are of no value.

Blanks are sent to each one for two sets of samples. From two to four weeks should elapse between the times of sending the two sets of samples.

If additional analyses are desired other blanks will be sent on application, but not more than four analyses can be made for any one person, except in special cases.

A model, showing how blanks should be filled out, is inclosed.

U. S. DEPARTMENT OF AGRICULTURE.

DESCRIPTION OF SAMPLE OF SUGAR BEETS.

Prepared by H. W. Wiley, Chief of Division of Chemistry.

Variety ....

Date planted ....

Date thinned ....

Date harvested...

Character of soil..

....

....

....

Character of cultivation (dates, implements, etc.) ....

....

....

....

....

Length of row harvested (feet) ....

Width between rows (inches) ....

Number of beets harvested..................................

Total weight of beets harvested, less necks and tops, (pounds) ....

....

Weather for each month.....................................

....

....

....

....

State..

Post-office..

Date...

Name...

Note—Samples of beets will not be analyzed unless accompanied with this blank filled out as indicated in model B.

The first samples were taken September 13, when the crop showed no signs of ripening. Several samples were taken during the next week and quite a number on September 24 and 25. In every case the beets were found in full growth and far from ripe. Analyses of these samples showed them to be low in both sugar and purity.

Of thirty-three samples taken, only two were found that were above twelve per cent in sugar and also above eighty per cent in purity, this being the ordinary standard adopted by sugar factories for merchantable beets. Four other samples showed below eighty per cent purity, but enough above twelve per cent sugar to make them of value for factory use.

In the following table the results of these early samples are omitted as the crops evidently, were too green for harvesting. Many of these fields were again sampled later in the season and the results of the second set of samples are given in the table.

Several statements need to be made in regard to these tables. They are intended to represent ripe crops. Besides the samples just mentioned, quite a number of other analyses were omitted when it was know that the crops were not ripe when the samples were taken. All analyses of ripe crops are entered, even though the analyses show that the crops were unfit for factory use.

These tables represent the character of the beets that were received for analysis, at the time they were received. It does not necessarily follow that they represent a fair average of the field from which they were taken or that when received at the labratory they were in the same condition as when pulled in the field. A great many of the samples were not taken by employes of the Station and we have to trust to the judgment of the person sending the sample, that it correctly represents the field. The greatest single chance for error is in the drying out of the sample between the time it is pulled and the time of analysis. In some cases this would increase the analysis, while in others, through fermentation of the beets, the results would be lowered. The instructions say clearly to wrap the beets carefully in paper in order to keep from drying out, and where the instructions have been followed the results are closely correct. But some samples have been received in bad shape. Indeed the analyses of some fifteen or more samples have been omitted from the tables because the samples themselve showed that they had dried out to such an extent that their analyses did not represent the beets as they stood in the field.

For the purpose of this bulletin, the State has been divided into five sections.

1. The valley of the South Platte and its tributaries.
2. The Divide, south of Denver where crops are raised without irrigation.
3. The valley of the Arkansas.
4. The valley of the Grand.
5. The San Luis Valley.

Under each section the samples are given in the order of time that the beets were dug, since it is found that this factor has been more powerful than any other in determining the quality of the beets.

All the seed used was Kleinwanzlebener except the samples double starred which are Vilmorin and those starred which are Imperial White.

PLATTE VALLEY.

No	Name.	Address.	Date when sample was dug.	Average weight of the beets analyzed.	Sugar.	Purity.	Weight of crop per acre.
				Ounces.	Per cent.	Per cent.	Tons.
1	C M C Woolman.....	Sterling	Sept 18	11	14.5		16
2	" "	Sterling	" 18	9	12.5	76.3	16
3	F C Marks............	Sterling	" 18	13	13.2	86.0	9
4	T B Robinson........	Fort Morgan	" 29	20	13.3	82.8	*9
5	S M Scott.............	Fort Morgan	" 29	13	16.1	81.3	8
6	J A Davis............	Berthoud	Oct 2	21	13.9	81.6	29
7	C A Caykendall.......	Loveland	" 3	22	14.4	78.7	30
8	L A Dwight...........	Boulder	" 4	24	13	77	29
9	Arthur Ling...........	Greeley	" 5	40	13.4	87	40
10	J W Bacon ** Upland	Longmont	" 15	63	14.6	81.4	21
11	" " **.......	"	" 15	15	15.4		21
12	" " ** Lowland	"	" 15	26	12.5	76.2	22
13	" " **.......	"	" 15	19	14	82.1	22
14	D M Lambert.........	Bellevue	" 20	14	15.5	76.4	
15	Fred Greve...........	Crook	" 15	18	16.5		15
16	Chas Johnson.........	Atwood	" 20	14	15.2	82.4	11
17	R S True..............	Highl'nd Lake	" 20	27	16.2	85.9	
18	W S Simpson.........	Fort Morgan	" 28	19	16.1		20
19	W W Remington......	"	" 16	29	13.7	80.4	25
20	J A Davis.............	Berthoud	" 28	28	16.7	84.5	35
21	F M Wright..........	"	" 30	20	14.1	77.5	10
22	C Cornelius...........	Lafayette	Nov 1	28	14.3	77.7	30
23	C Reed................	Orchard	" 1	13	16.1	82.8	47
24	S M Scott.............	Fort Morgan	" 1	15	15.6	80.4	12
25	H C Hatch.	Sterling	" 1	43	12.7	75.6	23
26	L A Dwight	Boulder	" 4	16	18	84.3	31
27	J J Thomas *	Lafayette	" 23	29	20	86.4	36
28	" " *	"	" 7	73	14.4	80	
29	W M Post	Fort Collins	" 9	25	13.3	74.4	18
30	T R Baldwin..........	Bijou Basin	Oct 15	20	12.7	73.1	
31	Alfred Johnson.......	Atwood	Nov 12	19	15.3	83.3	
32	J A Davis............	Berthoud	" 7		15.5	86	
33	E K Smith............	Fort Lupton	" 8	19	14.5	80	
34	Fritz Neimeyer.......	Evans	" 6	74	14.2	81.2	
35	" "	"	" 6	53	12.6	78.3	
36	" "	"	" 6	41	11.5	81.8	

No.	Date of planting.	Pounds of seed per acre.	Stand.	Date of first cultivation.	Date of thinning.	Date of first irrigation.	Remarks.
1	May 22		Thick	June 15	July 3	July 1	Black heavy loam.
2		Same as	No. 1				
3	June 10		Good		July 10		First crop on new breaking bottom land.
4	May 5		Thick	May 25	June 29	May 14	Rich garden soil manured '97
5	May 15		Uneven		July 15	June 25	Sandy loam.
6	April 20	10	Thick	June 2	June 6	June 24	Sandy, with clay subsoil; broke ground May 28.
7	May 27	4	"				Rich bottom, irrigated 3 times.
8	May 7		"		June 15		Clay soil, manured in 1897.
9	May 10	4	"	July 15	July 10	Sept 5	Black bottom land, irrigated only once.
10	May 20	3	Good				Heavy loam,
11	"	Same as	No. 10				
12	"	3	Good				On bank of river, considerable alkali.
13		Same as	No. 12				
14	May 23	4	Thin	June 25			Light mountain soil.
15	May 10		Thin				Sandy loam; subirrigation.
16	May 24	16	Thick		June 26	June 12	First crop on new land; plowed three inches deep.
17	June 1		very poor			July 2	Land irrigated before plowing
18	May 15	20	Thick	May 1	June 1	June 15	Medium heavy soil; irrigated three days before planting.
19	May 22	10	Medium		Never	Late	Irrigated by flooding, no after cultivation.
20	April 20	Same as	No. 6				Still growing October 28; manured 1896.
21	April 27	6	Poor		June 10		Rich clay soil; seed irrigated up; manured 1896.
22	May 1	15	Fair		June 10	June 15	Sandy with clay subsoil; manured 1897.
23	May 10	20	Thick				Sandy soil; seed irrigated up, Broken 1896.
24		Same as	No. 5				
25	May 15	8	Thick	June 10	Never		Alkali ground; seed irrigated up; manured 1897.
26		Same as	No. 8				
27	May 8		Thick				Manured 1897.
28		Same as	No. 27				
29	May 5	15	Medium	June 15	June 28	June 21	Mountain soil; manured 1897.
30	June 1	4	Medium			Never	Very sandy loam.
31	May 24	11	Fair	June 13	July 1		New land; seed irrigated up.
32		Same as	No. 6				
33	April 20		Thin	May 20	Aug 15	Never	Watered by seepage from reservoir; sandy loam.
34	May 26			June 20			Sandy loam; manured 1897.
35		Same as	No. 34				
36		Same as	No. 34				

DIVIDE, SOUTH OF DENVER, WITHOUT IRRIGATION.

No.	Name.	Address.	Date when sample was dug.	Average weight of the beets analyzed.	Sugar.	Puritty.	Weight of crop per acre.
				Ounces.	Per cent.	Per cent.	Tons.
37	C H Clark	Eastonville	Sept 12	6	14.7		
38	F Holkowiez	Elizabeth	Oct 1	14	13.1	71.5	22
39	Alex Brazelton.......	Elbert	" 2	18	13.4	77.9	9
40	Geo H Stein..........	Fondis			13.6	80.3	
41	J D Steves............	Parker	" 5	12	12.8	69.5	
42	W B Quein............	Hilltop	" 9	22	15.7	85.5	17
43	Alice H Kent.........	Kiowa		26	11.6	87.7	
44	" "	"		28	16.9	83.9	
45	S H Rasmussen *	"	" 11	19	13.3	76.0	9
46	" " *	"	" 11	10	15.0		9
47	H C Hansen *	"	" 12	8	17.0		10
48	" " *	"	" 12	12	17.1		10
49	Mrs John Underhill *	Fondis	" 15	9	18.7		
50	D C Dormer *	Castle Rock	" 15	18	18.7	78.4	
51	Chas Shedd...........	Otis	" 20	11	13.8	78.4	
52	Wm Duffy	Fondis	" 21	26	15.3	76.2	
53	G H Ellicott..........	Ellicott	" 30	38	14.2	80.1	
54	Miss H S Jones... ..	Elizabeth		12	16.7	75.7	
55	D C Dormer *	Castle Rock	Nov 14	27	18.6	81.2	

ARKANSAS VALLEY.

No.	Name.	Address.	Date when sample was dug.	Average weight of the beets analyzed.	Sugar.	Puritty.	Weight of crop per acre.
56	Sidney Flinn..........	Caddoa	Oct 3	18	14.7		
57	" "	"	" 3	20	19.4		
58	M D Parmenter	Lamar	" 6		15.0	78.5	
59	C G Anderson........	Eldred	" 7	14	12.4	75.6	
60	J W Jameson *	Howard	" 10	11	13.8	80.1	12
61	B F Wyckoff..........	Rocky Ford	" 15	35	13.5	79.3	
62	C G Anderson........	Eldred	" 23	19	16.0	84.8	13
63	B F Wyckoff.....,....	Rocky Ford	" 28	24	12.7	78.7	40
64	W F Crowley.........	" "	Nov 5	34	14.4	84.3	31
65	C K McHarg..........	Pueblo	" 13	16	20.2	85.9	24
66	M D Parmenter	Lamar	" 15	19	17.1	83.9	40
67	" "	"	" 15	26	12.4	77.8	
68	" "	"	" 15	34	12	72.8	
69	B F Rockafellow.....	Canon City	" 15	34	17.0		27

No.	Date of planting.	Pounds of seed per acre.	Stand.	Date of first cultivation.	Date of thinning.	Date of first irrigation.	Remarks.
37	May 20	20	Thick			Never	Black sandy soil.
38	May 17	20	Thick	June 20	June 20	"	Second crop from sod; daily rains Sept 16 to Oct 1
39	May 1	12	"	July 15	July 15	"	Sandy bottom land; manured 1897.
40	April 28	6	"	May 20	June 25	"	Sandy loam; 2d year from sod.
41						"	
42	May 2	8	Thin	May 26	May 26	"	Black sandy loam; second crop from sod.
43	Apr 29	2	Thin	May 27	June 1	"	Black sandy loam; manured 1897.
44		Same as	No. 43				
45	May 15	6	Thick	June 25	June 25	"	Firm sandy loam.
46		Same as	No. 45			"	
47	May 15	5	Thin	June 20	June 29	"	Black sandy loam.
48		Same as	No. 47			"	
49	June 1	8	Thick	June 18		"	Black sandy loam.
50	May 20	4				"	High prairie soil with a little adobe.
51	May 20	12	Thin	July 5	July 18	"	Sand with clay: manured 1897.
52		2		Never		"	Sandy loam; broken in 1896.
53	May 15	8				"	Light sandy loam.
54	June 1		Thick		July 10	"	Sandy loam; manured 1896.
55		Same as	No. 50			"	
56	May 25		Fair	June 3		June 26	New ground, rather heavy; seed irrigated up.
57		Same as	No. 56				From a dryer part of the field.
58	June 1		Thin	June 10	June 28	June 14	Sandy soil; maunred 1897.
59	Mch 25	10		April 13	April 15	April 20	Black sandy loam.
60	June 3	10	Poor	June 18	July 4	June 15	Light sandy soil.
61	April 30	20	Good	May 20	May 20	May 10	Clay soil, with some grit.
62		Same as	No. 59				
63		Same as	No. 61				
64	May 19		Good.	June 10	Never	June 28	Inclined to clay soil with some alkali.
65	May 10	9	Medium	June 15	June 26	June 15	Sandy soil, second year from breaking.
66		Same as	No. 58				No late irrigation.
67		Same as	No. 58				Medium late irrigation.
68		Same as	No. 58				Irrigated late in the season.
69	May 8	24	Thick	June 7	June 7	June 2	Adobe soil; manured 1897 seed irrigated up.

No.	Name.	Address.	Date when sample was dug.	Average weight of the beets analyzed.	Sugar.	Purity.	Weight of crop per acre.
				Ounces.	Per cent.	Per cent.	Tons.
70	Ira D Hale...........	Rocky Ford	Nov 20	35	13.4	77.3	17
71	" "	"	" 20	16	17.3		
72	J R Traxler...........	Lamar	" 1	10	16.5	75.5	25
73	" "	"	"	12	15.9		25
74	" "	"	" 10	15	14.7	85.4	
75	" "	"	" 10	16	14.4	81.	
	GRAND VALLEY.						
76	Levi Ward...........	Debeque	Sept 15	39	11.9	78.1	20
77	D G Edgerton *	Carbondale	" 18	10	14.4	82.5	18
78	H L Edgerton *	"	" 18	9	15.4		14
79	G S Osburn...........	Satank	Oct 1	11	14.1	78.0	
80	W C Smith	Cardiff	" 1	6	17.3	86.0	
81	Thos King	Glenw'd Spr'gs	" 1	19	13.3	83.0	
82	Mrs M H Lafever	Eagalite	" 1	22	17.0	88.1	
83	C R Thompson	Glenw'd Spr'gs	" 2	9	13.8	77.0	
84	C B Sewell...........	Carbondale	" 8	20	12.2	81.0	
85	C B Sewell...........	"	" 3	13	18.5		
86	J L Thomas	"	" 11	13	16.1	85.9	14
87	D G Edgerton.... ...	"	" 12	21	12.5	83.0	16
88	C H Harris	Catherin	" 12	13	17.4	85.0	
89	E Stanffacher.........	"	" 12	16	15.6	81.2	
90	Wm Gardner	Satank	" 12	10	19.0	86.9	
91	E E Westhafer........	"		28	18.9	84.9	
92	C M Rulison..........	Parachute	" 12	11	15.2	79.9	42
93	Levi Ward.....	Debeque	" 12	18	17.6	86.0	15
94	Geo Siever............	Glenw'd Spr'gs	" 15	18	15.0	80.1	
95	C D Fuller...........	"	" 15	17	14.9	83.0	
96	J L Brown	"	" 15	13	16.8	85.4	
97	B M White	"		10	15.2		
98	W V Hall	Peachblow	" 15	14	14.5	81.7	15
99	Cyrus King	Antlers	" 30	20	14.6	83.0	
100	J E Thomas	"	Nov 15		14.0	74.0	
	SAN LUIS VALLEY.						
101	C M Thomas...........	Monte Vista	Oct 1	11	13.4	77.5	14
102	M B Colt.............	Alamosa	Sept 28	17	11.5	80.5	23
103	Mrs H C Hefner......	Mosca		12	15.9	86.9	

No.	Date of planting.	Pounds of seed per acre.	Stand.	Date of first cultivation.	Date of thinning.	Date of first irrigation.	Remarks.
70	May 10		Thick	June 5	June 1	May 25	Sandy loam.
71		Same as	No. 70				
72	May 25		Good	June 20	June 25	May 28	Hard soil.
73	May 1		Thick	May 25	June 10	May 28	Sandy loam.
74		Same as	No. 73				
75		Same as	No. 72				
76	May 15		Thick	June 10	June 10	June 10	Sandy loam, manured 1897; seed irrigated up.
77	May 15	8	Poor	June 24	June 24	May 25	Black sandy loam; manured 1897; broke ground June 1.
78	May 1	16	Thick	May 30	June 15	June 1	Clay loam, heavily manured 1896 and 1897.
79	May 10			June 6			Red sandy loam.
80	May 5	70	Medium	June 10	June 15	May 25	Sandy loam.
81	May 20			June 15			Sandy loam.
82	May 3	4	Thick	June 15	June 19	June 15	Sandy soil, manured 1897; daily rains Sept. 15-30.
83	May 16				June 7		Sandy loam.
84	May 16	32	Thick	June 10	July 7	June 1	Sandy loam, heavily manured 1897.
85		Same as	No. 84				
86	May 2				June 15	July 1	Sandy loam; heavily manured 1897.
87		Same as	No. 77				
88	May 1		Thick	May 25	June 20		Yellow sandy loam; seed irrigated up.
89	May 26		Good		July 10	July 10	Gypsum soil.
90	May 20				June 25		Red sandy loam.
91	May 28		Thick	June 22	July 10	June 20	Very sandy soil.
92	June 6			June 20	Never	June 21	Heavy sandy bottom land.
93		Same as	No. 76				
94	May 14				June 27		
95	May 1	13	Thick		May 25		Red sandy loam.
96							
97							
98	May 20	20	Good				Sandy loam; seed irrigated up injured by hail.
99	May 15	5	Thin	June 28	July 2	June 6	Alluvial soil, seed irrigated up; manured 1897.
100	June 20						Sandy loam.
101	May 12				June 15	Sub	Rich sandy loam; heavy rains before digging.
102							Alkali soil.
103	May 25		Thick	June 14	July 15		Sandy loam; seed irrigated up.

No.	Name.	Address.	Date when sample was dug.	Average weight of the beets analyzed.	Sugar.	Purity.	Weight of crop per acre.
				Ounces.	Per cent.	Per cent.	Tons.
104	David Albright.......	Poncha Spr'gs	Oct 4	29	13.6	79.5	16
105	W A Lockett..........	Saguache	" 7	10	16.5		11
106	S L Pierce............	Montevista	" 10	7	17.3		14
107	Chas Milne............	La Jara	" 12	38	13.4	78.7	33
108	M B Colt....	Alamosa	" 13	9	15.7	78.9	
109	N G Shaw.............	"	" 22	14	17.9	85.9	31
110	David Albright.......	Poncha Spr'gs	" 25	16	17.4		19
111	Chas Milne...........	La Jara	" 28	31	16.4	84.3	33
112	M B Colt	Alamosa	Nov 3	25	16.1	83.6	23
113	G J Stafford *	Montevista	" 11	15	12.4	76.5	10
114	Mrs H C Hefner......	Mosca		13	16.3	84.6	
115	W G Bradshaw	Alamosa	Oct 25	39	14.2	74.2	9
116	" "	"	" 25	38	11.9	70.6	
117	Wm Cross	"		34	13.4	74.5	
118	C M Thomas	Montevista	" 26	33	15.0	81.9	
119	A K Deitrich	"	" 10	17	17.6	84.1	18

OTHER PARTS OF THE STATE.

No.	Name.	Address.	Date when sample was dug.	Average weight of the beets analyzed.	Sugar.	Purity.	Weight of crop per acre.
120	Geo H Hammond....	Hotchkiss	Nov 15	23	15.5	76.7	20
121	J L Ellis **	Craig		10	19.0	81.2	
122	" " **	"		11	18.6		
123	Chas A Barnes **	Delta	" 10	16	18.6	84.3	
124	Chas R Peter..........	Holyoke	Oct 4	61	11.4	75.4	
125	" "	"	" 4	37	14.7	70.0	

No.	Date of planting.	Pounds of seed per acre.	Stand.	Date of first cultivation.	Date of thinning.	Date of first irrigation.	Remarks.
104	May 9	13	Good				Rather sandy; heavily manured; seed irrigated up.
105	May 15	10	Fair			June 16	Sandy loam.
106	May 20		Thick	June 25	June 10		Sandy loam; manured 1896
107	May 8		Thick	June 1	June 4		Sandy loam; manured 1897; seed irrigated up.
108							Adobe soil.
109	May 20	2	Uneven	July 2	July 2		Black sandy loam; seed irrigated up.
110		Same as	No. 104				
111		Same as	No. 107				
112		Same as	No. 108				
113	May 5	8	Thick	June 1	June 15		Sandy soil, manured last three years; seed irrigated up.
114		Same as	No. 103				
115	May 24	16	Thick	June 24	July 1	July 3	Dark yellow soil and gravel.
116		Same as	No. 115				
117	June 2	4	Uneven	July 1	July 1		Clay: manured last two years; seed irrigated up.
118		Same as	No. 101				
119	May 10	15	Thick	July 1	June 15		Sandy soil; fifth year continuously in beet.
120							Sandy loam.
121							
122							
123	May 25		Good	June 20	July 1	June 1	Sandy soil; new breaking.
124	May 1	6	Thin	June 1	June 20	Never	Sandy loam; manured 1897.
125		Same as	No. 124				

TIME OF RIPENING.

From the standpoint of the manufacturer, the date at which the beets become sufficiently ripe for use, is one of the most important parts of the problem. A beet sugar factory costs several hundred thousand dollars. At the most, it can work but about a third of the year and must be idle capital the rest of the time. In the climate of Colorado, it would not be safe to calculate on running later than the last of January. If the factory should start the first of October, it could have a run of a hundred and twenty days. Every day before the first of October that it could run would increase the amount of beets that could be handled and the profit on the whole investment. As the net profits of a well conducted factory are more than five hundred dollars per day, every additional day is of great importance.

The results given in the foregoing table throw much light on the date at which sugar beets in Colorado may be expected to ripen.

In the valley of the South Platte, north and northeast of Denver, the samples taken in September showed conclusively that the beets were not yet ripe. But a great change takes place in the last days of September and in the first week of October. The average of the samples taken between September 25 and October 10 is 14.1 per cent sugar and 80.7 per cent purity. This is an excellent grade of beets for factory use. Had a factory been in operation in the valley of the Platte during the season of 1897, it could have started up about September 25 with beets running over thirteen per cent in sugar and about eighty per cent in purity. It is not meant by this that all the beets raised in the valley had reached that average at that date, but that on the three to four thousand acres of beets that would be grown for a factory, there would have been enough beets ready by September 25 to have kept the factory running until other beets ripened.

This is a very important matter and cannot be too carefully considered. To get the crop ripened is the principal aim of the beet grower since it is in the last stages of growth that the beet forms most of its sugar, and it is only when the beet becomes ripe that the juices become pure enough for profitable manufacture.

Several factors come in to influence the ripening of the sugar beet. The most important is this that *the beets shall keep growing all the time from the sprouting of the seed until harvest.* All of the directions given for the planting and cultivation of the crop have this object in view;

because if this is attained, both the quantity and quality of the crop are almost necessarily correct.

If the beets receive no set back, they make a large growth, ripen early, and at the end of the growing season, get rid of much of the impurities in the juice, and store up in the root a large amount of pure sugar. If, however, for any reason the growth of the beet is checked, even for a few days, the ripening is delayed for a much longer period; if the check is severe the beets will never ripen, but start a second growth that will keep on growing until killed by the frost.

Provided the beet grower has given the proper care, the actual date of ripening will then depend on several conditions, some of which are beyond his control. If the ground is very rich it will tend to increase the size of the beets and retard the time of ripening. But an important fact is to be remembered in this connection. No matter how rich the ground is, if the beets are properly cared for, they will eventually ripen and be all the better, both in quantity and quality for the abundance of plant food that has been at their disposal. But the richer the ground is the easier it is to start a second growth and produce an enormous weight of crop of a poor quality.

An abundance of moisture in the soil retards the ripening of the beet, so that if the fall is unusually rainy the crop will be late in maturing. In Colorado it is true in general that the crop will not ripen until the vigor of the growth has been checked by frost.

The fall of 1897 in northeastern Colorado was exceptional, in that the frost held off two or three weeks later than usual and more than the average amount of rain fell. If, then, under these adverse natural conditions, a factory could have started September 25, it is fair to presume that under average conditions it could have begun operations several days earlier.

In this connection it is important to note the fact that on September 18, there were found at Sterling, two fields of beets that were fully ripe, weighing ten and sixteen tons of beets respectively per acre, and the beets of a good quality for factory use. This shows that with extra good care these beets had been brought thus early to merchantable condition in spite of the unfavorable weather. What these two men did, others similarly situated, could have done by equal care. Both of these crops were on medium to light soil. It is probable that no one on a heavy clay soil could have brought the beets to ripeness by this early date.

But one other factor remains to be noticed in regard to the ripening of the crop. All of the beets in northeastern Colorado were grown from seed imported from Germany. The experiments conducted at Lehi, Utah, make it probable that by using seed grown in the United States at five thousand feet altitude the ripening of the crop is hastened from a week to ten days.

In view of all the foregoing statements, we have a right to conclude that whenever a factory is actually built in northeastern Colorado, it will find beets ready for manufacture soon after the middle of September.

After what has been said of the ripening of beets in northeastern Colorado, there need be but little said concerning the other portions of the state. The same principles govern the ripening everywhere. On the Divide, south of Denver, where beets are grown without irrigation, the crops matured somewhat later than in the valley of the Platte, with irrigation. The content of sugar reached thirteen per cent by the first of October, but the purity was then too low for manufacturing purposes. By the middle of the month the beets were all right for the factory.

The Arkansas Valley is one hundred and fifty miles south of that of the Platte and as a natural result frosts hold off late and the beets are late in ripening. Had a factory started up October 15, it could probably have found beets enough to keep it running, but the bulk of the crop was hardly in marketable condition before the first of November. On the other hand, the winters here are so open and mild that there would be little trouble in a factory running all winter or until the crop was all handled.

The analyses from the valley of the Grand show that the crops were easily ready for the factory by the first of October and probably several days earlier. The bulk of the crop was ready at least a week or ten days earlier than that of the valley of the Platte. The climate of the valley of the Grand is a little warmer than that of the Platte and hence it would be supposed that the crop would ripen later rather than earlier. The cause of this result must be due either to better care, or to different seed, and is probably due to both these causes. The farmers in this valley have been experimenting in the raising of sugar beets for several years, and many of them have made a careful study of the subject. Hence their fields were better cared for, the quality of the crop was better, and it ripened earlier.

The remaining section of Colorado is the San Luis valley. The analyses from this section are so mixed that it is difficult to judge when the crop in general was ripe. There were only two samples dug before October 15 that could be profitably manufactured. These two, however, show such a very high grade as to seem to indicate that the lateness in ripening of the other crops was due to lack of care or the presence of too much alkali in the soil.

INFLUENCE OF RIPENING.

The process that goes on in the ripening of the beet is both an increase of pure sugar and a decrease of the impurities. This raises both the per cent of sugar and the per cent of purity. By the purity of the beet is meant the relation of the sugar to the whole amount of material in the beet that is not water. Suppose 100 pounds of the juice of some beets contain 80 pounds of water and 20 pounds of solids; and of that 20 pounds of solids 16 pounds are sugar; then it is said that the beet has sixteen-twentieths or eighty per cent of purity.

The following table gives ten cases where samples were taken from the same field at different times in the fall.

EARLY AND LATE SAMPLES.

Name.	Place.	Date when sample was dug.	Average weight of the beets.	First sample.		Second sample.	
				Sugar.	Purity.	Sugar.	Purity.
			Grams.	Per cent.	Per cent.	Per cent.	Per cent.
S M Scott	Fort Morgan	Sept 24 Nov 1	430 425	11.5	71.7	15.6	80.4
T B Robinson	"	Sept 24 " 29	310 567	11.9	78.3	13.3	82.8
J A Davis	Berthoud	Oct 2 " 28	595 794	13.9	81.6	16.7	84.5
L A Dwight	Boulder	Oct 4 Nov 4	680 454	13.0	77.0	18.0	84.3
C G Anderson	Eldred	Oct 7 " 23	397 538	12.4	75.6	16.0	84.8
Levi Ward	Debeque	Sept 15 Oct 12	1389 510	11.9	78.1	17.6	86.0
Mrs H C Hefner	Mosca		340 368	15.9	86.9	16.3	84.6
David Albright	Poucha Spr'gs	Oct 4 " 25	824 454	13.6	79.5	17.4	
M B Colt	Alamosa	Oct 13 Nov 3	240 709	15.7	78.9	16.1	83.6
Chas Milne	La Jara	Oct 12 " 28	1361 879	13.4	78.7	16.4	84.3
		Averages.	617 570	13.3	78.6	16.3	83.9

It is not claimed that this is an exact scientific comparison between early and late samples, for in some cases the samples were taken from different parts of the field and in others they were quite different in size. The figures, however, serve to illustrate forcibly the general truth that in the late days of its growth, the beet accumulates sugar rapidly and becomes of much purer quality.

In the ripening of sugar beets, there is not only an increase of sugar and consequently a relative decrease of the impurities, but there is also an absolute decrease of impurities. This is shown in the next to the last column of the following table, which is based on the results of about two hundred analyses of the Colorado beet crop of 1897.

Beets ranging in per cent. of Sugar from	Water.	Total Solids.	Insoluble Fiber.	Sugar.	Soluble Impurities.	Per cent of Purity.
8 to 11	81.0	19.0	5.0	9.9	4.1	70.2
11 to 12	79.7	20.3	"	11.6	3.7	76.0
12 to 13	78.8	21.2	"	12.5	3.7	77.0
13 to 14	77.9	22.1	"	13.5	3.6	78.8
14 to 15	77.1	22.9	"	14.4	3.5	80.9
15 to 16	76.1	23.8	"	15.4	3.4	82.0
16 to 17	75.4	24.6	"	16.5	3.1	84.1
17 to 20	73.8	26.2	"	18.2	3.0	85.8

QUANTITY OF CROP.

There seems almost no limit to the amount of sugar beets that can be grown on an acre of ground in Colorado. The soil of the State is wonderfully rich and the large amount of sunshine stimulates the growth of the crop wonderfully. The yields given, represent in most cases, estimates based on the digging and weighing of rather small areas, and would need to be decreased considerably to represent whole fields. But even if shrunk one-half, which is far more than necessary, the yields are above those of any state that now has a beet sugar factory in operation. The writer visited a great many beet fields during the fall of 1897 and was everywhere struck with the rank growth and general healthy, vigorous look of the crop. It is a common belief that it is not difficult to raise a large crop, but that a large crop always means one poor in sugar and purity. Such does not seem to be the case in Colorado. Some of the largest yields have been accompanied by a high percentage of sugar and extra good purity.

It would be difficult to make an estimate of the average yield per acre of sugar beets in Colorado during 1897. The extreme would be from half a ton to nearly forty tons per acre. The beets on the College farm were a very poor stand owing to bad weather at the time of planting. The different fields varied from half a stand to hardly a quarter of a full stand. The rows were two feet apart and the entire crops, taking all the ground planted, were from eight to twelve tons to the acre.

The average of fifteen fields at Sterling and Fort Morgan is 17.4 tons of beets per acre gross weight, equivalent to about 15 tons of trimmed beets ready for the factory.

The weights of the crops on the Divide are of course much less than these figures. The valleys of the Arkansas and Grand have given about the same yields as that of the Platte, while the San Luis valley comes forward with some surprisingly large yields. Chas. Milne, at LaJara, reports about thirty tons to the acre, testing 16.4 per cent sugar and 84.3 per cent purity; while N. G. Shaw, at Alamosa, harvested over fifteen tons of beets from a measured half acre of ground and the beets tested 17.0 per cent sugar and 85.9 per cent purity. One of the heaviest yields reported is that of J. A. Davis, at Berthoud, who raised at the rate of 35 tons to the acre testing 16.7 per cent sugar and 84.5 per cent purity.

Probably the most profitable sugar beets raised in Colorado the past season were those grown by J. W. Bacon, seven miles east of Longmont. When his field was prepared for wheat, he left out about an acre and planted this later to sugar beets, giving the land but one more harrowing in addition to its preparation for wheat. Only three pounds of seed were used per acre, in drills thirty-two inches apart, sown with the ordinary wheat drill. The plants were not thinned, were irrigated but twice, when the water was turned on the wheat, and received only such cultivation as would be given an ordinary field of corn. The crop from the acre was twenty-one tons of beets, which tested 15.0 per cent sugar and 81.4 per cent purity.

QUALITY OF CROP.

The question of the quality of the crop has been referred to several times in speaking of its quantity. In making any estimate of the quality of the beets raised in Colorado in 1897, it is of course unfair to use any of the analyses made of crops that were known to be unripe. By the middle of October it is fair to presume that the sugar content had about reached its full limit. There were fifty-one samples reported after that date ranging from 10.5 per cent sugar with 72.4 per cent purity, to 20.9 per cent sugar and 85.3 per cent purity, with an average of 15.5 per cent sugar, and 81.6 per cent purity. What has been done by these growers on their first attempt ought certainly to be equaled on a large scale for factory use when they are better aquainted with the best methods.

One point needs to be specially mentioned. The large crops average the highest in quality. The nine fields, of which we have analyses from the ripe crops, reporting over twenty tons of beets per acre with an average of twenty-seven tons, test 16.0 per cent sugar and 82.6 per cent purity. Such fields would return to the grower over a hundred dollars per acre and give to the factory nearly three hundred dollars worth of sugar per acre.

COMPARISON OF 1897 WITH PREVIOUS YEARS.

Sugar beets have been raised on the Station farm and in various parts of Colorado for the past nine years. The records of the analyses include many high and many low results. The records from outside the Station are not accompanied with the dates when the samples were dug, or any statement of the ripeness of the crop, so it is not possible to tell whether the low analyses are due to the poor quality of the crop or to the early date at which the samples were taken.

The different varieties of beets raised at the Station in 1897 agree in quality quite closely with the samples of previous years, when the samples were taken at the same date or stage of growth. Judged by this standard, the year 1897 was the same or a little poorer than previous years.

In all the states that have factories, and raise beets on a large scale, the universal report is that the year 1897 has been exceptionally poor; indeed about the worst known since the factories started. Since this report comes from Nebraska, Utah and New Mexico, east, west and south of Colorado, it is probable that in this state it was not any better than an average year.

METHODS USED BY BEET GROWERS.

There are certain principles of beet growing that have been learned by experience and by experiments in this country and in Europe, that are considered as essential to the production of the best beets. It is undoubtedly true that these principles are correct, and that the beet growers of

Colorado will eventually accept and practice them, and thereby increase the quantity of their crops and improve their quality. But the point to be considered here is this: most of the tests in 1897 were made by persons who had never grown beets before; they violated all of the proper methods and still produced large crops of good beets. What stronger proof could be obtained that the soil and climate of Colorado are especially adapted to the sugar beet?

One of these rules is that sugar beets should never be planted on new ground. Such soil it is claimed is so full of soluble salts as to make the beet too impure for factory use. Chas. Johnson, at Atwood, reports that his beets were planted on newly broken land and they tested 15.2 per cent sugar and 82.4 per cent purity. Sidney Flinn, at Caddoa, under similar conditions on rather clay ground, which in Colorado would ordinarily be very rich in soluble salts, produced beets that contained 19.4 per cent sugar. Though the purity was not determined, it could scarcely have been less than 83 per cent.

The only other two persons who reported beets on new ground, had samples taken in September before the beets were ripe, but even in these two cases the beets tested better than the average of their neighbor's beets on old ground.

There were six cases reported where the beets were raised on ground that had been broken a year before and had raised one crop before the beets. These give uniformly fine beets and average 17.3 per cent sugar and 82.6 per cent purity.

All rules for sugar beet culture say to subsoil if possible, but if not, to plow very deep, and better if plowed in the fall. No subsoiling was done by any of the farmers; about a third of them plowed in the fall and but few plowed more than eight inches deep. It is probable that subsoiling in Colorado under irrigation is labor lost. Deep plowing is an advantage with the clay soils, but in the alluvial soils of the river bottoms which will be the land most used for beet culture, the roots go deep into the soil, whether the plow is run deep or shallow.

Another point was noticed in all the fields visited. The beets grew with the entire root under ground. This makes a little more labor in digging, but it lessens the amount of the top of the beet that has to be cut off with the leaves and increases the amount of sugar in the upper part of the root. It is probable that this fact goes far toward explaining the higher average quality of Colorado beets over those of the neighboring states. Just why the beets should grow so in Colorado is not yet evident, unless it is due to the furrow irrigation which deposits the water below the soil rather than on its surface and tempts the beet to go deep for it. The writer noticed particularly at Grand Island, Nebraska, the past season, that nearly one-third of the weight of the beet was above ground, making a loss in the amount that was trimmed off and a poor quality in the upper inch that was left on the beet.

All writers on sugar beet culture are agreed that beets should not be planted on ground that has recently been manured with stable manure, because its tendency is to make a large beet that is late in ripening and is low in sugar and purity. Sixteen persons report that they manured their beet ground before planting it. The crops were large as was to be expected, and it was also true that unless the samples were dug late in the season the quality is low. The stable manure seems to have made them late in ripening, but on the ripe crops, the quality is good with three exceptions. As these three are almost the only ripe crops that are poor it seems a fair conclusion that the result is due, in part at least, to the stable manure. Taking the results as a whole they indicate much more gain than loss from the addition of stable manure.

One of the special advantages claimed for Colorado in the matter of beet raising is, that under irrigation, water can be kept away from the crop during the latter part of the season, allowing it to ripen and reach the full amount of sugar and purity. This is undoubtedly correct, but one queer sample shows that even this rule may have exceptions. Mrs. M. H. Lafever of Eagalite, sent a sample that was dug the first of October, after two weeks in which it had rained every day. Yet the beets tested 17 per cent sugar and 88.1 per cent purity.

The effect of alkali on sugar beets is still an open question, as is also the result of growing beets on seepage ground. As throwing some light on the latter question, two examples may be quoted. At Greeley, A. L. Camp Jr., planted beets on some strongly alkali seepage ground and they tested 6.8 per cent sugar and 46 per cent purity. Mr. Camp makes the statement that these beets were the first things he had found that were able to grow in the presence of so much alkali. E. K. Smith at Fort Lupton, grew beets on land kept moist by the seepage from a reservoir and his beets tested 14.5 per cent sugar and 80 per cent purity. Both raised large crops without irrigation, but in the first case the beets showed a large amount of second growth indicating that there had been a time when they had suffered from lack of water, while the other beets were some of the finest seen during the season. They were finely shaped, thoroughly ripe, with nothing on the crown but the first growth of leaves. In other words the seepage from the reservoir had been constant through the season and just enough to give the beets all the water they wanted all the time.

STAND.

The number of beets to the acre determines in large measure the weight of the crop and its character. In general it can be stated that the more crowded the beets, the smaller they will be, but richer in sugar and of a higher purity; the farther apart, the larger and poorer they will be.

There should be some medium ground that will produce the largest amount of sugar beets per acre. This is approximately when there is one beet for each square foot of ground. If the rows are two feet apart, this would leave six inches between the plants. With eighteen inch rows, the distance between the beets would be increased to nine inches.

The hardest part of beet raising is to get a full stand all over the field. More than half of those who raised beets in 1897 report the stand as thin or poor. Two pounds of beet seed contain enough seed to make a full stand on an acre of ground, but to get this stand in practice it is necessary to sow a much larger amount. The idea is to sow a good deal more than is needed and then thin out the plants to the required distance. It is customary in the vicinity of factories to sow fifteen to twenty pounds of seed to the acre. The records show that different beet raisers in Colorado sowed varying amounts from two pounds to two hundred and seventy-five pounds to the acre. The average was nine pounds per acre, but more than half of the persons used less than eight pounds per acre or less than half the proper amount.

The poor growth of the seed is due to lack of moisture in the ground, too deep planting, and poorly prepared ground. East of the range, in Colorado, the first, due to the dry winters, will always be the greatest objection. It is possible to overcome this in two ways; by irrigating the field before the seed is planted, or by irrigating after the seed has been sown. The first is better if it can be done, but it is very likely that the second will come to be used as the regular method in growing beets for factory use.

Quite a number of persons tried this method in 1897. Fifteen persons report the resulting stand as follows: one, poor; two, fair; one, uneven; two, good; one, thick in places; eight, thick. In other words eight out fifteen obtained a thick stand by irrigating up the beets.

This is about twice as large a proportion as those who obtained a thick stand by depending on rain or the original moisture in the ground.

Of two persons who irrigated ten days after the seed was planted, both report poor stands. Of two persons who irrigated before the seed was planted one reports a good stand and the other poor.

No relation can be traced between the stand and the analysis of the crop, for there is no record to show whether the beets analyzed grew by themselves or were taken from thick places in the field.

RECAPITULATION.

The results of the season of 1897 may be summarized in a few words.

Good sugar beets can be raised anywhere in Colorado that is adapted to any kind of farming. Large crops of good beets can be raised in any portions of these districts that are supplied with water for irrigation. The season opens early enough and the winters are mild enough so that a factory could have a run of at least one huudred and twenty days.

The average quality of the ripe crops of Colorado in 1897 was 15.5 per cent sugar and 81.6 per cent purity. The average quantity of beets per acre was not far from sixteen tons.

FACTORY CONDITIONS IN COLORADO.

Those who contemplate putting their money into a beet sugar factory will desire to receive answers to several questions in addition to those already presented.

It has been shown that Colorado has the soil and climate for the production of high grade beets. A natural question follows as to whether the people of the State are enough interested in the matter to raise the beets if a factory was built. The answer to this must be in the affirmative. This has been tested on several occasions and there would be no trouble in getting the necessary acreage pledged at several places in either the Platte, Arkansas, Grand or San Luis valleys.

A home market exists in Colorado for all the sugar that would be produced by three large factories, thus saving freight on the finished article. Each of the above mentioned regions is near to enormous deposits of coal, affording an abundance of cheap fuel. The deposits of limestone are adjacent to the farming districts and much of the lime itself is almost chemically pure. Pure water for factory use can be easily obtained.

Indeed it can be said in all truthfulness that no place where a factory is now in operation presents advantages equal to those posesed by any one of half a dozen localities in Colorado.

INFLUENCE OF DRYING ON BEETS.

In the raising of sugar beets for a factory, it is customary to dig beets during the early part of the season, as fast only as the factory can use them. At the end of the season, in countries where there is danger of the ground freezing, all of the crop is harvested and either brought to the factory and stored in bins or piles or else the surplus of beets are piled up in the field where grown and covered with a thin layer of dirt to prevent their freezing.

It becomes a question of great importance to both beet grower and beet manufacturer as to what changes if any will occur in the beet during the weeks that elapse between digging and slicing.

Some investigations along this line were made at the station in 1897. Samples of beets were weighed and placed where the conditions would be much the same as those in the field, other samples remained in the cellar of the laboratory, others in the laboratory itself, while still others were buried in dirt.

The two ideas were to find out how fast beets dry out under these conditions and whether there is any loss of sugar when the beet dries. The first is important to the grower, because if he sells his beets by the ton, all the drying out reduces his tonnage. The second is equally important to the manufacturer, because having bought the beets and paid for the sugar in them at the time of delivery, he wants to know whether the sugar will keep until he is ready for its extraction.

A few of the results obtained will be given here in anticipation of the fuller figures to be published in a technical bulletin on the chemistry of the growth and handling of sugar beets.

On October 29th, a lot of beets were taken from a field on the College farm and divided into three equal lots; one was taken to the laboratory at once and kept in a cool, dark place; the second lot was left lying on the ground in the field exposed to the sun as would happen in ordinary practice. The next day this lot was gathered and analyzed, together with the first lot. The third lot was piled up in the field, covered with a few inches of dirt and allowed to remain for five weeks before analysis.

The results are as follows.

	Per cent sugar.	Per cent purity.
Kept one day in a cool place,..	14.0	82
Left one day in the open field,.	14.9	79
Covered five weeks with dirt,..	14.7	84

The results show that the beets dried considerably during the one day exposed to the sun, but that in this case and also where covered with dirt, the loss was merely one of water, the sugar in the beet remaining without fermentation.

This was with ripe beets taken from a dry soil. No judgment can be drawn from this as to what would happen with unripe beets.

On October 6th, two lots of beets were taken; one from a field fairly ripe and the other still green and growing. Half the beets in each lot were analyzed at once; the other half were weighed, wrapped tightly in paper and put on the ground in the cellar of the laboratory. Both lots were weighed each day for sixteen days, to note the loss in weight and then each was analyzed.

In each case the beets lost one-twentieth of their weight in the first twenty-four hours or at the rate of a hundred pounds for each ton of beets. In five days each lot lost a little more than one-fifth of its weight. In sixteen days each lot lost thirty-eight pounds for every hundred pounds of original weight.

The more nearly ripe beets tested, when put in the cellar 9.8 per cent sugar; at the end of sixteen days they had dried out until they tested 15.9 per cent sugar. When the weights are taken into consideration it is found that of the 9.8 per cent of sugar in the original beets 9.55 per cent was still present, showing that the sugar had not fermented in the drying out and that the loss was merely one of water.

The green beets tested 9.3 per cent sugar when taken from the field and 12.6 per cent sugar after drying sixteen days. Making the same calculation, shows that of the original 9.3 per cent sugar, only 7.7 remained, indicating a fermentation and a loss of one-sixth of the sugar.

On January 3, 1898, some beets were dug that had been covered with straw for two months. They had started a slight second growth, but not enough to injure them for factory use. After analyzing enough of these beets to get their average composition, the remainder were brought to the laboratory and left for one day exposed to the air. They lost just one-twentieth of their weight the same as in the fall. They were then covered with three thicknesses of sacking, but continued to dry out and in five days had lost nearly one-fifth of their weight. At the end of fifteen days they had lost just the same as the beets did in the fall in sixteen days. The beets tested originally 14.4 per cent sugar; fifteen days afterward they tested 21.6 per cent sugar. Calculations of weight show that of the original 14.4 per cent sugar, 13.4 per cent remained, or a loss by fermentation of about one-fourteenth of the sugar.

EFFECT OF FREEZING ON BEETS.

When the beet fields on the college farm were harvested, several small patches were left and allowed to freeze. After the tops had frozen and thawed several times the whole was covered with a thick layer of straw. Samples of these beets were analyzed at various times up to the middle of January 1898. From near the edge of the straw some beets were dug that had been partially frozen.

The first beet analyzed had been only slightly frozen. It was cut into thirds by weight and each third analyzed.

	Per cent. sugar.	Per cent. purity.
Upper third	12.9	78.7
Middle third	12.0	91.1
Bottom third	12.0	81.4

The second beet had been decidedly frozen.

	Per cent. sugar.	Per cent. purity.
Upper third, all froxen	10.9	73.2
Middle third, partly frozen	11.2	70.3
Bottom third, not frozen	14.3	88.3

Here the effect of the freezing seems to have been to drive the sugar into the lower part of the beet.

One of the patches of beets covered by straw tested the first of November when covered, 12.3 per cent. sugar and 77 per cent. purity. On January 3, the same patch tested 13 per cent. sugar and 86 per cent. purity. This was a patch of large beets and and to the eye they had increased in weight during their two months under the straw.

COLORADO SOILS.

The relation between the growth of the sugar beet and the character of the soil in which it grows has been studied very carefully in Europe. Almost nothing of this kind has been done in the United States. The results of the work in 1897 seem to indicate that it is not safe to apply the rules formulated in Europe with beets dependent on rainfall, to our Colorado conditions, where the beets are grown with irrigation. This opens up a wide field for experiment and research. No one station in any one season can hope to compass the problem. The following soil analyses made by Mr. Chas. Ryan are presented as a contribution to the subject. They should be studied in connection with the analyses of the beets grown in the several sections.

Much more of this work will need to be done before any generalizations can be drawn.

PLATTE VALLEY.

	No. 3 Weld County	No. 53 Weld County	No. 32 Logan County	No. 36 Morgan County
Water		1.48	1.57	1.33
Soluble and insoluble silica	85.92	86.12	86.38	86.98
Potash	0.38	0.54	0.70	0.56
Soda	0.30	0.16	0.46	0.86
Lime	0.97	1.38	1.36	0.19
Magnesia	0.40	0.42	0.18	0.05
Iron Sesquioxide	3.01	2.43	1.76	0.99
Alumina	3.96	3.52	6.19	5.53
Phosphoric acid	0.31	0.11	0.03	0.04
Sulphuric acid	0.26	1.13	0.05	0.39
Carbonic acid	0.28			0.06
Volatile and organic matter *	4.42	2.52	2.02	2.67
Chlorine	0.05	0.05	0.05	0.05
Total	100.26	99.86	100.12	99.60
* Containing nitrogen	0.13	0.07	0.11	0.16

DIVIDE SOUTH OF DENVER.

	No. 14 Douglas County	No. 16 Elbert County
Water	1.42	1.34
Soluble and insoluble silica	82.12	87.04
Potash	0.37	0.46
Soda	0.51	0.93
Lime	0.24	0.12
Magnesia	0.28	0.42
Iron Sesquioxide	2.54	1.54
Alumina	8.34	3.83
Phosphoric acid	0.03	0.01
Sulphuric acid	0.20	1.19
Carbonic acid	0.02	0.48
Volatile and organic matter *	3.10	2.66
Chlorine	0.07	0.04
Total	99.24	100.06
* Containing nitrogen	0.13	0.12

ARKANSAS VALLEY.

	No. 38 Otero County	No. 27 Las Animas County	No. 42 Prowers County
Water	1.55	1.66	2.65
Soluble and insoluble silica	83.26	83.04	78.00
Potash	0.91	0.25	1.69
Soda	0.52	0.11	0.54
Lime	1.76	1.55	1.44
Magnesia	1.06	0.11	0.79
Iron sesquioxide	2.38	2.93	2.78
Alumina	4.45	4.70	5.94
Phosphoric acid	0.14	0.90	0.09
Sulphuric acid	0.50	0.45	0.60
Carbonic	1.15	1.01	
Volatile and organic matter *	3.25	3.70	5.79
Chlorine	0.09	0.04	0.03
Total	100.12	100.45	100.34
* Containing nitrogen	0.12	0.06	0.13

GRAND AND GUNNISON VALLEYS.

	No. 19 Garfield Co	No. 21. Gunnison Co
Water	2.82	2.30
Soluble and insoluble silica	77.88	72.51
Potash	1.38	0.75
Soda	0.63	0.86
Lime	0.71	2.05
Magnesia		0.58
Iron sesquioxide	2.07	2.86
Alumina	8.27	10.24
Phosphoric acid	0.14	0.01
Sulphuric acid	0.44	1.46
Carbonic acid	0.21	
Volatile and organic matter *	5.32	6.21
Chlorine	0.06	0.05
Total	99.93	99.98
* Containing nitrogen	0.16	0.13

SAN LUIS VALLEY.

	No. 5. Rio Grande County.	No 44. Rio Grande County.	No. 9. Conejos County.	No. 10. Costilla County.	No. 40. Saguache County.
Water		1.48	3.50	2.17	3.97
Soluble and insoluble silica	80.75	80.67	70.24	79.77	75.05
Potash	0.53	0.90	0.68	0.26	0.11
Soda	0.94	0.77	1.98	2.31	0.44
Lime	1.62	1.55	1.46	1.65	2.10
Magnesia	1.40	0.95	0.44	0.14	0.67
Iron sesquioxide	1.84	5.40	2.94	1.42	3.60
Alumina	7.90	5.09	5.07	8.03	5.33
Phosphoric acid	0.21	0.09	0.06	0.07	0.11
Sulphuric acid	0.22	0.67	0.02	0.39	1.10
Carbonic acid	0.70		0.38	0.01	
Volatile and organic matter *	3.63	3.00	13.10	4.57	7.41
Chlorine		0.09	0.03	0.06	0.09
Total	99.78	100.66	99.90	100.85	100.18
* Containing nitrogen	0.11	0.09	0.23	0.18	0.24

THE CAMPAIGN OF 1898.

It is evident that the more interest there can be aroused in Colorado in the culture of the sugar beet, the more likelihood there is of the erection of factories.

The Experiment Station has taken an active interest in the matter for several years and proposes to devote more time and energy than ever before to the campaign of 1898.

Seed will be distributed, free of charge, to those who desire to make tests of raising sugar beets. The seed wiil be sent out early in April, to those who desire it. Applications should be sent in at an early date. Enough seed will be sent to each applicant to plant fifteen rows, fifty feet long or their equivalent. This small area is selected because it is desired to know the best that Colorado can do, and that is most likely to be ascertained when the amount planted is small enough so that it can be put on the best land and given the best of care and attention.

Those who receive seed will be expected to keep full records concerning the crop.

About the middle of July the following circular will be sent out. It is suggested that those who receive seed make their records directly on this bulletin, of which they will have a copy, and from which they can copy these records on to the blank when it is received.

COLORADO AGRICULTURAL COLLEGE.

SUGAR BEET CIRCULAR NO. 1.

FACTS CONCERNING THE PLANTING OF THE CROP.

Date planted..

Character of soil....................................

....

Much or little alkali in soil.........................

Previous cropping and handling.......................

....

....

When last manured...................................

Date plowed..

Plowed how deep.....................................

Other preparation given...............................

Seed planted with what implement........................

Seed planted how deep.....................................

Width between rows...

Was all the seed sent used?...............................

How much land was planted?..............................

Date beets began to show above ground.................

Date of each cultivation........ ....

How cultivated..

Date of thinning..

Distance between plants after thinning.................

Is the stand thick or thin?.................................

Date of each irrigation......................................

(Signed) Name........................

Postoffice ....

NOTE.—Fill out the blank the first of August and send by mail to

THE STATE AGRICULTURAL COLLEGE,
Fort Collins, Colorado.

The analyses of the beets will be made at Fort Collins. Instructions for taking and sending samples will be sent out next fall. No beets will be analyzed unless accompanied by the full history of the planting, cultivation and harvesting of the crop.

It is desired that two samples of the crops be taken, one early in October and the other about the first of November. No samples will be analyzed after the middle of November.

INSTRUCTIONS FOR THE GROWING OF SUGAR BEETS.

Select the best land on the farm. A rather heavy loam produces the best crops. Avoid light, sandy soils, poorly drained soils, heavy clay soils and alkali soils. Do not plant on newly broken ground unless it can be plowed very deep. Never plant beets on alfalfa sod. Beets do best after corn or potatoes. The freer the land is from weeds the easier and cheaper will the crop be raised. On land that has been manured just before plowing, it is difficult to get a good stand of beets, but if the choice has to lie between poor land and rich land recently manured, always take the rich land.

Plow at least eight inches deep; harrow thoroughly and smooth the ground before planting. Fall plowing is best, to be again plowed in the spring before planting. Whether fall plowed or not, the spring plowing should be done as short a time as possible before planting. If possible the seed should be planted the same day that the ground is plowed so as to have the benefit of all the moisture in the ground for germinating the seed. If a large acreage is to be planted, it should be handled in sections, plowing only what can be planted at once. On a large acreage it is advisable to plant the ground in three sections from five to seven days apart, so that the thinning will come at different times and economize labor.

Sugar beets can be planted from early in April until the last of May. In general they are planted about the same time as corn. They should always be sown under such conditions of warmth and moisture that the seed will germinate at once and the young plants show above ground within ten to fourteen days after planting.

Beet seed should be sown in drills from 16 to 24 inches apart; most beet seeders are made for 18 inch drills. The seed can be sown by hand, by the common garden drill, by a wheat drill closing up some of the holes, or regular beet drills can be used that are made for the purpose and sow four rows at a time. Sow the seed from half an inch to an inch and a half deep. Sow as near the surface as it is possible for the seed to get enough moisture to germinate. The earlier in the season the seed is sown, the less depth it should be planted. If the ground is very dry, sow near the surface and then irrigate up the seed by making a small furrow between every other row and running a small stream of water until the ground has wet sideways to both rows. Remember that getting a good stand is the hardest part of sugar beet raising.

Sow plenty of seed ; never less than fifteen pounds to the acre and from that to twenty pounds.

The thinning should be most carefully and promptly done, as on it depends in large measure the weight and quality of the crop. There is but one time to do this work, and that is while the plants are very young—just as soon as the third or fourth leaf becomes well defined and the root is nothing but a mere thread. If delayed the plant receives a set back from which it can scarcely recover. Just before thinning, work the ground between the rows with a hoe or with a horse cultivator made to work the same number of rows at a time as were sown by the seeder. Next follow with a sharp hoe four to six inches wide, cutting across the row and dividing it into bunches six to nine inches apart. These bunches are thinned by hand to a single plant. The plants should be from six inches apart in a twenty-four inch drill up to nine inches apart in an eighteen inch drill.

After the thinning go through the field once more with the hoe and be sure that every weed is killed. The rest of the cultivation needed during the season is only such ordinary cultivation as would be given to a crop of corn.

Irrigate the beets only when they show the actual need of it. Delay the first irrigation as long as possible unless it is necessary when the seed is planted to produce germination, in which case the water should be turned on within two days after the seed is in the ground.

A slight wilting during the day does not necessarily mean need of water, but when they wilt and do not revive as soon as the sun sets or the weather is cloudy, they should be watered. After the first watering they will usually dry out quickly and need subsequent irrigations every ten to fourteen days. Few beets can be raised in Colorado without irrigation, the number of irrigations varying from two to five according to the ground and the season. Beets will seldom need irrigation after the middle of August and usually not after the last of July. Unless the ground is very compact it will be sufficient to run the water in every other row. At the next irrigation use the rows omitted the previous time. Cultivate after every irrigation. Never flood sugar beets if it can possibly be avoided. Be careful in cultivation and in furrowing not to throw any dirt on to the crown of the plant. Keep the irrigation water as much as possible away from actual contact with the plant.

Wait until the beets are ripe before harvesting; ripeness can be told by the wilting and dying of the outer leaves, by slicing a beet and noting that the cut surface remains white for a half hour or more, but best of all by a chemical test for the sugar it contains. At a factory this latter method is the one always employed.

On a small scale the beets can be dug out, plowed out or pulled. On the large scale they are always loosened by a beet puller made specially for the purpose. They are then lifted out by hand, thrown into piles and topped by hand with a corn knife or a heavy chopping knife.

GROWING SUGAR BEETS FOR FACTORIES.

BY GEORGE H. WEST.

DR. ALSTON ELLIS, DIRECTOR,
UNITED STATES EXPERIMENT STATION.
Fort Collins Colo.

DEAR SIR:—The following investigation of beet growing and the conditions at and around the beet sugar factories in Nebraska, Utah and New Mexico, was made for the purpose of learning if it pays the farmers to grow beets for the sugar factories of four dollars per ton, and how they are grown to produce good beets at a minimum cost.

The writer has tried to present the absolute facts, whether favorable or not, leaving the reader to draw his own conclusions.

The visits to Utah and New Mexico were by authority of the Denver Chamber of Commerce, thus making it possible to investigate the important features of beet raising by irrigation.

The trip to Norfolk, Nebraska, was made early in October, 1897, and to Grand Island, Nebraska, the latter part of that month. Lehi, Utah, was visited late in December, 1897, and the Pecos Valley, New Nexico, late in January, 1898.

Yours Respectfully,
GEORGE H. WEST,
Greeley, Colo., Feb. 18, 1898.

THE NORFOLK, NEBRASKA, BEET SUGAR FACTORY.

The Norfolk Beet Sugar Co. has operated this factory since 1891. It is owned by the Oxnards, no stock being held by residents of Norfolk. The factory is located about two miles north of the city, and obtains its water from the north fork of Elkhorn creek. It has a nominal capacity of about 250 tons of beets per day. The machinery is said to be mostly of German make. The Steffen process is used to obtain the sugar from the molasses.

The price paid for beets is for delivery at the factory, and the following deductions are made for freight charges on the U. P. and F. E. & M. V. railroads: 25 miles or under, 30 cents per ton; over 25 miles and under 45 miles, 50 cents per ton; over 45 and under 100 miles, 80 cents per ton. C., St. P., M. & O. R. R., 30 miles or under, 50 cents per ton; over 30 and not over 40 miles, 60 cents per ton; over 40 and not over 50 miles, 80 cents per ton; switching charges $2 per car added to these rates on latter line. All beets in 1897 were grown inside the 45 mile limit.

The factory employs 200 hands, on two shifts, of twelve hours each. A few boys are employed. Common factory wages are from $1.50 to $2 per day. Skilled labor from $60 per month upward. The employes are paid every two weeks, in cash. There are no company stores. All business is done through the local banks.

The factory uses about 12,000 gallons of crude oil (Eastern) per day, for fuel in generating steam for power and other factory uses. This is two tank cars of 6,000 gallons each. Two men do all the work in the boiler house, where fourteen were required up to 1895, when coal was used. Cost of oil was not given, but the manager says that bituminous coal, within fifty miles of a factory, would be cheaper than the fuel used at either Norfolk or Grand Island. About fifty tons (three cars) of lime rock are used per day. This comes from Nemeha county, Neb., near Plattsmouth, some 100 miles distant. Cost not given. About a car load of sulphur is used each season.

The same forms of contracts are made with farmers for growing beets there and at the Grand Island factory. There are about 500 beet growers supplying this factory. They average some ten acres of beets each, making about 5,000 acres in all. The largest growers are: The Humphrey Sugar Beet Co., of Humphrey, Neb., 200 acres; H. A. Pasewalk, Norfolk, Neb., 90 acres; Conrad Wagner, Hadar, Neb., 50 acres, etc. A large part of the beets reach the factory by rail—some 1,200 acres being grown by 82 farmers in Platte County, south of Norfolk. 1,100 acres of these beets averaged 7.8 tons per acre yield.

Beets are received by the company on cars where loaded, so the factory stands any freezing en route. The frozen beets are all right if worked before they thaw. No beets for this factory are grown by irrigation, but contracts have been made for beets to be raised near Monroe, Platte County, by irrigation in 1898. In 1897 the yield of beets was greatly reduced by a drouth. In the early history of this factory, 1891 to 1893, it had to grow a large part of its own beets. Out of 2,500 acres of beets used in 1893, 1,500 acres were grown by the company, on rented land.

The farmers are largely Germans with some Russians, they retain largely the old country manner of dress and living, and women and children work with the men in the fields. This applies to all kinds of farm work. In the larger beet fields, or where there is a lack of hands on the place, the work of thinning, weeding, hoeing, pulling and topping the beets is largely none by contract—by the row, or by the acre.

Farm laborers there are paid $15 to $20 per month and board. Per day, the usual rate is $1, and board. On contract work, the rate is 50 cents to $1, per day for boys, and $1, per day, for men and women, the workers boarding themselves and often camping near the fields. A man and team there are paid $2.50 per day, and a man and horse $1.75 per day; use of seeder costs 25 cents per acre. These figures are used in estimates of cost later on. Many farmers there raised beets also in Germany. Land rents there at $3.50 to $6 per acre—average about $5 per acre. Hauling is done by the ton. About one and a half to two tons is an ordinary wagon load of beets. Many days over 300 wagon loads are received at the factory, beside the car load lots. Cars are loaded to their visible capacity.

Very little alfalfa is raised around Norfolk and there is no systematic crop rotation. The following data are given for the business of this factory.

NORFOLK FACTORY.

Year.	Tons of beets.	Tons of sugar made.	Per cent sugar extracted from the beets	Pounds of sugar per ton of beets.
1891	8185	659	8.0	161.0
1892	10725	849	7.9	158.0
1893	22625	2054	9.0	181.5
1894 *	25633	2778	10.8	217.0
1895	27204	2486	9.2	183.5
1896				
1897	36270	3970	10.95	218.0

Their factory work began September 24, 1896, and September 13, 1897. It closed its run January 1, 1898, making the season 110 days. The average for 1897 is 7.25 tons of beets per acre. These data make the sugar extracted in

* The Grand Island factory did not run. A dry season and a short crop 14,000 tons of beets, tributary to the Grand Island district, are said to have been sent to Norfolk. The drought accounts for the richness of the beets and for the large percentage of sugar extracted.

1897, 1588 pounds per acre. The beets used in the run of 1897 are said to have averaged 13.6 per cent sugar in the beet and 81.5 per cent co-efficient of purity.

THE GRAND ISLAND, NEBRASKA, BEET SUGAR FACTORY.

The Oxnard Beet Sugar Company built its factory at Grand Island in 1890, making its first run that year. The factory is located about two miles west of Grand Island. They use about 2,500,000 gallons of water per day from the Wood river. The capacity is the same as at Norfolk, Nebraska, nominally 350 tons of beets per day. The machinery is said to be mostly of French manufacture. They do not use the Steffen process here. Part of the molasses made here is sent to Norfolk to be worked there by that process. This may explain since 1892 the higher per cent of sugar per ton of beets produced at Norfolk.

The general terms of the contract with the farmers there are the same as at Norfolk. The deductions made for freight on beets shipped to the factory are: 30 cents per ton, for 25 miles or under; 50 cents per ton, for over 25 miles and under 45 miles; and 80 cents per ton, for 45 miles and under 100 miles. Carload minimum is 24,000 pounds and they can be loaded to their visible capacity. Some 580 farmers contracted to grow about 5,000 acres of beets for this factory in 1897—averaging about 8.5 acres each. Among the large beet growers are Murr & Pinch, 125 acres; Sass Brothers, 115 acres; Theo. Hapke, 102 acres; Edmund Starke, 100 acres; H. G. Leavitt, 50 acres and J. N. Newell, 40 acres.

This factory uses 75 to 100 tons of Rock Springs slack coal per day for fuel. It also uses about 50 tons of lime rock per day. This comes from Nemaha county, Nebraska. It uses about one-half carload of coke per day and about a carload of sulphur during a season's run. The factory exceeds its rated capacity, and used October 24th, 1897, 377, tons of beets; other days 382, 383, 327 and 359 tons respectively. September 26th, 1897, they ran 397 tons of beets. They averaged last season, about 700 sacks of refined sugar per day. One day that season they produced 829 sacks of sugar. They started work September 6th, 1897, and closed down December 31st, 1897, making the total run 117 days. Including the "clean ups" and repairs, they averaged 333 tons of beets per day. 4,800 acres of beets were harvested for factory use, an average of 8.1 tons per acre. This would seem to leave only 200 acres, or say 4 per cent short of the average seeded, which would be explained by imperfect stands, unmerchantable beets etc. The yield from the beets is about 1,400 pounds of refined sugar per acre.

This factory now employs 178 hands on its two twelve-hour shifts including 20 boys. The wages paid in the factory are, boys, 7½ cents per hour; men, 12½, 15 and 17 cents per hour; skilled labor by the month, at higher wages. Employes are paid in cash, every ten days or two weeks—at every "clean-up." All business is done through the local banks. About 20 per cent of the employes raise beets for the factory.

As at Norfolk, this factory grew a large part of its beets for the first two or three years. In 1891, it raised 1,250 acres of beets near Grand Island. In 1892, nearly half the total amount, or 1,183 acres, were raised by the company some 60 miles west of Grand Island; 450 acres were raised 12 miles distant and some 500 acres 100 miles away. In 1895, the farmers around Grand Island raised 700 acres of beets; in 1896, this was increased to 1,300 acres and in 1897, to 2,600 acres. About one-half the beets are still shipped in by rail, some coming (1897) from North Bend, Nebraska, 80 miles distant. The company has grown none of its own beets since 1892. It had applications from growers last spring to plant about 10,000 acres in beets, or double its requirements.

That locality was settled by a colony of Germans in 1857. Many of these are among the best farmers, and are men of means. There are some Russians and other foreigners, but perhaps one-half the farmers are Americans. Much of the hand labor is done there also by contract—by the acre, the row, or the ton.

The farm wages there range from $14.00 to $20.00 per month and board; by the day, $1.00 and $1.25. The women and children generally work on the contract plan. Many girls get $1.00 per day in the beet fields and prefer it to housework; boys 10 to 18 years are paid 50 to 80 cents per day. Man and team are counted at $2.50 per day there and man and horse at $1.75 per day. In exceptional cases, contracts could be made, as in Colorado, at $2.00 per day for man and team.

The same drought prevailed there in 1897 as at Norfolk, reducing the yield fully one-third, the average beets being 8 tons per acre. No crops are raised by irrigation there, and no factory beets are raised by that method. Land rentals there range from $4.00 to $7.00 per acre—perhaps $5.00 is a fair average.

The following data are given of the operations of this factory from the time it started in 1890:—

GRAND ISLAND FACTORY.

Year.	Tons of Beets used.	Tons refined Sugar Produced.	Per Cent Sugar made from Beets.	Pounds of Sugar per ton of Beets.
1890	5,000	368	7.36	147
1891	11,500	708	6.16 *	123
1892	13,000	1,055	8.12	162
1893	12,000	918	7.65	153
1894	14,000	Factory not run. Beets	shipped to Norfolk,	Nebraska, Factory.
1895	24,300	1,490	6.13 *	122
1896	30,100	2,516	8.36	167
1897	39,000	3,399	8.72	175
Averages.	18,612	1,493	7.50	150

This makes the extraction for 1897, 1,418 pounds of refined sugar per acre of land. The beets used in the 1897 run averaged, it is said, 12.87 per cent sugar in the beet and 79.5 per cent co-efficient of purity.

Special thanks are hereby tendered to Resident Manager Henry S. Ferrar for courtesies extended during the visit to Grand Island and since then; also for numerous beet analyses made without charge, for the Colorado growers.

GENERAL NEBRASKA NOTES.

Assuming the foregoing data, as to the operations at the two Nebraska Beet Sugar Factories, to be correct, we get from reported figures of the average sugar in the beets used by these factories, the following tables:—

	1890	1891	1892	1893
Per cent sugar in the beets,	15.20	13.30	14.40	13.30
Per cent sugar extracted from beets,	7.36	7.00	8.00	8.53
Per cent of sugar lost in manufacture	7.84	6.30	6.40	4.77

(This table would be of more value, had we also the average purity of the beets for the years stated, and the full details up to date.)

* The beets were low in sugar and in purity in 1891 and 1895, owing to cold, wet weather.

The United States data of rainfall for 14 years in the Loup valley, south of Norfolk, show an average precipitation of 23.74 inches. The distribution shows most of this to be between March and September of each year. This indicates a dry fall and winter, which are favorable for beet ripening and harvesting and also for the factory operations.

Dr. Max Hollrung, of Halle, Germany, shows the following mechanical analysis of the soils around the Nebraska sugar factories:—

	Per Cent Coarse Sand.	Per Cent Fine Sand.	Per Cent Finest Sand.	Per Cent Silt.
Grand Island (average)...........	0.72	10.85	63.38	25.05
Norfolk,....	0.20	3.49	52.00	44.40

THE LEHI, UTAH, BEET SUGAR FACTORY.

The Utah Sugar company was formed in 1890 and erected its factory at Lehi, Utah, beginning operations in 1891. It was the first beet sugar factory fully equipped with American-made machinery. It was installed by E. H. Dyer & Company, Cleveland, Ohio. It has made a fine record and greatly exceeds its rated capacity of 350 tons per day. In October, 1896, it worked 435 tons of beets in one day. It requires but 60 hands, including six boys, on each twelve-hour shift, where foreign factories of the same capacity use 100 to 150 hands per shift for the same hours' work. The 1897 run was made without any delay for breaks and repairs, and four tons beets more were cut per day than in 1896. The factory uses some 50 tons of Pleasant, or Castle Gate bituminous coal per day, costing $3.50 per ton. Its lime rock is hauled by teams and costs $2.00 per ton. About 18 tons per day are used. It is excellent rock, containing less than two per cent silicia. Cardiff, Colorado, coke is used there. The sulphur used comes from natural deposits some 100 miles south of Lehi.

The capital stock of this company is owned in Utah. It has a large number of stockholders, including many farmers. Its relations with the farmers are close and seem very pleasant. General Manager Thomas R. Cutler, Supt. C. A. Granger and George Austin, agriculturist, have been very courteous and all proper information was promptly given us. The factory is located two miles from Lehi and thirty miles south of Salt Lake City. The company owns about 139 acres of land around the factory, about 42 acres of this being covered by a reservoir, made by damming Spring

Creek. The factory water supply comes from this source and from four artesian wells in its yards. The water is fairly pure and contains but little alkali. The artesian water is the purer. The population of Lehi is some 2,500; altitude about 4,535 feet; annual rainfall reported to average some 14 inches.

In 1896 about 74 per cent of the beets came to the factory by rail, and 70 per cent. in this way in 1897. The minimum car rate on beets is $7.00, or 35 cents per ton, where 20 tons are loaded in a car. This rate extends to Payson, 35 miles, making there 1 cent per ton per mile.

From Springville—22 miles distance—the rate is about 25 cents per ton. Perhaps an average car rate is about 2 cents per ton per mile. The beets are mostly grown around Lehi and Springfield, but American Fork, Provo, Pleasant Grove, Mapleton, Payson, Riverton, Lake View, etc., are other shipping points. The Sugar Company stands about one-third of the freight charges on the beets. The Lehi Company raised beets on only about 200 acres of land in 1896 and 1897.

The season of 1896-97 was the banner year of this factory; 43,203 tons of beets were cut and 9,156,000 pounds of refined sugar were made.

The conditions around Lehi are almost ideal for growing beets and running a sugar factory. Fully nine-tenths of the farms are worked by the owners. The farms vary in size from five to forty acres, but there are said to be more farms under five acres than there are over forty acres. The farmers mostly live in the towns, which are but a few miles apart. The factory beets in 1897 were raised by about 700 farmers on 2,750 acres, thus averaging less than four acres to each grower. Mortgages on either farm or town property are very rare. There was no delinquent town tax at Lehi in 1897, and it is said that no tract of beet land has ever been sold at forced sale. There is more intense cultivation there, less expensive machinery, and more primitive methods in the field work. These latter increase the cost of production materially, but the families are generally large, and but little labor is hired on the farms. The women do not work in the fields, and the girls seldom work there, unless at home. Much of the hand labor in raising beets is done by boys. Crop rotation is practiced in an erratic way, and live stock is kept on most of the farms, so that manure is freely used in fertilizing. As the alfalfa is needed for stock feed it is seldom plowed under. All the beets for this factory are raised by irrigation.

The Utah Sugar company is said to have a capital stock of $1,000,000 and a bonded debt of $400,000. It is a very prosperous company. The refined sugar produced in 1896 is said to have cost $3,625 per hundred pounds. At a public meeting held in Ogden, Utah, November, 1897, to establish a beet sugar factory there, David Eccles said, among other things, "I am an Ogden stockholder in the Lehi sugar factory, and I may say that during the past two years they paid 37 1-2 per cent. dividend on the investment to the stockholders." The *Salt Lake Herald*, December 25, 1897, says: "The cost of the sugar company's plant at Lehi was over $500,000. It paid its stockholders no dividend for several years. Lately it has paid 10 per cent per annum dividends. Its stock is held stiffly at $8.00 per share, with few sellers. There has not been a delinquent tax payer in the vicinity of Lehi for years past."

We present the following analysis of the business of the Utah Sugar company, for the past seven years. The figures below are largely taken from an able report by Henry Michelsen, of Denver, Colo., on the beet sugar industry:

LEHI FACTORY.

Year.	Acres beets grown.	Average tons per acre.	Average per cent sugar in beets.	Average per cent purity.	Average per cent sugar extracted.	Tons of sugar made.	Pounds sugar per ton beets.	Refined sugar yield per acre.
1891	1500	6.6	11.	80.	5.52	550	110	733
1892	1500	6.5	11.	80.	7.50	737	150	983
1893	2755	9.7	11.6	79.5	7.65	2050	153	1488
1894	2850	11.5	12.7	80.2	8.41	2750	168	1930
1895	3300	11.5	13.5	81.5	9.66	3684	193	2233
1896	3200	13.5	13.9	82.5	10.60	4578	212	2861
1897	2700	6.75	13.2	82.	9.90	1838	198	1337
Averages.	2551	9.44	12.4	80.8	8.46	2312	169	1652

The land rentals around Lehi vary from $7.50 to $15.00 per acre. The conditions there, as to irrigation, soil, rainfall etc., are so similar to Colorado, that the study of this industry there is of peculiar interest. A dry spring, deficient water supply for irrigation, blight and insect depredations were all factors in cutting down the yield of beets in 1897 in Utah. The Utah Sugar Company cut 18.560 tons of beets in its factory run of 54 days in 1897 and made 3,676,700 pounds of refined granulated sugar.

The average rainfall for Utah is about 12 inches. It is about 16.5 inches near Salt Lake City. December is the wettest month, and the largest precipitation of the year is between December 1st and June 1st, each year; June is the dryest month. September shows more precipitation than any of the fall months. October and November average fairly dry weather, suitable for ripening and gathering the beet crop.

The soil shows a great diversity around Lehi, but is generally a heavier soil than the uplands of Northern Colorado. There is more sand in the soil near Springville. Many Lehi farmers claim the soil averages better for beets in the Springville district.

THE EDDY, N. M. BEET SUGAR FACTORY.

The Pecos Valley Beet Sugar Company erected this factory in 1896. The local stockholders have some $16,000 invested, but the larger part of the stock is owned by J. J Hagerman, of Colorado, and by wealthy manufacturers of Milwaukee, Philadelphia and New York City. A large part of the machinery was formerly in use in Canada. About $175,000 is now invested in the business. The factory is said to have a rated capacity of 225 tons of beets per day. The owners contemplate enlarging it this season, and 3,500 acres of beets are to be contracted to be grown for its use.

They use Thurber lump coal--some 30 tons per day. This is a semi-coking coal and makes a large amount of gas, soot and ashes. It costs $4.55 per ton, unloaded in bins at the factory. The blue limestone used, some nine tons per day, comes by wagon from Dark Canon, some 12 miles distant. It is 97 per cent carbonate of lime, about 3 per cent silica (a little too much) with a little iron, sulphate of lime and alumina and only a trace of magnesia. It costs $1.75 per ton at the factory. Pocahontas coke is used, from Memphis, Tenn. Sulphur deposits have been recently found, fifty miles distant, that will supply the factory needs next season.

The Pecos river water is very alkaline. The town of Eddy is supplied with domestic water by a pipe line from Dark Canon, two miles southwest. This supplies the factory when in operation also with a million gallons per day.

The factory cut an average of 134 tons of beets per day, the first season, and about 160 tons per day, during the last year's run. The company receives its beets "on board the cars at any station on the line of the Pecos Valley Railway," paying its own freight. It started the factory operations in November, 1896. and November 15, 1897.

The factory employs about 60 hands on each shift. A local stockholder says the company has estimated that the present working capacity of the factory can be doubled by an expenditure of $25,000. The present factory capacity is too small to secure the best results. The factory beets are raised at various points between Pecos City, Texas and Roswell, New Mexico. The Company raised 200 acres of beets in 1897. All its beets are raised by irrigation. Some 2,000 acres of beets were planted last spring and only about 1,700 acres were harvested. A fungus disease, blight and insect depredation, are given as causes of the small yield last season. One car load of beets in 1896 ran 24 per cent sugar in the beets and 92 per cent purity.

Supt. Vallez planted "mother" beets in the spring of 1897, raised beet seed, planted this seed and raised beets for the factory, all in the one season. Some 30 tons of "mother" beets were kept over and planted in February, 1898, to raise seed. They tested 19 per cent sugar and 84 per cent purity.

EDDY FACTORY.

	1866	1897
Acres of beets grown	1500	1900
Tons of beets produced	7800	5700
Average yield of beets ifi tons per acre	5.2	3.0
Per cent of sugar in beets	16.2	14.2
Per cent of purity of beets	82.0	80.0
Per cent of sugar extracted from beets	5.77	10.53
Pounds of sugar made per ton of beets	116	210
Pounds of sugar made per acre of beets	600	632
Tons of sugar produced	450	600
Days factory run	60	40

The population of Eddy is about 1,200. The Pecos Valley has an ample water supply, and a fine canal and reservoir system. The water assessments on lands is $1.25 per acre per year. The valley is a natural fruit garden, but is new, and lacks the farming population and, perhaps too the close careful cultivation, deep plowing, crop rotation, and knowledge of irrigation that pertains to the older farm districts of Colorado. It is doubtful also if beets do well when planted late, and grown during the extreme heat of their summers. It may be possible to grow there two crops of beets—an early one and a late one. That will be tried this year, since the company advises the farmers to plant a part of their beet seed early and the remainder between June 15 and July 20. There is a large amount of gypsum in the soils there, and the lime rock crops out on the surface over large areas. The winters are mild and the records show at times high ranges of temperature in May, June, July and August. The average precipitation there is about 13 inches, but in 1897 it was 15.5 inches. The records show peculiar conditions—the rainy months being July, August, September and October. May is generally a dry month; in June there is more moisture. The record at Eddy for three years shows no precipitation in March, and very little in April, or November- The dry months are November to June inclusive.

COST OF GROWING SUGAR BEETS.

The investigation as to the cost to the farmers of growing the sugar beets has been very thorough. It covers the personal experience of 116 farmers, growing beets for the Norfolk factory, and also a large number around Grand Island and Lehi. It involves the question of labor, machinery, land rental, distance from factory, etc. In all cases the data cover all details from seed to delivery at the factory. The land rental is also included in each instance, whether the grower owns the land or is a tenant. The yield was obtained for 1897 and also for other years when possible, and the data enable us to figure the cost per acre and per ton, with the profit or loss. The figures obtained cover no allowance for cost of fertilizers, nor for profit on the beet tops, leaves and pulp. It was assumed that with our systematic crop rotation and alfalfa fertilizing in Colorado, the soil would ordinarily be rich enough.

In considering the figures obtained, we must remember that the beet crop of 1897 in Nebraska and Utah was only about sixty per cent of the ordinary yield, while in New Mexico the results did not warrant making any figures on cost of production. A larger tonnage would increase the cost per acre of topping and delivery to the factory. In general, however, the grower overestimates his yield, in giving the figures for 1897. By a like human tendency he may forget to mention some items of expense, or undervalue them. Where the factory does not receive all the beets before freezing weather, there is certain labor in putting the beets into pits, or silos, with a later uncovering and rehandling. This matter and the taking of sample beets to the factory before digging, to ascertain if ripe, are uncertain items of expense. It is assumed that any beets raised, that were not of proper sugar content or purity, would be worth the factory price in Colorado for feed for cattle, sheep or hogs. The figures are made uniformly $4 per ton for the beets, as representing probable conditions here. The Nebraska growers received $5 per ton, one year, under a bounty law. The Utah growers were paid $4.25 per ton in 1896 and are to receive that price this year.

NORFOLK FACTORY.

The 116 beet growers, whose figures were obtained around Norfolk, claimed to have grown 1941 acres of beets of beets in 1897. The average yield given me was 9.4 tons (which at $4 per ton gives $37.60) average cost per acre $26.56, and average profit per acre $11.04, above all expenses, including delivery of beets to factory, rental, etc. This covers yields of from five tons to fifteen tons per acre and *net* results from a loss of $7.55 per acre to a profit of $29 per acre.

Believing in conservative figures, we think the yield to have been actually about eight tons average per acre there for 1897, while the average cost per acre may be put at $30, and the average profit at $2 per acre. It has been a hard year for the beet growers.

The contract price and usual cost of thinning beets at Norfolk is $4.00 per acre. The 18 pounds seed at $.15 was arbitrary, under the contract. Here is given the actual details from a German grower, Herman Wachter, as a typical instance, as he hires no help outside of his family and his beets were already dug, and delivered to the factory, thus verifying the yields:

SUGAR BEET GROWING, NORFOLK, NEB.

Name, Herman Wachter. Address, Norfolk, Neb.

Acres grown, 10 Year, 1897.

EXPENSES PER ACRE WERE:

Plowing	$ 1.50
Harrowing	
Rolling, or leveling	1. 0
Seeds 18 lbs. @ 15 c	2.70
Seeding	.50
Cultivating, 6 times @ 30 c	1.80
Thinning	4.00
Hoeing, 3 times @ $2	6.00
Pulling	1.00
Topping	3.00
Hauling, 10 tons, 1 mile @ 21c	2.10
Rental of land per acre	5.00
Total cost per acre	28.60
Yield, 10 tons per acre @ $4	40.00
Net profit per acre	11.40

Cost per ton, $2.86. Net profit per ton $1.14.

OTHER CROPS GROWN BY ME WERE:

YEAR.	Acres grown.	Yield per accre	Cost per acre.	Profit per ton.	Profit per acre.
1891	3	16	30.00	2.13	34.00
1892	5	16	30.00	2 13	34.00
1893	14	17	31.00	2.18	37.00
1894	12	6	28.00	loss .67	loss 4.00
1895	12	14	29.35	1 90	26.65
1896	12	12	29.00	1.58	16.00

Oct. 11, 1897.

An increase of $1.00 in cost of topping, would have made Mr. Wachter's details for '97 typical of most of those obtained; the data vary generally in the number of times cultivating and hoeing, the yield, the hauling, and land rental.

GRAND ISLAND FACTORY.

At Grand Island the inquiry as to cost of growing the beets was less thorough, owing to a special request to look into the question of cheap foreign labor, claimed to be used in this industry. The details, covering the growing of 459 acres of beets around Grand Island, Lockwood and Rivers, Nebraska, show an average reported yield of 9.5 tons (paying the grower, $38.00,) average cost per acre $28.73, and average proflt per acre of $9.27. The actual average yield reported from the factory there for 1897 is 8.1 tons per acre. The yield reported there varied from five tons to twelve tons per acre, and the *net* results from $17.00 per acre profit to $12.00 per acre loss. Upon a review of these figures, the increased cost seems to be from the grower's living more distant from the factory—many shipping by rail. The average cost per acre may be fairly put at $30.00 there, the same as at Norfolk. The officials at both these factories put the cost per acre at the value of seven tons of beets, or $28.00 per acre.

Mr. R. M. Allen, of Ames, Nebraska, president of the American Sugar Growers' Society, and who raised for several years an average of over 500 acres of sugar beets, keeping the exact details of every item of cost, is firmly convinced, from his own records and experience, that sugar beets can be grown and marketed in Nebraska, at a cost of $30.00 per acre.

LEHI FACTORY.

George Austin, agriculturist for the factory at Lehi, gives the average cost to the grower of raising beets there for the past seven years, at $32.50 per acre. This does not, however, cover the land rental, which is from $7.50 to $15.00 per acre in that locality. We have averaged the rental at $10.00 per acre. The figures given me on the yield there average 10.1 tons per acre, but the actual average yield of all beets grown in 1897 was 6.75 tons per acre. From the figures given us, the average cost per acre there is $40.00. This may be assumed as fairly accurate, since there is added to the Nebraska cost, an average of $5.00 per acre increased rental, the cost of irrigation and a lack of proper machinery to do work quickly and cheaply. The one-row cultivator is often used instead of the four-rowed machinery, while the beet puller, used in Nebraska, is not used or known in Utah. As a comparative instance, a grower at Springville reports 20 tons of beets per acre. Prices of labor are the same there as in Nebraska, yet he reports a cost of $14.00 more per acre than the current figures around the eastern factories. Very little of the work is done by contract in beet growing in Utah.

PROFIT IN GROWING SUGAR BEETS.

In these average conditions we include the failures The prospective beet-grower will probably judge that he can do better than the average. Large yields are regularly obtained by those farmers who do thorough, clean work. Twenty to thirty tons per acre are not uncommon yields, while over forty tons are reported, on good authority, as being of proper sugar content and purity.

In 1893, the Standard Cattle Company, of Ames, Nebraska, R. M. Allen, manager, raised 500 acres of sugar beets, and shipped 7,514 tons, over 100 miles to the Grand Island sugar factory. The average yield was 17.46 tons per acre. Among the yields were 5 acres averaging 30.2 tons, 28 acres averaging 22.7 tons and 59 acres averaging 20.5 tons per acre. After reserving the unmerchantable beets and topping the balance, the factory shipment averaged 15.02 tons per acre, *net* yield. After paying some $6,000.00 freight charges, there still remained a *net* profit of $6.25 per acre, besides over 1,200 tons of beets for cattle feed.

BEET CONTRACT

WITH

UTAH SUGAR COMPANY FOR 1898.

Acres........ *Lehi, Utah.................1898.*

This agreement made and entered into this......day of ....1898, between the Utah Sugar Company (a corporation) the first party and.............................. of Lehi, second party, witnesseth: That the first party agrees to purchase from second party any and all beets he may produce (from seed furnished by the first party at the rate of 15 cents per pound) on the...........acres of land hereby agreed upon, that do not weigh over 3½ pounds each and contain not less than 12 per cent sugar in the beet and that have a purity co-efficient of not less than 80 per cent, paying him therefor at the rate of Four Dollars and twenty-five cents per ton, delivered and piled in a proper manner under first parties' direction and unloaded at the Utah Sugar Company's factory at Lehi at cost of second party in first class condition, with the tops closely and squarely cut off at the base of the last or bottom leaf. The beets so delivered shall reach all the requirements of this agreement, and not contain any diseased, frozen, damaged, or improperly topped beets, nor any beet that weighs over 3½ pounds, otherwise the entire load so being delivered may be rejected. The dirt weighed with the beets shall be tared and deducted from the gross weight by the first party in its customary manner, and shall be conclusive. Payment shall be made on or about the 15th day of each month for beets delivered the previous month. Said beets to be delivered only when ordered by the first party up to October 15th, 1898, after which time and until November 30th, 1898, second party may deliver beets as fast as they may desire if the said beets reach the required standard. To ascertain the quality of the beets, the first party shall at various times before and including November 30, 1898, and also at times of delivery, sample and polarize in the usual manner, the results of which shall be conclusive. If said beets have not reached the required standard by November 1st, 1898, tested in the usual and customary manner, and if after that time and up to time of the delivery attain it, then the first party may deduct 50c per ton from the contract price. After the 30th of November, 1898, it shall be optional with the first party whether or not it accepts any beets that have not been delivered. The second party hereby agrees to plant, cultivate, and harvest, in a husbandmanlike manner......acres of sugar beets on the land agreed hereon and protect them from the frost and sun while being harvested and delivered, and deliver them at the times, places, and in the manner set forth in this contract for the sum of Four Dollars and twenty-five cents per ton, to be paid as above set forth.

This contract is not transferable.

UTAH SUGAR COMPANY.
By.........................

CONTRACTS BETWEEN FARMERS AND FACTORY.

We present the above 1898 contract of the Utah Sugar Company, as a sample form, which in its general terms has been used for years, and has satisfied the growers. The 1897 contract was identical, excepting that the price was then $4.00 per ton, and the beet seed 18 cts. per pound. This factory will use in 1898 about 33,000 pounds of German seed and 26,000 pounds of seed of its own raising. Home grown seed was used at Lehi and in the Pecos Valley, N. M. last year and produced better results than any imported seed. In the seven years the factory has run, it has not rejected over 2 per cent of the beets, on an average, for size and deficiency in sugar or purity. They have contracted 3,500 acres to be grown there to beets this year.

The two Nebraska factories use the same form of contract. That for 1897 agreed to pay $4.00 per ton, for 12-80 beets, $3.25 for 11–75 beets and $2.50 for 10–70 beets. The grower was to pay 15 cts. per pound for beet seed and plant 18 pounds. Beets of any weight are accepted. Their 1898 contract is changed. They agree to pay for beets containing 12 to 14.4 per cent sugar and not less than 78 per cent purity $4.00 per ton; for beets of equal purity, and 14.5 to 15.4 per cent sugar $4.25 per ton and 25 cents per ton additional for every like per cent of sugar over 15.4 per cent, and purity not less than 78 per cent. Then 11–78 beets are to be $3.50 per ton; 10–70 beets $3.00 per ton. Fifteen cents per ton reduction for every degree (or fraction thereof) of purity below 78, and no beets to be accepted containing less than 10 per cent sugar and of 73 per cent purity. The contract at first provided that if Hawaii is annexed to the United States, a reduction of 50 cents per ton is to be made from all the above prices; but this clause was cut out. The growers may also have a chemist check the analyses at their own expense.

The other Oxnard factory, operated by the Chino Valley Beet-Sugar Company, of Chino, California, makes a reduction in its contract of 15 cents per ton for each and every degree of purity below 78 per cent, and of 50 cents per ton for each and every per cent of sugar below 12 per cent, down to and including 10 per cent, below which no beets are to be received. The company pays $3.50 per ton for beets with 12 per cent sugar, and 20 cents per ton increase for every additional per cent of sugar in the beets. It reserves the right to reject very large beets. The growers are allowed to have a representative in the tare room, and the weigh room, and a check chemist in the laboratory.

The Pecos Valley Beet-Sugar Company pays under its contract $4.00 per ton for 12–80 beets.

The Spreckles Sugar Company, of Watsonville, California, has a very simple contract. It provides beet seed at 10 cents per pound. It rejects beets weighing over five pounds, and deducts 5 per cent tare in all cases, for dirt etc. It pays $4.00 per ton for all beets, and makes no limitations as to sugar or purity, except that they shall be fit for sugar-making purposes.

GENERAL CONTRACT NOTES.

All beet contracts are for one year only, and define the acreage of beets to be grown, agreeing to take all that are as per contract. In all beet contracts the grower is to be paid the 15th of each month for all beets delivered the previous month. All factories provide the beet seed to be planted and supervise the growing of all beets by their field agent. The factory determines when the beets are ripe, by chemical tests of sample beets delivered by the grower, and directs when they shall be dug and delivered.

THE LABOR PROBLEM.

Perhaps the most serious problem involved in the growing of sugar beets, is the large amount of hand labor required, a part of which, the thinning and weeding, must be done on the hands and knees. The topping of the beet is another tedious matter. The hand labor, on the knees in the dirt, is a factor which the average adult American farmer will personally reject. The natural inference, in seeing women, children, Germans, Russians, Chinamen, Japanese and Mexicans doing this hand work, is that it is *cheap labor, or foreign contract labor*, and that such cheap labor is a necessity to produce the beets and sugar at the current market price. The investigation does not warrant any such idea. It is not a fact. It is simply an humble occupation, rejected by those tillers of the soil who can do better in raising other special crops. The prices paid the Chinese and Japanese for work in the beet fields of California, are reported to be fully equal to Nebraska and Utah wages for similar work. The beet growers of Anaheim and Chino employ white labor exclusively and profitably. The price paid per day in the beet fields, is everywhere the same as that paid for other farm work. On contract work it often exceeds the ordinary farm wages, and it is reported that some Chinese laborers have made $3.00 per day in this way, on contract work in the Pajaro Valley.

The beet-sugar factories in Nebraska faced this problem in the first three years of their operation. It threatened their very existence, and endangered the million dollars invested. It was solved by bringing in Germans and Russians from other parts of the state, who took the work gladly at current prices.

It has been the serious problem to every factory, how to get the labor to raise the proper beet tonnage. At current Nebraska contract prices, of $4.00 per acre to thin the beets, and the same amount to top them, this pays $8.00 for *hand labor*, on every acre of beets grown. It requires work equal to one person six days at $1.33 cents per day. Each Nebraska factory requires the beets from 5,900 acres of land. Leaving out any hand hoeing, we have necessary then, for each beet-sugar factory, hand labor equal to that of 30,000 persons for one day! All thinning too must be done in less than thirty days, requiring, therefore, more than five hundred persons to be at this work during that month.

COST OF MAKING BEET SUGAR.

Few facts are made public regarding this important question.

The figures obtained are incomplete. The results in 113 German beet-sugar factories in 1889-90, showed the mean capital invested in each factory to be $193,400 and the mean *net* profit for each factory, $34,240, or nearly 18 per cent. The average sugar product is not stated. These factories used an average of 10,503 tons of beets. The profit per ton of beets was $3.26.

Unofficial data from Lehi, Utah, show the 1896 expenses to have been :—

Cost of 43,203 tons beets	$190,000.00
Labor in factory	32,000.00
Coal, coke, etc.	30,000.00
Limestone, sacks, filter cloths, oil etc.	25,000.00
Interest, 8 per cent on $400,000	32,000.00
Salaries, insurance, repairs etc.	20,000.00
Total	$329,000.00

This makes the cost of the sugar $3.60 per cwt.

FACTORY CUSTOMS.

The grower is required to take sample beets to the factory at intervals in the fall, that the chemist may determine when they are ripe. At some factories the beets can only be delivered when required. They may be ripe, but they cannot be dug. A rain may come, followed by warm weather, and the beets may begin a second growth. Then a test may show they are below standard, in which case they may be taken at a lower price, or they may not be taken at all, *i e*, they may be too low in sugar and purity. If the factory delay its call until freezing weather, then the beets must be pulled and covered in pits, at the grower's expense for handling, and perhaps some loss by freezing.

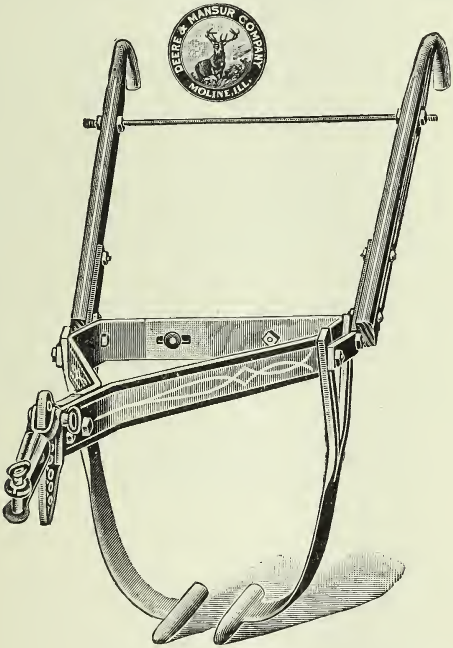
A tare is deducted at all factories for dirt and any improper topping of the beets. A sample lot is taken usually from each wagon load, and several samples from each car load, and the dirt is removed with brushes or a dull knife and the beets are properly topped, if necessary. The loss in weight determines the tare per ton.

When the beets are bought on a value based upon their sugar percentage and purity, the grower sometimes thinks the factory is unjust, and rates the beets too low. A check chemist is permitted the growers at such factories, but he is seldom employed, especially if the contract states that the factory test shall be final.

Some of the factories furnish quite an amount of the seeders, cultivators, and pullers, charging a rental. The Lehi factory seeds most of the land for the growers, charging 40 cents per acre, besides the seed.

BEET MACHINERY.

The best machinery we saw was at Norfolk, Nebraska; there are three seeders used there. The Jewell four row beet planter is made by Jewell Brothers, Platte Centre, Neb.



The Superior Drill Co., of Springfield, Ohio, a
a four row beet drill; and the Moline Plow Co., of Moline, Ill., sells a two row beet seeder and a two row beet cultivator. The Deere & Mansur Co., Moline, Ill., sells two varieties of two row beet cultivators. They also sell an adjustible beet puller, a cut of which is shown herein. This is an adaptation by Theo. Hapke, of Grand Island, Neb., from the more cumbersome beet pullers used in Germany. A puller is made by the local blacksmith at Norfolk, Neb.,

which some prefer. The forks are slightly curved and narrowest at the center.

FACTORY REQUIREMENTS, MACHINERY, ETC.

The Sugar company at Norfolk, Neb., was given a bonus of $100,000 cash and fifty acres of land to build and operate its factory there. The Grand Island company is said to have been given also a bonus of $100,000. The Utah Sugar company was given as a bonus, quite an amount of land for the factory site, including a reservoir covering some 42 acres, together with all water rights and privileges connected with it.

The first necessity of a beet sugar factory is that it have a sure supply of good beets. A modern factory of the minimum size for economy now built, will cost some $300,000, besides the capital to run it. This would use 350 tons of beets per day, and would need beets to be grown on from 3,000 to 5,000 acres of land. Allowing for crop rotation, this means that some 10,000 to 15,000 acres of good beet land should be fairly near a sugar factory. Such a factory would use some 50 tons of coal, and say 20 to 50 tons of good limestone per day. The lime rock must be very free from silica, iron, magnesia, or sulphate of lime. It must be nearly pure carbonate of lime. One of the verv necessary needs is a fair amount of good water, not alkaline, for steam purposes, diffusion process, praying the sugar, etc. It is claimed by French sugar journals that it is never desirable to use in a diffusion battery, a water containing more than one part of solid matter in two thousand.

The following is an average of 25 analyses of the water of the Pecos river, at Eddy, New Mexico, showing the solids in 100,000 parts of water.

Chloride of sodium	100
Carbonate of lime	10
Sulphate of lime	130
Carbonate of magnesia	3
Sulphate of magnesia	50
Silica	2
Alumina and sesqui-oxide of iron	3
Sundries	2
	300

A like average of the analyses of 25 samples of water from Dark Canon, shows in 100,000 parts of water, solids as follows :

Carbonate of lime	20
Sulphates of lime and magnesia	28
Chloride of sodium	1
Silica, alumina, etc	1
	50

FEEDING SUGAR BEETS AND BEET PULP.

Volumes might be written on the value of the sugar beets for food. They are a table delicacy that should be grown in every garden. As food for cattle, sheep and hogs, they may be profitably grown by every farmer. One farmer pertinently says, "There is no better factory for the profitable use of sugar beets than running them through the live stock on the farm, and converting them into milk, meat and manure." An analysis shows the dry material contains about the same nitrogen, free extract, and crude protein and about one-half the crude fat of ground wheat. In Utah they are largely used as hog feed, and it is even claimed that their use will prevent the hog cholera.

The beet chips (tops) and leaves are also largely fed where the beets are raised for the factories. In France the beet chips are worth $2.70 and the leaves $1.30 per ton.

The beet pulp produced at the sugar factories is of especial value as a food for live stock. At the Nebraska factory it is given away free. At other factories it is sold for 50 to 75 cents per ton. At or near all the factories a very large number of cattle and sheep are fed. It is a fine feed for dairy cows, but care must be taken not to feed an excess with alfalfa hay, as it is too fattening. It has proven to be especially good food for sheep, when used with alfalfa hay.

The factories produce in pulp about 50 per cent in weight of the beets, or say 180 tons per day at Lehi, Utah. In the silos it loses about 10 per cent more water by the natural compression and is like a soft cheese. In Nebraska the pulp contains about .5 per cent sugar and in Utah about .3 per cent sugar.

Prof. H. W. Wiley writes, January 10, 1898, "Beet pulp is not a complete ration by itself, but needs to be fed in conjunction with a rich nitrogenous food, such as cotton or linseed meal, peas, beans or clover. Beet pulp is easily preserved in silos, does not tend to ferment, and can be kept indefinitely, when properly preserved."

Prof. Wiley in this letter gives the composition of a beet pulp containing 60 per cent of water, as follows :

	Per Cent.
Moisture,	60.00
Ash,	3.21
Crude protein,	2.98
Fiber,	8.72
Non-nitrogenous matter,	24.77
Fats,	.27
Total,	99.95

At the Lehi sugar factory the pulp is carefully stored in immense silos built in the ground, without any covering. About half a per cent in weight of salt is sprinkled on every layer of pulp as it goes into the silos. These two silos are built of heavy timber and are 10 feet deep 20 feet wide on the bottom, 24 feet wide on top and 800 feet long. Storage capacity of both, 14,000 tons of pulp. They are floored.

Tracks are run into the center of these silos, which are open at one end. A water-way is built under the center of the tracks, to carry away the water draining from the wet pulp. The tracks run between the feed yards, and horses pull the small cars out of the silos. The pulp is fed in open troughs and the alfalfa hay from racks. The pulp is fed to both cattle and sheep. The stock have always access to plenty of hay, pulp and water. *They never feed a pound of grain in fattening the stock,* unless the pulp gives out. In 1895 they fed the pulp which had accumulated for three years. Both here and at Eddy the sheep seemed especially fond of the dry pulp from the top of the silos.

The cattle at Lehi were put on this feed November 3, 1897, and the sheep about two weeks later. The cattle get on full feed in about ten days, and the sheep at once. They were a rough lot of cattle but many were then (Dec. 20) ready for the butcher. The sheep were mostly May lambs, with about 200 head of broken mouthed ewes. They were in splendid condition, not ten poor sheep in the lot. Supt. George Austin says that they feed about a hundred days; that cattle consume about 15 pounds of hay and 100 pounds of pulp per day, and the sheep two pounds of hay and three to four pounds of pulp per day. He said from the way the sheep were gaining they would reach the market averaging 90 pounds per head. (They were weighed into the yard at 60 pounds per head.) He also says that the pulp gives the best results after fermenting in the silos for thirty days, and should not be fed before then. He says that if there be any criticism on this feed, it is that the stock *get too fat*, but that the sheep top the Chicago market and find ready sale also in foreign markets. They have not nearly enough pulp to supply the local demand.

At the Eddy, N. M. factory stock yards they are feeding only sheep this season. The sheep there are said to use per day eight pounds of pulp and one pound of hay per head per day.

From the Grand Island factory pulp is furnished to feed sheep at Shelton, Nebraska. Ed Graham, (manager for E. F. Swift) and Matthews and Stockwell are feeding there. The latter wrote Jan. 1, 1898, that they are feeding 25,000 head of lambs on the pulp; that they consume about three pounds per head per day, and that the freight on pulp is 30 cents per ton from Grand Island.

John Reimers has fed pulp to cattle for three years at Grand Island. He uses about 50 pounds of pulp, 20 pounds corn meal, a little bran, and oil cake, and the usual amount of hay per head per day, as a full ration.

Hake Bros., of Grand Island, Neb., fed 200 head of cattle and 20,000 head of lambs on beet pulp, at the factory feed yards this season. They have fed cattle on beet pulp, both there and at Norfolk for several years. They feed about 80 pounds of pulp and 12 to 20 pounds of corn meal per head per day. They say that the cattle coming to the feed yards from the ranges, find the moist pulp a great help in making the change from grass feed to hay; say the sheep get on a full feed of pulp within 24 hours, and that the lambs use about 4 pounds of pulp and 1 to 1½ pounds of corn meal per head per day, mixed, beside the hay.

W. H. Butterfield fed 1,000 head of cattle on pulp at the Norfolk, Neb., sugar factory yards this season. Has fed there several years. He feeds about 70 pounds pulp mixed with 15 pounds corn meal per head per day; also all the hay they will eat. Says the steers on this feed use only about a ton of hay per head during the entire feeding season; says beet pulp is an especially fine feed for sheep.

CONCLUSIONS.

That the beet sugar industry is still in its infancy, or in the experimental stage, both as to the factory operations and the growing of sugar beets by the farmers. American inventive genius has not yet found enough demand for this special factory and farm machinery to fairly grasp the problems and solve them, namely: How to simplify the mechanical and chemical methods and save the necessity of the present great cost of beet sugar factories, and how to reduce the handlabor in the fields, or do away with it entirely.

That a sure supply of sugar beets may be obtained every year for factory uses, where raised by careful, thorough farmers, having an ample supply of water for irrigation.

That many localities in Colorado and adjoining states have every qualification necessary to establish a paying beet sugar factory, excepting the laborers to raise the beets.

That a single beet sugar factory will produce enough beet pulp in a single season's run of 100 days, to fatten 35,000 head of sheep—the pulp filling the place of hundreds of cars of corn, now shipped to this State every fall and winter. That this pulp would be produced just when needed for feeding, and should be a stimulus to that industry and a profit to a Colorado factory.

That to become a leading national industry, it must be so simplified as to be beyond political hazard and the need of a protective tariff.

That a closer relation must obtain between the producer of sugar in the field and those who extract it, at the factory, so that the profit may be believed to be more equitably shared. The present enormous expense of factory construction invites this, since the beet grower risks but a few dollars in farm machinery, and can stop growing beets any time, while the greatest risk to the factory, under proper management, is a shortage in its supply of beets.

That when the conservative Colorado farmer undertakes to grow sugar beets commercially, he will as surely succeed and top the mark and market in that industry, as he has in the growing of wheat, potatoes, fruit, and melons, and in the feeding of sheep on alfalfa hay.

THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 43.

(Technical Series, No. 3.)

I. Colorado Lepidoptera.

II. A Few New Species of Deltocephalus and Athysanus from Colorado.

III. A List of Original Types, etc., in Collection.

Approved by the Station Council.

ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

MARCH, 1898.

Bulletins will be sent to all residents of Colorado, interested in any branch of Agriculture, free of charge. Non-residents, upon application, can secure copies not needed for distribution within the State. The editors of newspapers to whom the Station publications are sent are respectfully requested to make mention of the same in their columns. Address all communications to the

DIRECTOR OF THE EXPERIMENT STATION,

Fort Collins, Colorado.

The Agricultural Experiment Station,

FORT COLLINS, COLORADO.

I.

COLORADO LEPIDOPTERA.

CLARENCE P. GILLETTE.

Since entering upon my duties as Entomologist of this Station, I have kept records on all our captures of insects within the State. These records contain notes in regard to dates and localities of captures, names of collectors, food-plants, altitudes, and such other data as might be considered of interest.

There have been requests that these records be published for the information of those who are interested in entomology, but who cannot have access to our collections and records. Bulletin 31, gave our records upon the order *Hemiptera*, and in the present paper are given our records upon the order *Lepidoptera*, so far as the species have been determined.

In this connection, I wish to state that I am greatly indebted to the following specialists for the determinations of the great majority of the species here reported: Dr. J. B. Smith, Dr. C. H. Fernald, Rev. Geo. D. Hulst, Mr. David Bruce, and Dr. Henry Skinner.

Opposite each species in the following list will be found one or more of the Accessions Catalogue numbers. By looking up these numbers in the list of Accessions Catalogue numbers, following the list of names, the records of each will be found:

LIST OF SPECIES WITH THEIR ACCESSIONS CATALOGUE NUMBERS.

RHOPALOCERA.

Family NYMPHALIDAE.

Danais archippus—1001, 791.
Danais berenice—2806.
Danais strigosa—2806.
Agraulis vanillæ—2806.
Euptoieta claudia—564, 638, 691, 1002, 2196.
Argynnis leto—2806.
Argynnis cipris—638, 655, 2686.
Argynnis electa—785, 787, 788, 791.
Argynnis hesperis—640, 790, 791, 2196, 2214, 2216.
Argynnis halcyone—788, 791, 2143, 2149.
Argynnis nevadensis, var. meadii—788.
Argynnis edwardsii—785, 787, 818
Argynnis liliana—781.
Argynnis eurynome—684, 787, 792, 1368.
Argynnis triclaris—785, 2171.
Argynnis helena—2806.
Argynnis freya—687.
Melitæa augusta—537, 787.
Melitæa anicia—544, 337, 564, 681, 687.
Melitæa anicia, var. eurytion—687.
Melitæa nubigena—2806.
Melitæa acastus—567, 1002.
Melitæa palla—2806.
Melitæa chara—2806.
Melitæa minuta—1, 786, 1002, 2112, 2214, 2617.
Melitæa brucei—2806.
Phyciodes nycteis—355, 360.
Phyciodes drusius—360, 564.
Phyciodes carlota—360, 564, 659, 2096, 2463, 2465, 2499.
Phyciodes tharos—537, 559, 564, 602, 2565.
Phyciodes pratensis—388, 554, 687, 2565.
Phyciodes mylitta—2289.
Grapta satyrus—317, 785, 1531, 2096.
Grapta umbrosa—2198
Grapta zephyrus—655, 785, 795.
Vanessa antiopa—35, 209, 719, 1002.
Vanessa californica—738.
Vanessa milbertii—548, 689, 791, 1002, 1531.
Pyrameis atlanta—741, 785, 1002.
Pyrameis huntera—1002.
Pyrameis cardui—786, 791, 1002, 1115.
Pyrameis carye—1426, 2565.
Junonia cœnia—2806.
Limenitis ursula—2806.
Limenitis ursula, var. arizonensis—1390.
Limenitis weidemeyerii—537, 564, 638.
Limenitis dissippus—566, 1002.
Aptura montis—2196.
Anæa andria—2806
Debis portlandia—2806
Neonympha canthus—2806.
Neonympha henshawi—1002.
Neonympha eurytris—2806.
Cœnonympha ochracea—537, 567, 687, 738, 1733, 2143, 2198, 2214, 2227, 2565, 2684.
Cœnonympha pamphiloides—544, 2565.
Erebia callias—785, 788, 791.
Erebia epipsodea—547, 687, 720, 730, 738, 788, 1704.
Erebia epipsodea, var. brucei—2806.
Erebia magdalena—687, 729.
Hipparchia ridingsii—564, 587, 1002, 2683
Hipparchia dionysus—2806.
Satyrus nephele—638.
Satyrus nephele, var. boopis—686, 1368.
Satyrus nephele, var. ariane—638, 1002.
Satyrus meadii—2806.
Satyrus sylvestris, var. charon—638, 655, 1002.
Chionobas chryxus—548, 567.
Chionobas ivallda—2806.
Chionobas uhleri—1002.
Chionobas taygete—726.
Chionobas jutta—2806.
Chionobas semidea—2171.
Chionobas brucei—726, 738, 1706.
Libythea bachmani—2806.

Family LYCAENIDAE.

Lemonias virgulti—2806.
Lemonias nais—655, 2617.
Thecla crysalus—2250.
Thecla halesus—2806.
Thecla melinus—1002, 2091, 2096, 2465.
Thecla dryope—2806.
Thecla calanus—2196.
Thecla sæpium—789.
Thecla nelsoni—2806.
Thecla spinetorum—2806.
Thecla blenina—2806.
Thecla behrii—638, 655, 786, 791.
Thecla augustus—360, 424, 2465.
Thecla henrici—60, 360, 1559, 2078, 2091, 2465.
Thecla eryphon—60, 424, 467, 2096.
Thecla niphon—2806.
Thecla affinis—564, 2112, 2465, 2565.
Thecla dumetorum—360, 2078, 2112, 2465, 2565.
Thecla sheridanii—245, 467, 1559, 2078.
Thecla titus—637, 638, 780, 791, 1002, 2207, 2250.
Chrysophanus virginiensis—2806.
Chrysophanus xanthoides, var dione—599, 602.
Chrysophanus editha—1704.
Chrysophanus thoe—1002.
Chrysophanus helloides—1002, 537, 684, 738, 785, 1704.
Chrysophanus helloides, var. florus—687, 785.
Chrysophanus snowi—2806.

Chrysophanus rubidus—581, 636, 684, 720, 1959.
Lycæna heteronea—537, 790, 793, 1734.
Lycæna lycea—337, 537, 541, 685, 1732, 1734, 2112, 2214, 2509, 2565, 2586.
Lycæna dædalus—2806.
Lycæna lygdamas, var. oro—424, 467, 1114, 2078, 2091, 2465.
Lycæna sagittigera—2806.
Lycæna aquilo—735, 2171.
Lycæna battoides—2565.
Lycæna shasta—45, 360, 1145.
Lycæna melissa—51, 559, 602, 684, 691, 1002, 1174, 2143, 2215.
Lycæna acmon—792, 2198, 2565.
Lycæna pseudargiolus, var. violacea—602.
Lycæna pseudargiolus, var. neglecta—360, 1114, 2091, 2112.
Lycæna comyntas—360, 2112, 2216, 2465.
Lycæna isola—1002.
Lycæna marina—2806.

Family PAPILIONIDAE.

Neophasia menapia—1002.
Pieris beckerii—337, 548, 566, 2294.
Pieris sisymbri—360, 424, 2078, 2091, 2096.
Pieris protodice—559, 674, 732, 738, 785, 791, 1002, 1706, 2227.
Pieris bryoniæ—2684.
Pieris napi, var. oleracea-æstiva—684, 687, 735, 738, 787, 1700.
Pieris rapæ—1002, 747, 759, 1559. Extremely abundant.
Nathalis iole—892, 1002, 2617.
Anthocharis olympia—360.
Anthocharis ausonides var. coloradensis—360, 424, 492, 687, 1559, 2091, 2096, 2465.
Anthocharis julia—567.
Anthocharis eubule—1002.
Meganostema cæsonia—2806
Colias meadii—687, 2171.
Colias elis—785.
Colias eurytheme—541, 738, 741, 785, 818, 1002, 1368.
Colias eurytheme, var. eriphyle—564, 674, 686, 791, 793, 1002, 1368.
Colias eurytheme, var. alba—1002, 2258.
Colias philodicé—537, 541, 544, 674 684, 688, 788, 818.
Colias alexandra—1368, 1704, 2198.
Colias scudderii—687.
Terias nicippe—1002.
Parnassius smintheus—548, 564, 644, 687, 787, 1368
Parnassius smintheus, var. behrii—644, 793, 1002, 2168, 2227.
Papilio eurymedon—644, 2112.
Papilio rutulus—566, 567, 2096
Papilio daunus—1, 428, 2565.
Papilio troilus—1002.
Papilio oregonia—2806.
Papilio zolicaon—1002, 2078.
Papilio indra—1002, 2096, 2143, 2565.
Papilio bairdii—2806.
Papilio asterias—1002, 1374, 1375, 1376, 1432, 1448.

Family HESPERIDAE.

Ancyloxypha numitor—2806.
Thymelicus poweschiek—537, 559.
Pamphila taxiles—581, 1002.
Pamphila colorado—564, 780, 1174, 2169
Pamphila nevada—687, 787.
Pamphila manitoba—537, 564, 644, 2169, 2196.
Pamphila juba—2196.
Pamphila napa—1217, 2298.
Pamphila uncas—1002.
Pamphila rhesus—2465.
Pamphila agricola—1418.
Pamphila snowi—2684.
Pamphila mystic—1217
Pamphila cernes—541, 1217.
Pamphila verna—2617.
Pamphila vestris—564, 1002, 1209, 2565, 2617, 2684.
Pamphila bimaculata—581.
Amblyscirtes vialis—2465.
Amblyscirtes ænus—739, 2564.
Pyrgus ericetorum—2806.
Pyrgus tessellata—818, 1002, 2206, 2509.
Pyrgus cæspitalis—60.
Nisoniades brizo—2112.
Nisoniades icelus—60, 388, 467, 544, 548, 655, 738, 1002, 2091.
Pholisora catullus—360, 1002, 2096, 2112, 2206, 2524.
Pholisora hayhurstii—564, 684, 739.
Eudamus tityrus—556, 559, 1002.
Megathymus yuccæ—537

HETEROCERA.

Family SPHINGIDAE.

Hemaris rubens—687, 1145.
Hemaris senta—2806.
Hemaris brucei—2806.
Lepisesia guaræ—1166, 1649.
Deilephila gallii—535, 556.
Deilephila lineata—808, 818, 830, 1002, 2563, 2653, 2659.
Chœrocampa tersa—2806.
Sphinx drupiferarum—1002.
Sphinx gordius—2806.
Sphinx vancouverensis—
Sphinx chersis—1922.
Sphinx oreodaphne—2806
Sphinx lugens—1002.
Triptogon modesta—1, 740, 1402, 2508, 2553, 2604, 2610, 2654, 2659, 2666 2679.
Smerinthus geminatus—535
Smerinthus cerisyi—565, 1002, 2565.
Paonias myops—2806.

Family SESIIDAE.

Albuna montana—687, 785,
Sannina exitiosa—693.
Sesia tipuliformis—85, 1002, 1220
Pyrrhotænia coloradensis—1002.

Family THYRIDAE.

Thyris montana—602.

Family AGARISTIDAE.

Alypia octomaculata—86, 351, 555, 1002.
Alypia ridingsii—687, 1700.

Family SYNTOMIDAE.

Anatolmis grotei—1002, 1804, 2218.
Lycomorpha miniata—2207.

Family PYROMORPHIDAE.

Harrisina coracina—401, 1165, 1659, 2123.

Family CTENUCHIDAE.

Scepsis fulvicollis—778, 1002, 1440, 2221, 2610, 2679, 2719, 2721, 2722, 2730, 2737, 2743, 2748, 2750.
Ctenucha venosa—1002.

Family PERICOPIDAE.

Gnophæla vermiculata—785, 790, 2179.

Family LITHOSIIDAE.

Lithosia bicolor—685, 790, 2570, 2654, 2659, 2666.

Family ARCTIIDAE.

Crocota rubicundaria—112, 564, 655, 2165, 2610, 2620, 2654.
Crocota brevicornis—627.
Emydia ampla—2806.
Callimorpha lecontei—2806.
Epicallia virginalis—652.
Euprepia caja—791.
Arctia intermedia—1002.
Arctia rectilenia—2652, 2668.
Arctia elongata—
Arctia blakei—2737.
Arctia flavorita—2806.
Arctia dahurica—
Arctia nevadensis—2806
Arctia incorrupta—1002, 2743—
Arctia bolanderi—2225, 2693.
Arctia docta—705.
Arctia ochracea—2806.
Arctia geneura—302.
Arctia arizonensis—2806.
Arctia determinata—2806.
Arctia speciosa—2685, 2750
Arctia pallida—2806
Arctia virguncula—1704.
Leptarctia californiæ—280, 360, 1606, 2091, 2465.
Nemeophila petrosa—687, 2168, 2227, 2755
Pyrrharctia isabella—535, 536.
Phragmatobia rubricosa—334, 2552, 2654, 2670, 2685.
Antarctia brucei—2204.
Leucarctia acræa—334, 371, 428, 436, 523, 535, 562, 807, 1002, 2462, 2573, 2663.
Spilisoma virginica—431, 474, 535, 536, 565, 2110, 2404, 2550.
Hyphantria cunea—556, 672, 1575, 1576, 1577.
Euchætes spraguei—689.
Euchætes egle—690.
Euchætes oregonensis—602, 2610, 2625
Arachnis picta—420.
Arachnis citra—2806.
Ecpantheria permaculata—494, 567, 1714, 2610.
Halisidota tessellata—636, 565, 689, 2604, 2610, 2637, 2647, 2691, 2738.
Halisidota maculata—254, 523, 2621, 2676.
Halisidota labecula—2806.
Halisidota argentata—2806.
Halisidota subalpina—2806.
Halisidota ambigua—2806.
Halisidota occidentalis—2806.
Halisidota trigona—2806.

Family NOTODONTIDAE.

Ichthyura inclusa—331, 2171, 2469, 2471
Ichthyura inornata—2806.
Ichthyura albosigma, var. specifica—2621, 2662.
Ichthyura brucei—2806.
Datana perspicua—1226.
Hyparpax venus—2806.
Hyparpax aurostriata—2806.
Gluphisia trilineata—535.
Gluphisia ridenda—82, 428.
Lophopteryx notaria—536, 1002, 2118, 2573.
Notodonta stragula—2614, 2625.
Odemasia perangulata—2806.
Cerura albicoma—334, 2101.
Cerura cinerea—535, 1002, 1900, 2567, 2570, 2573, 2578.
Cerura candida—2806.

Family SATURNIIDAE.

Attacus co umbia—2423.
Attacus gloveri—1002.
Telea polyphemus—1002.
Saturnia galbina—2806.
Hyperchiria io—107.
Coloradia pandora—2693.

Family BOMBYCIDAE.

Pseudohazis eglanterina—1002.
Hemileuca maia—1002.
Clisiocampa fragilis—112, 115, 118. 125, 623, 693, 739, 893, 1002, 1715, 2178, 2657, 2685.
Clisiocampa thoracica—739.
Gastropacha mildei—690.
Gloveria arizonensis—1002.

Family COSSIDAE.

Hypopta bertholdi—2806.
Hypopta henrici—2806.
Cossus brucei—2806.
Prionoxystus robiniæ—2567, 2604, 2621, 2662.

Family THYATIRIDAE.

Pseudothyatira cymatophoroides—673, 683, 690.

Family NOCTUIDAE.

Panthea gigantea—2806.
Panthea pal· ta—2806.
R.phia coloradensis—535, 629.
Raphia frater—2614.
Charadra deridens—2806.
Merolonche spinea—2806.
Acronycta furcifera—2048.
Acronycta felina—2806.
Acronycta lepusculina—431. 488, 535, 565.
Acronycta americana—101, 433, 671, 683.
Acronycta dactylina—539, 690, 1002, 2578.
Acronycta luteicoma—523.
Acronycta brumosa—334.
Acronycta sperata—535.
Acronycta barnesii—2806.
Acronycta parallela—1127, 2526.
Cerma olivacea—2693.
Rhynchagrotis vittifrons—2806.
Rhynchagrotis mirabilis—1743.
Rhynchagrotis minimalis—2737.
Rhynchagrotis placida—1261, 2164, 2235, 2743, 2750, 2751, 2753, 2748, 2708.
Pachnobia littoralis—2168, 2198, 2224.
Agrotis aurulenta—2806.
Agrotis ypsilon—671, 682, 683, 809, 1453, 1494, 2235, 2610, 2513. 2614. 2635, 2637, 2661.
Agrotis geniculata—2806.
Peridroma saucia—170, 300. 320, 323, 1454, 1464, 1492, 2164.
Pronoctua typica—1743. 2693.
Noctua baja—260, 323, 672.
Noctua rosaria—2158, 2169, 2191, 2198, 2200, 2224.
Noctua patefacta—2164.
Noctua sierræ—2164, 2169, 2191. 2224, 2661.
Noctua nigrum—565, 2169.
Noctua oblata—2168.
Noctua haruspica—688.
Noctua clandestina—96. 496, 555, 563, 2115.
Noctua havilæ—107, 555, 1216, 2168, 2224, 2684.
Noctua piscipellis—1377, 1743, 2685.
Noctua vocalis—2693. 2806.
Noctua atricincta—2552.
Chorizagrotis auxilaris—352, 355, 1002, 1120, 1126, 1142, 2107, 2110, 2682.
Chorizagrotis introferens—352, 563, 1120, 1126, 1142, 1183, 2171, 2610, 2689.
Chorizagrotis agrestis—53, 96, 103, 319, 323, 355, 435, 437, 1120, 1142, 1183, 1453, 2420, 2610, 2682, 2696, 2759, 2765.
Rhizagrotis albicosta—2252, 2647, 2659, 2662, 2663, 2670, 2676, 2679.
Rhizagrotis apicalis—2693.
Rhizagrotis lagena—538.
Feltia subgothica—225, 413, 1440, 1442, 2298, 2610, 2663, 2670, 2676, 2666 2685, 2696.
Feltia venerabilis—435. 523, 536, 2487, 2527, 2480, 2751, 2759, 2763.
Porosagrotis murænula—2135.
Porosagrotis catenula—1451, 1455, 1743, 2737. 2743, 2751, 2759.
Porosagrotis vetusta—2693, 2753, 2758, 2759, 2763.
Porosagrotis mimallonis—1743, 2693.
Porosagrotis rileyana—1973.
Porosagrotis orthogonia—120, 2337, 2763, 2336, 2758.
Porosagrotis pluralis—2610.
Porosagrotis dædalus—2526, 2806.
Carneades quadridentata—810, 891, 1419, 1453, 2748, 2753.
Carneades niveilinea—683, 688, 759, 1453. 2758.
Carneades oblongostigma—
Carneades ridingsiana—1744, 2748, 2164.
Carneades flavidens—1002, 1452, 1457, 2332, 2333, 2733, 2737, 2743, 2748, 2751, 2752.
Carneades flavicollis—681, 2610, 2612.
Carneades brocha—1743.
Carneades hollemani—1514.
Carneades misturata—1743.
Carneades mœrens—1743.
Carneades pleuritica—120, 2610, 2693.
Carneades rufula—2168, 2191, 2198, 2224, 2272.
Carneades friabilis—613.
Carneades detesta—1419.
Carneades cænis—1466, 2758.
Carneades medialis—891, 1494.
Carneades messoria—393, 809. 811, 1357, 1362, 1440, 1454, 1466, 1743, 2295, 2348, 2733, 2734, 2737.
Carneades lutulenta—1743.
Carneades lætificans—2693. 2333.

Family NOCTUIDAE.---(Continued.)

Carneades pedalis--2806.
Carneades infausta--2272.
Carneades munis--2806.
Carneades basiflava—2806.
Carneades insignata--1453, 1456, 1743, 2178, 2272, 2348, 2610, 2722, 2750, 2787, 2743, 2748, 2751, 2759, 2763.
Carneades lewisii--2806.
Carneades tessellata--381, 681, 683, 670, 689, 1655, 1657, 1673, 2347, 2348, 2485, 2621, 2651, 2652, 2634.
Carneades albipennis--800, 811, 1452, 1743, 2198, 2737, 2743, 2748, 2752, 2783.
Carneades pallipennis—451, 1437, 1440, 2332, 2610, 2613, 2614, 2637, 2659, 2663, 2664, 2737, 2743, 2748, 2750, 2751, 2752, 2758, 2763.
Carneades fusimacula--2586.
Carneades basalis—2235, 2298, 2613, 2614, 2621, 2625.
Carneades furtivus—2621.
Carneades servitus—2272.
Carneades obeliscoides—1743, 2235, 2651, 2748.
Carneades conjuncta—2737, 2743, 2759.
Carneades divergens—2168, 2169, 2198, 2224, 2235, 2689.
Carneades brunneigera—2693.
Carneades redimicula—1705, 2272, 2693.
Carneadea tesselloides—1437.
Carneadea silens—2134, 2272, 2610.
Richia aratrix—1743.
Richia parentalis—1002.
Richia decipiens—2693.
Agrotiphila colorado—1002.
Admetovis oxymorus—2806.
Mamestra imbrifera—688, 690, 2178, 2614.
Mamestra juncimacula—2693.
Mamestra lustralis—2806.
Mamestra discalis—2164.
Mamestra determinata—714, 2750.
Mamestra fusculenta—2471, 2476.
Mamestra farnhami—535.
Mamestra liquida—2806.
Mamestra atlantica—1126.
Mamestra candida—1743, 2295.
Mamestra subjuncta—671, 683, 689, 718, 2610.
Mamestra grandis—1118.
Mamestra invalida—2806.
Mamestra trifolii—431, 523, 569, 1705, 1714, 1803, 2103, 2106, 2109, 2110, 2171, 2178, 2198, 2235, 2298, 2610, 2689, 2710, 2730, 2734, 2731.
Mamestra oregonica—688.
Mamestra rosea—509, 555, 565.
Mamestra congermana—2552, 2610, 2651, 2654, 2663.
Mamestra picta—523, 535 808, 1574, 2550, 2689.
Mamestra noverca—1126.
Mamestra renigera—125, 556, 628, 655, 688, 1236, 2633, 2648, 2719.
Mamestra olivacea—2131, 2164, 2178, 2709.
Mamestra lorea—601, 2133, 2164.
Mamestra vicina—131, 639, 672, 2128, 2150, 2235, 2576, 2 , 2610, 2614, 2693.
Scotogramma phoca—787.
Ulolonche orbiculata—538.
Ulolonche disticha—1889, 2215.
Ulolonche fasciata—493, 495.
Hadena niveivenosa—2691, 2699.
Hadena fractilinea--2715.
Hadena longula--1743, 2693.
Hadena passer—2105, 2621.
Hadena illata—103.
Hadena lateritia—535, 2164, 2682.
Hadena apamiformis—2806.
Hadena exornata—2274.
Hadena morna—790.
Hadena alticola--2689.
Hadena devastatrix—673, 682, 800, 2164, 2168.
Hadena arctia—1002, 2164.
Hadena occidens—2806.
Hadena lignicolor—673, 681, 685, 717, 2621, 2654, 2666.
Hadena inordinata--2806.
Hadena semilunata--535, 1180, 2133.
Hadena evelina—1467.
Hadena violacea—2806.
Hadena modica—800.
Hadena mactata—2164.
Hadena chryselectra—2693.
Hadena hulstii—2164.
Hadena plutonia—2164, 2178.
Hadena binotata—2298, 2693.
Hillia senescens—2806.
Pseudanarta flavidens--2806.
Pseudanarta flava—2806.
Pseudanarta singula--2806.
Oligia festivoides--564.
Perigea pulverulenta--1454, 2806.
Adita chionanthi--2806.
Homohadena figurata—2570.
Oncocnemis hayesi--2295.
Oncocnemis dayi—2271, 2272, 2806.
Oncocnemis fasciatus—2806.
Oncocnemis umbrifascia—690.
Oncocnemis levis--1743.
Oncocnemis augustus--1441, 1465, 1806, 1891, 2753.
Oncocnemis mirificalis--2295.
Oncocnemis iricolor—2806.
Oncocnemis extremis—2806.
Oncocnemis occata—523, 2753, 2963.
Oncocnemis chandleri—2693.
Oncocnemis colorado—2806.
Oncocnemis cibalis—1973.
Lathosea pullata—2806.
Polia ædon—2806.
Polia theodori—2806, 2693.
Laphygma frugiperda—1452, 1454.
Laphygma flavimaculata--2298.
Dargida (Eupsephopæctes) procinctus—
Nephelodes violans—2693.
Helotropha reniformis—2806.
Hydrœcia nictitans—683, 2552, 2621, 2663, 2679 2689.
Hydrœcia limpida—671, 673.
Hydrœcia cerussata—2806.
Bellura (Arzama) obliquata—2523, 2587, 2806.
Leucania patricia--334.
Leucania alblilinea—488, 523, 2178, 2610.

Leucania phragmatidicola—685.
Leucania commoides—107, 2178.
Leucania unipuncta—1437, 2610, 2613.
Ufeus plicatus—320, 334, 741, 1495, 1743, 2612, 2622, 2642, 2643, 2645.
Ufeus unicolor—34, 2806.
Ufeus satyricus—2642.
Catabena (Adipsophanes) miscellus—111, 2110, 2126, 2147.
Crambodes talidiformis—536, 2471, 2563, 2567, 2752.
Caradrina civica—1743.
Caradrina extimia—523, 526, 555, 1632, 1633, 1634.
Prophila glabella—1362, 2203, 2333, 2748, 2752, 2758.
Himella thecata—527.
Himella contrahens—2603.
Orthodes crenulata (infirma)—682.
Orthodes cynica—80.
Tæniocampa curtica—1729, 1743, 2147, 2151, 2163, 2637, 2699, 2730.
Tæniocampa incincta—811.
Tæniocampa pacifica—31, 334, 1078.
Tæniocampa alia—320, 323, 325, 371.
Tæniocampa oviduca—1642, 2110, 2200, 2610, 2700. 2727.
Stretchia plusiiformis—301, 2610, 2613. 2614.
Stretchia variabilis—334.
Cosmia paleacea—2164.
Perigonica fulminans—2806.
Ipimorpha pleonectusa—326, 690, 756, 805.
Pyrrhia umbra—
Orthosia helva—2200.
Orthosia euroa—2693.
Scoliopteryx libatrix—555. 1002, 2128, 2695.
Litholomia napæa—334.
Xylina ferrealis—355.
Xylina bethunea—288. 360, 1464.
Xylina fagina—320, 323. 350.
Xylina georgii—1495.
Xylina carbonaria—334.
Xylomiges simplex (crucialis)—270.
Pleroma obliquata—2806.
Calocampa nupera—1464.
Calocampa cineritia—334, 350.
Cleophana antipoda—689.
Cucullia similaris—2806.
Cucullia asteroides—690, 1215, 2235, 2486.
Cucullia dorsalis—103.
Cucullia intermedia—539.
Cucullia cinderella—334.
Abrostola uretis—2653.
Deva palligera—2666.
Plusia æreoides—2621, 2676.
Plusia putnami—2806.
Plusia mappa—2806.
Plusia biloba—2552.
Plusia californica—638, 1002, 2118, 2168.
Plusia brassicæ—569, 690, 805, 776, 1002, 1716, 1726, 2610, 2637, 2763.
Plusia angulidens—2806.
Plusia epigæa—2806.
Plusia ampla—2806.
Plusia simplex—685, 690, 2550, 2578, 2610, 2613, 2756.
Plusia parilis—688.
Plusia snowii—2806.
Plusia russea—371, 2552, 2659.
Caloplusia hochenwarthi—2806.
Caloplusia divergens—2806.
Basilodes chrysopis—1714, 2235, 2298.
Stiria rugifrons—690, 2178, 2610, 2651, 2654, 2670, 2674.
Stibadium spumosum—689, 1714, 2200, 2699.
Plagiomimicus pitychromus—2203, 2652, 2670.
Plagiomimicus expallidus—2203.
Fala ptycophora—1714.
Acopa carina—1002, 1442.
Oxycnemis perfundis—565.
Nycterophæata luna—556, 565.
Copablepharon album—2806.
Copablepharon absidum—335, 336, 2235, 2298.
Thyreion rosea—556 565.
Heliothis paradoxus—2048, 2077, 2118, 2178, 2235, 2298, 2614, 2670.
Heliothis armiger—807, 1806, 2252, 2298, 2763, 2764.
Heliothis dipsaceus—1002, 2091, 2203, 2219, 2235, 2252, 2298, 2708, 2709.
Heliothis scutosus—103, 530, 2153.
Heliothis suavis—623, 2163, 2471. 2526, 2573, 2696, 2708.
Heliothis phlogophagus—488, 505, 807, 1247, 1493, 2168, 2178, 2235.
Alaria gauræ—1906, 2203, 2652, 2615, 2663.
Alaria citronellus—689.
Rhododipsa volupia—2806.
Pseudacontia crustaria—2693.
Schinia cumatilis—1002, 2226, 2252, 2298, 2676, 2685, 2708, 2713, 2731, 2733, 2750, 2751, 2765.
Schinia trifascia—2252.
Schinia simplex—565.
Schinia acutilinea—2806.
Schinia brucei—2699.
Schinia separata—2252, 2806.
Schinia albafascia—2663, 2679, 2719, 2722, 2730, 2733.
Schinia jaguarina—107, 112, 115, 565, 685, 1002, 1236, 2162, 2252, 2610, 2689, 2709, 2722.
Schinia nobilis—2806.
Dasyspoudæa meadii—536, 555, 565, 2576, 2604, 2610.
Melaporphyria ononis—687, 2171.
Melicleptria græfiana—687, 2171.
Melicleptria pulchripennis—2806.
Melicleptria sueta—1514, 1733.
Heliolonche modicella—2806.
Heliaca nexilis—2565.
Anarta cordigera—2806.
Anarta quadrilunata—785.
Anarta melanopa—112, 334.
Anarta schœnherri—2806.
Acontia candefacta—602, 2096, 2143, 2151, 2526, 2573, 2634, 2654.
Acontia augustipennis—103, 112, 334.
Fruva obsoleta—360.
Xanthoptera semiflava—1732.
Lithacodia bellicula—602, 2610.
Erastria carneola—56, 107, 555, 559, 721.
Galgula partita (subpartita)—2048, 2077.
Drasteria erechta—334, 1733, 2227, 2252, 2610, 2734, 2737.
Euclidia cuspidea—566.

Family NOCTUIDAE.---(Continued.)

Synedoida inepta—1559.
Synedoida scrupulosa—1514.
Synedoida insperata—2806.
Syneda athabasca—1732, 2214.
Syneda adumbrata—541, 1531, 2565.
Syneda howlandii—523, 565, 2128, 2693.
Syneda perplexa—2806.
Syneda tejonica—2692.
Cirrhobolina deducta—1514.
Cirrhobolina mexicana—2693.
Catocala verrillana—2806.
Catocala relicta—2806.
Catocala pura—2666, 2700.
Catocala ultronia—800.
Catocala nebraskæ—2806.
Catocala californica—2730, 2734.
Catocala arizonæ—718.
Catocala aspasia—2806.
Catocala subnata—2090.
Toxocampa victoria—2806.
Phurys bistrigata—334.
Erebus odora—1311 1312, 1348.
Renugia latipes—2738.
Thysania zenobia—2806.
Homoptera calycanthata—2693.
Pheocyma lunifera—32, 103, 125.
Pseudaglossa lubricalis—119, 628, 1236, 2693.
Epizeuxis æmula—1348, 1440.
Philometra gaosalis (longilabris)—1730.
Philometra eumelusalis—602.
Bleptina caradrinalis—628.
Hypena humuli—282, 298, 334, 807, 1595, 2475

Family GEOMETRIDAE.

Tetracis grotearia—337.
Tetracis coloradia—730, 786, 1677.
Tetracis lorata—2686.
Metanema inatomaria—1002, 1181.
Ennomos magnarius—892, 2338, 2663, 2709, 2719, 2722, 2731, 2734, 2743.
Azelina hubnerata—428, 2693, 2694.
Endropia madusaria—655, 1732.
Endropia duaria—369.
Opistograptis baltearia—638.
Angerona crocataria—665, 134, 654, 689, 2694.
Synchlora excurvaria—103, 111, 536, 588, 2147, 2289.
Acidalia hepaticaria—1531.
Acidalia perirrorata—807.
Acidalia luteolata—687.
Acidalia ancellata—568, 623, 689, 1174, 2110, 2112, 2143, 2216.
Acidalia quinquilinearia—602, 1733, 2112.
Deilinia variolaria—2048.
Corycia vestaliata—1174, 2112.
Eumacaria brunnearia—1174.
Semiothisa delectata—371, 488, 689, 690, 807, 1714.
Semiothisa respersata—307, 689, 2048.
Semiothisa californiata—523, 685, 689.
Phasiane meadiata—565, 696, 2135, 2178, 2573, 2586, 2610.
Phasiane mellistrigata—488, 2235, 2252.
Phasiane irrorata—1236.
Marmopteryx marmorata—1732, 1733, 2683, 2765.
Thamnonoma quadrilinearia—2765.
Thamnonoma quadraria—100, 785, 2138.
Thamnonoma wauaria—646.
Thamnonoma subcessaria—2048.
Thamnonoma sulphuraria—638, 1654, 1733, 2676, 2719, 2733, 2737, 2752.
Thamnonoma brunnearia—787.
Thamnonoma flavicaria—654.
Eufitchia ribearia—176.
Selidosema juturnaria—655.
Caripeta gertruda—2806.
Fidonia fimetaria—1114, 2091, 2096, 2112, 2693.
Hæmatopis grataria—56, 530, 635, 2147.
Caterva catenaria—832.
Euaspilates spinitaria—2604, 2666.
Gorytodes uncanaria—2110, 2112.
Biston ursarius—360.
Eubyia quernaria—1002, 2693.
Anisopteryx pometaria—218, 256.
Oporagena coloradensis—218, 1528.
Phibalapteryx intestinata—307, 2143.
Petrophora destinata—2143.
Petrophora montanata—2198, 2224.
Petrophora diversilineata—133, 1714.
Rheumaptera ruficillata—2806.
Hydriomane lustrata—269, 1114, 1531, 1559, 2078.

Family PYRAUSTIDAE.

Margaronia quadristigmalis—690, 2298.
Nomophila noctuella—119, 1225, 2178.
Metra ostreonalis—1744, 2178, 2200, 2610.
Pyrausta signatalis—112.
Pyrausta plumbosignalis—790, 1733, 2168, 2198, 2227.
Pyrausta unifacialis—687, 689, 1710, 2694.
Pyrausta fodinalis—986, 1709, 1710, 2143, 2196, 2216.
Loxostege sticticalis—555, 2147, 2178, 2471, 2480, 2487, 2666.
Loxostege obliteralis—2110, 2133, 2143, 2165, 2610.
Loxostege coloradensis—488, 536, 539, 565, 612, 654, 1225, 2203, 2235, 2603, 2604, 2610.
Loxostege lepidalis—54, 523, 2147, 2150.
Loxostege cerealis—588, 1115, 1351, 1440, 1559, 2110, 2133, 2147, 2471, 2480, 2603.
Prorasea simalis—488, 523, 530, 536, 2178, 2692, 2708, 2731.
Titanio thalialis—56, 82, 112, 510, 516, 523, 530, 534, 535.
Scoparia centuriella—687.
Evergestis simulatilis—334, 431.
Chalcœla durifera—79, 82.
Schœnobius tripunctellus—125, 807.

Family PYRALIDIDAE.

Ugra griphalis—723, 1236, 2203.
Pyralis farinalis—91, 532.
Stericta breviornatalis—120, 588.

Family PHYCITIDAE.

Salebria delassalis—53.
Laodamia fusca—807, 1531, 1559, 2171, 2298.
Pyla scintillans—787.
Pima albiplagiatella—79, 539.
Etiella zinckenella—488, 523, 536, 539, 565.
Melitara dentata—74, 79, 2743. 2748, 2756, 2759.
Euzophera aglæella—21, 269, 1531, 2078.
Sarata perfuscalis—535, 556.
Heteroghraphis morrisonella—431, 2178.
Heteroghraphis albiella—689.
Honora oblitella—565, 1236, 2126, 2135, 2178.
Honora undulatella—544, 690, 2128, 2133.
Homœosoma impressale—107, 2127.
Homœosoma electellum—35, 103, 112, 2143, 2178.
Plodia interpunctella—828, 1449.
Peoria hæmatica—690.
Petaluma illibella—523, 654.

Family CRAMBIDAE.

Euchromius texanus—565, 689.
Crambus præfectellus—1002.
Crambus luteolellus—2135, 2148.
Crambus laqueatellus—2298.
Crambus innotatellus—689.
Crambus anceps—687, 689, 790.
Crambus teterrellus—807, 2198, 2221, 2227.
Crambus vulgivagellus—2198, 2298.
Crambus interminellus—2127.
Crambus caliginosellus—126, 235, 628, 2135.
Crambus mutabilis—107, 565. 623, 807, 2154.
Thaumatopsis repandus—635, 883, 892, 1236. 1463, 2200.
Thaumatopsis pexellus—690, 1714.
Thaumatopsis longipalpus—2048.

Family PTEROPHORIDAE.

Platyptilia carduidactyla—537, 1710, 2198, 2224.
Alucita monodactyla—685.
Oxyptilus periscelidactylus—2216.
Pterophorus lobidactylus—1973.

Family TORTRICIDAE.

Cacœcia rosaceana—120, 602.
Cacœcia zapulata—655.
Cacœcia argyrospila—716, 1258, 1906.
Cacœcia semiferana—123, 150, 1906.
Tortrix peritana—811.
Sciaphila osseana—2198, 2214.
Œnectra distincta—590, 672, 811.
Cenopis testulana—1907, 1908.

Family CONCHYLIDAE.

Idiographis ægrana—2168, 2224.

Family GRAPHOLITHIDAE.

Sericoris nubilana—103.
Sericoris puncticostana—
Pædisca circulana—599, 635, 2133, 2143.
Pædisca robinsonana—360.
Pædisca monogrammana—523, 2135.
Pædisca caniceps—628.
Pædisca agricolana—2133, 2148.
Pædisca cataclystina—602.
Pædisca matutina—565, 623, 628, 635.
Pædisca morrisoni—2135.
Pædisca albiguttana—2298.
Semasia striatana—2143.
Semasia taleana—2126.
Semasia ochreicostana—348.
Phoxopteris spiræifoliana—2143.
Phoxopteris spoliana—2091.
Carpocapsa pomonella—151, 311, 2252.

Family CHOREUTIDAE.

Choreutis onustana—785, 1117, 1531, 1557.
Choreutis diana—45, 60, 1531, 1559, 1606, 2078, 2091.
Acrolophus plumifrontellus—602.

Family TINEIDAE.

Tinea bisselliella—2071, 2205.

Family PRODOXIDAE.

Pronuba yuccasella—1231, 1219.
Porodoxus decipiens—537.

Family PLUTELLIDAE.

Plutella cruciferarum—45, 628.

Family GELECHIIDAE.

Psecadia discostrigella—785, 1531, 1117, 1537.
Depressaria nebulosa—29, 198, 623.
Depressaria posticella—690.
Depressaria umbraticostella—29.
Amydra effrenatella—29.

NOTES ON LEPIDOPTERA FROM THE ACCESSIONS CATALOGUE.

Cat. Nos.	*Dates of Captures*	*Collectors.*	*Localities.*	*Remarks.*
21	April 20	C. P. G.*	Fort Collins	Pupæ under stones.
29	April 25	C. P. G	Fort Collins	General collecting.
31	April 27	C. P. G	Fort Collins	Taken at light.
34	April 30	C. P. G	Fort Collins	Taken in office.
35	April 29	C. P. G	Fort Collins	General collecting.
37	May 3	C. P. G	Spring Canon†	General collecting.
45	May 11	C. P. G	Spring Canon	General collecting.
51	May 17	C. P. G	Fort Collins	General collecting
53	May 22	C. P. G	Fort Collins	General collecting.
54	May 23	C. P. G	Fort Collins	General collecting.
56	May 28	C. P. G	Fort Collins	Taken at light.
60	May 29	C. P. G	Rist Canon‡	In the foothills.
74	June 7	C. P. G	Fort Collins	Taken at light.
79	June 10	C. P. G	Fort Collins	Taken at light.
80	June 10	C. P. G	Fort Collins	About willows, pairing.
82	June 11	C. P. G	Fort Collins	Taken at light.
85	June 14	C. P. G	Fort Collins	Flying about currant bushes.
86	June 15	C. P. G	Fort Collins	General collecting.
91	June 17	C. P. G	Fort Collins	Taken at light.
96	June 21	G. H. B.§	Fort Collins	Taken at light.
100	June 22	G. H. B	Fort Collins	About currant and gooseberry bushes.
101	June 23	C. P. G	Fort Collins	General collecting.
103	June 22	C. P. G	Fort Collins	At light in laboratory.
107	June 23	G. H. B	Fort Collins	At light in laboratory.
111	June 24	G. H. B	Fort Collins	At light in laboratory.
112	June 25	G. H. B	Fort Collins	At light in laboratory.
115	June 27	C. P. G	Fort Collins	At light in laboratory.
118	June 20	C. P. G	Fort Collins	Larvæ from apple tree, May 19.
119	June 29	G. H. B	Fort Collins	At light in laboratory.
120	June 30	G. H. B	Fort Collins	At light in laboratory.
123	July 6	G. H. B	Fort Collins	Larvæ from box elder, June 19.
125	July 2	C. P. G	Fort Collins	At light in laboratory.
126	July 6	C. P. G	Fort Collins	At light in laboratory.
131	July 8	C. P. G	Fort Collins	
133	July 12	C. P. G	Fort Collins	
134	July 14	G. H. B	Fort Collins	From larvæ found on currant, in June.
150	Aug. 17	G. H. B	Fort Collins	At light.
151	Aug. 29	G. H. B	Fort Collins	From apples in orchard.
170	Oct. 15	C. P. G	Fort Collins	Taken at light.
198	Mar. 11	C. F. B.‖	Fort Collins	Flying about lamp.
209	Mar. 24	C. F. B	Fort Collins	From larvæ under stones, March 24.

* C. P. Gillette.
† In the foothills, seven to eight miles southwest of Fort Collins.
‡ In the foothills, eight to twelve miles northwest of Fort Collins.
§ G. H. Buffum.
‖ C. F. Baker.

Cat. Nos.	Dates of Captures.	Collectors.	Localities.	Remarks.
223	Mar. 27	C. P. G	Fort Collins	Larvæ under boards and stones.
235	Mar. 31	C. P. G	Fort Collins	In greenhouse.
245	April 9	C. P. G	Rist Canon	Under stones.
254	April 12	C. P. G	Spring Canon	From pupæ.
256	April 14	C. F. B	Spring Canon	At sugar.
260	April 16	C. P. G	Spring Canon	About light.
269	April 16	C. P. G	Rist Canon	Taken flying.
270	April 17	C. F. B	Fort Collins	About light.
280	April 18	C. P. G	Fort Collins	From pupæ under stones, April 9.
282	April 18	C. P. G	Fort Collins	On outside of window.
288	April 22	C. F. B	Fort Collins	Taken on window.
298	April 19	C. P. G	Fort Collins	On wing.
300	April 24	C. P. G	Fort Collins	At sugar.
301	April 25	C. P. G	Fort Collins	About light.
302	April 25	C. P. G	Fort Collins	From larvæ taken under stone, April 8.
319	April 28	C. P. G	Fort Collins	At light.
320	April 28	C. F. B	Fort Collins	At sugar.
323	April 29	C. F. B	Fort Collins	At sugar.
325	April 30	C. S. C.*	Fort Collins	From cocoons.
326	April 30	C. P. G	Fort Collins	Larvæ from cottonwood, June 29.
334	April 30	C. P. G	Denver	About light.
337	April 26	C. F. B	Denver	Larvæ taken under boards.
348	May 3	C. F. B	Denver	Taken on box elder.
350	April 30	C. F. B	Denver	At sugar.
351	April 30	C. F. B	Denver	From larvæ on Virginia creeper, July.
352	May 2	C. F. B	Denver	At light.
355	May 6	C. F. B	Denver	At sugar.
360	May 7	C. P. G	Larimer County	General collecting.
369	May 9	C. F. B	Fort Collins	Larvæ taken in winter.
371	May 9	C. F. B	Denver	About light.
381	May 12	C. F. B	Fort Collins	About light.
388	May 14	C. P. G	Trinidad	Under stones.
393	May 14	C. F. B	Fort Collins	General collecting in foothills.
401	May 17	C. P. G	Fort Collins	From larvæ on four-o'clock, Aug. 14
413	May 18	C. P. G	Fort Collins	From alfalfa.
420	May 9	C. P. G	Fort Collins	From larvæ under boards, April 12.
424	May 21	C. F. B	Horsetooth Gulch†	General collecting.
428	May 23	C. P. G	Horsetooth Gulch	General collecting.
431	May 14	C. P. G	Pueblo	At light.
433	May 7	C. P. G	Fort Collins	From pupæ under boards, March 3.
434	May 7	C. P. G	Fort Collins	From larvæ under boards, March 26.
435	May 14	C. P. G	Denver	At light.
436	May 14	C. P. G	Fort Collins	Larvæ from Virginia creeper, July 23.
437	May 14	C. P. G	Denver	From larvæ under boards, March 26.
441	May 20	C. P. G	Denver	From pupæ dug from ground.
451	May 26	C. P. G	Manitou	From rose galls, May 8.
467	May 28	C. F. B	Rist Canon	Taken in general collecting.
478	May 31	C. P. G	Fort Collins	From larvæ under boards, April 12.
488	June 5	C. P. G	Denver	At light.
492	May 19	C. P. G	Soldier Canon‡	On wing.
493	May 21	C. P. G	Fort Collins	From larvæ under boards, April 12. Fed on alfalfa.
494	May 21	C. P. G	Rist Canon	From larvæ under stones. Fed on grass.
495	May 22	C. P. G	Fort Collins	From larvæ under boards, April 12. Fed alfalfa.
496	May 24	C. P. G	Rist Canon	Larvæ under stones, April 16.
508	June 8	C. P. G	Trinidad	Taken under bark of cottonwood, May 14.
509	June 6	C. S. C	Fort Collins	From seed pods of *Glycyrrhiza lepidota*.
510	June 10	C. P. G	Fort Collins	Swept from beans.

* Prof. C. S. Crandall
† Foothills, about eight miles southwest of Fort Collins.
‡ Foothills, about five miles west of Fort Collins.

Cat. Nos.	*Dates of Captures.*	*Collectors.*	*Localities.*	*Remarks.*
516	June 13	C. F. B	Trinidad	Sweeping grass along river.
523	June 4	C. P. G	Denver	At light.
526	June 4	C P. G	Fort Collins	From larvæ under boards, May 3. Fed clover.
527	June 4	C. P. G	Fort Collins	From larvæ under boards, April 12. Fed clover.
530	June 19	C. F. B	Fort Collins	At light.
532	June 19	R. C. S.*	Fort Collins	In a barn stored with alfalfa.
534	June 18	C. P. G	Fort Collins	Larvæ in stems of currant in spring.
535	June 21	C. F. B	Fort Collins	At light
536	June 22	C. F. B	Fort Collins	At light.
537	June 16	C. P. G	Dolores	General collecting.
538	June 13	C P. G	Pueblo	At light.
539	June 12	C. P. G	Denver	At light.
541	June 15	C P. G	Dolores	General collecting.
544	June 17	C. P. G	Dolores	General collecting.
547	June 20	C. P. G	Hermosa	General collecting.
548	June 20	C. P. G	Silverton	General collecting.
554	June 25	C. F. B	Fort Collins	At light
555	June 13	C. F. B	Fort Collins	At light.
556	June 20	C. F B	Fort Collins	At light.
559	June 13	C. F. B	Fort Collins	Taken flying.
560	June 10	C. F. B	Fort Collins	From larvæ under boards, April 22. Fed clover.
562	June 1	C. F. B	Fort Collins	General collecting.
563	June 10	C. F. B	Fort Collins	At light.
564	June 25	C. F. B	Manitou	General collecting.
565	June 25	C. F. B	Denver	At light.
566	June 24	C F. B	Montrose	General collecting.
567	June 22	C. F. B	Ouray	General collecting.
568	June 25	C. P. G	Colorado Springs	At light
569	June 25	C. F. B	Fort Collins	At light.
581	June 30	C. P. G	Spring Canon	General collecting.
587	June 30	C. P. G	Spring Canon	On willow.
588	June 29	C. P. G	Fort Collins	At light.
590	July 2	C. F. B	Fort Collins	General collecting.
599	July 2	C. P. G	Fort Collins	General collecting.
601	July 3	C. P. G	Fort Collins	At light.
602	July 4	C. P. G	Fort Collins	From larvæ on raspberry, June 29.
613	July 5	C. F. B	Horsetooth Gulch	From larvæ on *Senecio*, May 21. Fed clover.
623	June 5	C. P. G	Fort Collins	At light.
627	June 23	C. F. B	Fort Collins	From larvæ under boards, April 22. Fed clover.
628	June 7	C. P. G	Fort Collins	At light.
629	July 6	C. P. G	Fort Collins	At light.
635	July 9	C. P. G	Fort Collins	At light.
636	July 7	C. P. G	Fort Collins	At light.
637	July 11	R. C. S	Fort Collins	
638	Ju y 12	C. P. G	Spring Canon	General collecting.
639	July 12	C. P. G	Spring Canon	On thistle blossom.
646	July 12	C. P.G	Ouray	From larvæ on *Ribes hudsonianus* and *R. floridanus*.
652	July 13	C. F. B	Rist Canon	From larvæ on rose, May 28. Fed clover.
654	July 14	C. P. G	Fort Collins	At light.
655	July 14	C. P. G	Rist Canon	General collecting.
659	July 8	C. P. G	Fort Collins	Reared from pupæ.
665	July 9	C. F. B	Larimer County	General collecting in foothills.
671	July 16	C. F. B	Fort Collins	At sugar.
672	July 17	C. F. B	Fort Collins	At sugar.

* Ross C. Stephenson.

Cat. Nos.	Dates of Captures.	Collectors.	Location.	Remarks.
673	July 18	C. F. B	Fort Collins	At sugar.
674	July 17	C. F. B	Fort Collins	General collecting.
681	July 19	C. F. B	Fort Collins	At sugar.
682	July 20	R. C. S	Fort Collins	At sugar.
683	July 21	C. F. B	Fort Collins	At sugar.
684	July 19	C. P. G	Georgetown	General collecting.
685	July 20	C. P. G	Denver	Taken at light.
686	July 21	C. P. G	Denver	General collecting.
687	July 15	C. P. G	Graymont	General collecting. About 9,000 feet altitude.
688	July 22	C P. G	Fort Collins	At light.
689	July 14	C. P. G	Denver	At light.
690	July 25	C. P. G	Denver	At light.
691	July 23	C. P. G	Fort Collins	General collecting.
693	July 24	C. P. G	Georgetown	Cocoons abundant on aspen.
695	July 19	C. P. G	Spring Canon	From larvæ on *Iva*, June 30.
699	July 19	C. P. G	Fort Collirs	From larvæ rolling cottonwood leaves, June 29.
705	July 20	C. P. G	Trinidad	From larvæ under stones, May 14. Fed clover.
713	July 25	C. P. G	Fort Collins	From larvæ on *Symphoricarpos occidentalis*, July 8.
714	July 5	C. P. G	Fort Collins	From larvæ under boards, April 12. Fed clover.
715	July 4	C. P. G	Ouray	From larvæ on *Ribes hudsonianus* and *R. floridanus*, June 23.
716	July 5	C. P. G	Fort Collins	Bred from pupæ on walnut, June 29.
717	July 20	C. F. B	Fort Collins	From larvæ under boards, May 8. Fed clover.
718	July 23	C. P. G	Fort Collins	At light.
719	July 5	C. P. G	Fort Collins	From larvæ on willow, June 6.
720	July 6	C. F. B	Fort Collins	General collecting.
721	July 20	C. F. B	Fort Collins	General collecting.
723	June 27	C. P. G	Fort Collins	From larvæ under boards, April 27. Fed clover.
726	July 15	C. P. G	Graymont	Altitude, 12,000 feet.
729	July 15	C. P. G	Graymont	Altitude, 12,500 feet.
730	July 15	C. P. G	Graymont	Taken 9,500 to 12 000 feet altitude.
732	July 15	C. P. G	Graymont	Altitude, 12,500 feet to summit of Gray's Peak.
735	July 15	C. P. G	Graymont	Altitude, 11,000 to 12,000 feet.
738	July 19	C. P. G	Graymont	Altitude, 9,5C0 to 10,000 feet.
739	July 19	C. P. G	Georgetown	Altitude, 8,600 feet.
740	July 18	C. P. G	Fort Collins	General collecting.
741	Aug. 5	C. F. B	Fort Collins	General collecting
747	Aug. 4	C. F. B	Fort Collins	From pupæ on cabbage.
756	July 29	C. P. G	Fort Collins	From larvæ on cottonwood.
757	Aug. 5	C. P. G	Graymont	From larvæ taken on yarrow, July 18.
759	Aug. 1	C. P. G	Fort Collins	From pupæ on cabbage, July.
776	Aug. 8	C. F. B	Fort Collins	Larvæ taken on cabbage, July.
778	Aug. 11	C. F. B	Fort Collins	General collecting.
780	Aug. 11	C. P. G	Rustic	General collecting.
781	Aug. 11	C. P. G	Beaver Creek	General collecting.
783	Aug 11	C. P. G	Owl Canon*	General collecting.
785	Aug. 1	C. P. G	Beaver Creek	General collecting; 10,000 to 12,000 feet altitude.
786	July 30	C. P. G	Stove Prairie†	General collecting.
787	Aug. 4	C. P. G	Cameron Pass	Between Big South and Clark's ranch.
788	Aug. 8	C. P. G	Long Gulch	Near Stove Prairie.
789	July 30	C. P. G	Rist Canon	General collecting

* Foothills, twenty miles northwest of Fort Collins.
† In foothills, sixteen miles west of Fort Collins.

Cat. Nos.	Dates of Captures.	Collectors.	Location.	Remarks.
790	July 31	C. P. G	Little South	General collecting in foothills.
791	Aug. 2	C. P. G	Hourglass Lake	Near timber line.
792	Aug. 3	C. P. G	Larimer County	Above and near timber line.
793	Aug. 7	C. P. G	Larimer County	General collecting.
795	July 30	C P. G	Rist Canon	General collecting.
800	Aug. 18	C. P. G	Fort Collins	At sugar.
805	Aug. 10	R. C. S	Denver	General collecting.
807	Aug. 25	C. P. G	Denver	At light.
808	Aug. 25	C. F. B	Fort Collins	General collecting.
809	Aug. 19	C. P. G	Fort Collins	At sugar.
810	Aug. 19	C. P. G	Fort Collins	At light.
811	Aug. 26	C. P. G	Fort Collins	At sugar.
813	Aug. 19	C. P. G	Fort Collins	On side of house.
818	Aug. 27	C. P. G	Fort Collins	Miscellaneous collecting.
823	Sept. 21	C. F. B	Boulder	General collecting.
828	Sept 21	C. P. G	Fort Collins	Larvæ in oatmeal.
830	Sept. 10	C. F. B	Fort Collins	About flowers in evening.
883	Oct. 8	C. F. B	Larimer County	Taken on shore of a lake.
891	Sept. 20	C. P. G	Denver	At light.
892	Sept. 30	C. P. G	Manitou	General collecting.
893	Aug. 1	C. F. B	Larimer County	General collecting in foothills.
986	Feb. 22	C. F. B	Fort Collins	From pupæ of *Philampelus achemon*.
1001	Feb. 27	C. F. B	Fort Collins	Larvæ from stems of *Œnothera biennis*.
1002	———	P. S.*	Larimer County	
1078	April 7	C. P. G	Fort Collins	Larvæ taken on steps.
1114	May 12	C. P. G	Fort Collins	General collecting in foothills.
1115	May 13	C. F. B	Fort Collins	General collecting along river.
1117	May 12	C. P. G	Fort Collins	From flowers in foothills.
1118	May 12	C. P. G	Fort Collins	Abundant on *Pinus ponderosa, var. scopulorum*.
1120	May 15	C. P. G	Fort Collins	From flowers in foothills.
1126	May 22	C. P. G	Fort Collins	Flying about laboratory.
1127	May 10	C. F. B	Fort Collins	Larvæ on apple tree, Sept. 17.
1142	May 26	C. P. G	Fort Collins	Flying about laboratory.
1145	June 5	C. P. G	Horsetooth Gulch	General collecting.
1153	June 5	P. K. B.†	Fort Collins	General collecting.
1159	June 9	R. C. S	Fort Collins	Sweeping a cruciferous plant.
1165	June 11	C. P. G	Fort Collins	General collecting.
1166	June 11	C. P. G	Fort Collins	General collecting.
1174	June 14	C. P. G	Soldier Canon	Flying in sunshine.
1180	June 12	C. P. G	Fort Collins	At light.
1181	June 7	R. A. M.‡	Fort Collins	At light.
1183	June 4	C. P. G	Fort Collins	On window.
1215	June 20	C. F. B	Fort Collins	From larvæ on *Solidago*, July 20.
1216	June 17	C. P. G	Fort Collins	On laboratory window.
1217	June 17	C. P. G	Fort Collins	On flowers of *Astragalus bisulcatus*.
1219	June 2	C. P. G	Fort Collins	From larvæ in yucca stems during winter.
1220	June 9	C. P. G	Fort Collins	From larvæ in currant stems.
1225	July 4	C. P. G	Fort Collins	General collecting.
1226	June 28	C. F. B	Fort Collins	From eggs deposited by moth.
1231	July 1	C. P. G	Fort Collins	From larvæ in yucca stems.
1236	July 7	C. F. B	Fort Collins	Flying about lamp.
1246	July 10	C. F. B	Horsetooth Gulch	From caterpillar, taken June 30.
1247	July 10	C. F. B	Fort Collins	Larvæ on *Ellisia nyctelea*, June 21.
1257	June 30	C. F. B	Fort Collins	From larvæ on *Ellisia nyctelea*.
1258	June 30	C. F. B	Fort Collins	Larvæ on apple in June.
1259	June 29	C. F. B	Fort Collins	From larvæ on nettle, June 24.
1261	June 30	H. S. K.§	Fort Collins	From larvæ on *Rumex*, June 1.

* Paul Schlarbaum.
† P. K. Blinn.
‡ R. A. Maxfield.
§ H. S. Kendall.

Cat. Nos.	Dates of Captures.	Collectors.	Localities.	Remarks.
1311	June 29	C. P. G	Fort Collins	At sugar.
1312	June 29	C. P. G	Fort Collins	At light.
1348	July 15	R. C. S	Fort Collins	At light.
1351	July 12	C. F. B	Fort Collins	Larvæ on garden weed in June.
1357	Aug. 8	C. F. B	Fort Collins	Bred from larvæ in ground about *Ellisia nyctelea*, June 21.
1362	Aug. 2	C. F. B	Fort Collins	At light.
1365	Aug. 10	C. F. B	Fort Collins	From larvæ on fennel, July 25.
1368	Aug. 10	E. D. V.*	Estes Park	General collecting.
1374	Aug. 17	C. F. B	Fort Collins	From larvæ on fennel, July 25.
1375	Aug. 24	C. F. B	Fort Collins	From larvæ on fennel, July 25.
1376	Aug. 14	C. F. B	Fort Collins	From larvæ on fennel, July 25.
1377	Aug. 13	C. F. B	Fort Collins	At light.
1402	Aug. –	P. K. B	Berthoud	General collecting.
1419	Sept. 13	H. S. K	Fort Collins	At light.
1426	Sept. 3	C. P. G	Fort Collins	Larvæ on hollyhock, August 26.
1432	Sept. 13	C. F. B	Fort Collins	From larvæ on fennel, June 25.
1437	Sept. 9	C. P. G	Fort Collins	At light and sugar.
1440	Sept. 7	C. P. G	Fort Collins	At light.
1441	Sept. 14	C. P. G	Fort Collins	At light.
1442	Sept. 13	H. S. K	Fort Collins	At light.
1448	Sept. 10	C. F. B	Fort Collins	From larvæ on fennel, June 25.
1449	Sept. 19	C. P. G	Fort Collins	Larvæ in old honey comb, Sept. 14.
1451	Sept. 18	H. S. K	Fort Collins	At light.
1452	Sept. 18	H. S. K	Fort Collins	At sugar.
1453	Sept. 25	C. P. G	Fort Collins	About laboratory windows.
1454	Sept. 28	C. P. G	Fort Collins	About laboratory windows.
1455	Sept. 29	C. P. G	Fort Collins	About laboratory windows.
1456	Sept. 25	H. S. K	Fort Collins	At sugar.
1457	Sept. 21	H. S. K	Fort Collins	At sugar.
1463	Oct. 4	C. P. G	Fort Collins	About windows.
1464	Oct. 8	C. P. G	Fort Collins	About windows.
1465	Oct. 9	C. P. G	Fort Collins	About windows.
1466	Oct. 12	H. S. K	Fort Collins	At sugar.
1467	Oct. 12	H. S. K	Fort Collins	At sugar.
1492	1893	———	Fort Collins	From larvæ on *Petunia*, Aug. 24.
1493	1893	———	Fort Collins	From larvæ in flowers of *Grindelia squarosa*, Sept. 1.
1494	Oct. 23	H. S. K	Fort Collins	At sugar.
1495	Nov. 3	H. S. K	Fort Collins	At sugar.
1514	1893	P. S	Loveland	Miscellaneous collecting.
1528	April 9	C. P. G	Fort Collins	From box elder tree.
1531	April 10	C. P. G	Rist Canon	Miscellaneous collecting.
1557	April 20	C. F. B	Rist Canon	Taken on wing.
1559	April 21	C. P. G	Horsetooth Gulch	Miscellaneous collecting.
1574	April 23	C. F. B	Fort Collins	From pupæ taken under stone, March 20.
1575	April 23	C. F. B	Fort Collins	From larvæ on walnut, April 9.
1576	April 25	C. F. B	Fort Collins	From larvæ on walnut, April 9.
1577	April 26	C. F. B	Fort Collins	From larvæ on walnut, April 9.
1595	May 14	H. S. K	Fort Collins	At light.
1606	May 7	C. F. B	Dixon Canon	
1632	June 3	C. F. B	Fort Collins	Larvæ under boards, May 20. Fed alfalfa.
1633	June 7	C. F. B	Fort Collins	Larvæ under boards, May 30. Fed alfalfa.
1634	June 12	C. F. B	Fort Collins	Larvæ under boards, May 20. Fed alfalfa.
1642	May 24	C. P. G	Fort Collins	At light.
1649	May 12	C. P. G	Pleasant Valley	On thistle bloom.
1654	May 30	C. P. G	Fort Collins	General collecting.
1655	July —	C. P. G	Fort Collins	From larvæ about *Rumex*, May 30.
1657	July —	C. F. B	Fort Collins	From larvæ about *Rumex*, May 30.
1659	July —	C. F. B	Fort Collins	Larvæ on *Oxybaphus hursutus*, July 12.
1673	July —	C. P. G	Fort Collins	From larvæ about cabbage, July 12.

* E. D. Varney.

Cat. Nos.	*Dates of Captures.*	*Collectors.*	*Localities.*	*Remarks.*
1677	July 19	C. P. G	Estes Park	General collecting.
1700	July 7	C. F. B	Cameron Pass	General collecting.
1704	July 12	C. F. B	Steamboat Springs	General collecting.
1705	Aug. 8	C. P. G	Colorado Springs	General collecting.
1706	July 5	C F. B	Cameron Pass	General collecting above timber line.
1709	July 9	C. F. B	Estes Park	General collecting.
1710	July 11	C. F. B	Estes Park	General collecting. •
1714	Aug. 3	C. F. B	Colorado Springs	At light.
1715	Aug. 6	C. F. B	Fort Collins	Bred from larvæ on cabbage, Aug. 4.
1716	Aug. 4	C. P. G	Colorado Springs	From pupæ on poplar, Aug. 1.
1726	Aug. 23	C. F. B	Colorado Springs	From larvæ on cabbage, Aug. 4.
1729	Aug. 10	C. F. B	Fort Collins	At sugar.
1730	Aug. 1	C. F. B	Fort Collins	General collecting.
1732	July 10	C. P. G	Estes Park	Miscellaneous collecting, altitude 9,000 ft.
1733	July 12	C. P. G	Estes Park	Miscellaneous collecting.
1734	July 16	C. P. G	Estes Park	Miscellaneous collecting.
1743	Aug. 23	C. P. G	Glenwood Springs	At light.
1744	Aug. 23	C. P. G	Leadville	Miscellaneous collecting.
1803	July 28	C. P. G	Cripple Creek	At light.
1804	July 20	C. P. G	Near Lyons	General collecting.
1805	Sept. 14	C. P. G	Long's Peak	Above timber; altitude 12,000 feet.
1806	Sept. 30	C. P. G	Denver	At light.
1889	June 15	C. P. G	Horsetooth Gulch	General collecting.
1891	June 19	C. P. G	Fort Collins	On apple.
1900	May 1	C. P. G	Fort Collins	From cocoons on rose, April 25.
1906	June 24	C. P. G	Fort Collins	Moths reared from apple and box elder.
1907	July 1	C. P. G	Spring Canon	Reared from choke cherry.
1908	June 28	C. P. G	Spring Canon	Reared from cherry.
1918	July 10	C. P. G	Fort Collins	Cottonwood leaf roller.
1922	July 10	P. S	Loveland	General collecting.
1950	June 18	C. P. G	Fort Collins	From cottonwood leaves in spring.
1959	Sept. 8	C. P. G	Fort Collins	General collecting.
1973	Sept. 25	C. P. G	Denver	At light.
2071	April 19	C. P. G	Fort Collins	Taken on inside of window.
2078	April 29	C. P. G	Dixon Canon	General collecting.
2090	May 4	C. P. G	Fort Collins	On *Amelinchier alnifolia.*
2091	May 4	C. P. G	Fort Collins	Miscellaneous sweeping.
2096	May 9	C. P. G	Dixon Canon	
2101	May 12	J. D. S.*	Fort Collins	Resting on ground.
2103	May 13	Mrs. J.D.S	Fort Collins	At light in room.
2105	April 28	C. S.†	Fort Collins	Miscellaneous collecting.
2106	May 20	C. P. G	Fort Collins	In lantern trap.
2107	May 19	C. P. G	Fort Collins	On laboratory windows.
2109	May 21	C. P. G	Fort Collins	In lantern trap.
2110	May 22	C. P. G	Fort Collins	In lantern trap.
2112	May 23	C. P. G	Boulder	In canon near town.
2113	May 27	C. P. G	Fort Collins	In lantern trap.
2115	May 28	C. P. G	Fort Collins	Taken on window.
2116	May 28	C. P. G	Laporte	Taken on ground.
2118	May 29	C. P. G	Fort Collins	Taken about lights.
2123	June 2	C. P. G	Fort Collins	Taken pairing on grass.
2126	June 4	C. P. G	Fort Collins	In lantern trap.
2127	June 7	C. P. G	Fort Collins	In lantern trap.
2128	June 8	C. P. G	Fort Collins	In lantern trap.
2131	June 9	C. P. G	Fort Collins	At sugar.
2133	June 9	C. P. G	Fort Collins	In lantern trap.
2134	June 10	C. P. G	Fort Collins	In lantern trap.
2135	June 11	C. P. G	Fort Collins	In lantern trap.
2138	June 15	C. P. G	Foothills	Near Fort Collins.
2143	June 15	C. P. G	Laporte	Larimer county.

* J. D. Stannard.
† Carlos Stannard.

Cat. Nos.	*Dates of Captures*	*Collectors.*	*Localities.*	*Remarks.*
2147	June 15	C. P. G	Laporte	In lantern trap.
2148	June 16	C. P. G	Laporte	In lantern trap.
2149	June 15	C. P. G	Foothills	On alfalfa bloom.
2150	June 17	C. P G	Foothills	In lantern trap.
2151	June 2	C. P. G	Foothills	In lantern trap.
2153	June 13	C. P. G	Larimer County	On bloom of *Erigeron*, sp.
2154	June 26	C. P. G	Fort Collins	At light
2159	June 25	C. P. G	Laporte	On bloom of thistle.
2162	June 29	C. P. G	Fort Collins	In lantern trap.
2163	June 27	C. P. G	Fort Collins	In lantern trap.
2164	July 9	C. P. G	Foothills	Twelve miles west of Fort Collins.
2168	July 3	C. P. G	Foothills	Little Beaver Creek 9,000 feet altitude.
2171	July 4	C. P. G	Larimer County	Taken above timber line.
2178	July 16	C. P. G	Denver	At electric light.
2179	July 15	W. T. P *	Estes Park	General collecting.
2191	July 6	J. H. C.†	Larimer County	Little Beaver Creek, 9,000 feet altitude.
2195	July 4	C. P. G	Larimer County	Between Little Beaver and timber line.
2196	July 18	C. P. G	Golden	Butterflies, mostly on *Clematis ligusticifolia*.
2198	July 3	C. P G	Golden	In lantern trap. 9,000 feet altitude.
2200	July 28	C. P. G	Fort Collins	In lantern trap.
2203	July 28	C. P. G	Fort Collins	In lantern trap.
2204	July 4	C. P. G	Larimer County	Taken above timber, Little Beaver Creek.
2205	July 21	J. H. C	Fort Collins	Larvæ eating saddle blanket.
2206	July 30	E. D. V	Fort Collins	General collecting.
2207	Aug. 2	C. P. G	Fort Collins	On flowers of *Mentha canadensis*.
2212	July 13	C. F. B	Fort Collins	General collecting.
2214	July 1	C P. G	Larimer County	Rist Canon.
2215	June 14	C. P. G	Larimer County	Taken at 7,000 feet altitude, in evening on flowers on *Jamesii americana*.
2216	June 14	C. P. G	Foothills	Ten miles northwest of Fort Collins.
2219	Aug. 5	C. P. G	Fort Collins	At light.
2221	Aug. 6	E. D. V	Fort Collins	Taken along river.
2224	July 6	C. P. G	Larimer County	In lantern trap, 9,000 feet altitude.
2225	July 20	J. H C	Fort Collins	
2226	Aug. 7	C. P. G	Fort Collins	In lantern trap.
2227	July 18	C. P. G	Larimer County	Taken between 8,000 and 9,000 feet altitude.
2235	Aug. 11	C. P. G	Denver	At light.
2248	Aug. 12	C. P. G	Palmer Lake	Taken in canon.
2250	Aug. 12	C. P. G	Palmer Lake	On little oaks in canon.
2252	Aug. 13	C. P. G	Denver	At light.
2258	Aug. 24	C. P. G	Canon City	
2271	Aug. 23	C. P. G	Mt. Ouray	Between 10,500 and 11,500 feet altitude.
2272	Aug. 23	C. P. G	Marshall Pass	On bloom of *Senecio* sp. 10,000 feet altitude.
2274	Aug. 23	C. P. G	Marshall Pass	On bloom of *Senecio* sp. 10,000 feet altitude.
2285	Aug. 22	C. P. G	Cimarron	Abundant on *Alnus viridis*.
2288	Aug. 21	C. P. G	Cerro Summit	On *Sarcobatus vermiculatus*.
2289	Aug. 21	C. P. G	Cerro Summit	At about 8,000 feet altitude.
2293	Aug. 16	C. P. G	Marshall Pass	Sweeping willow.
2294	Aug. 22	C. P. G	Cimarron	General collecting, 7,000 feet altitude.
2295	Aug. 22	C. P. G	Cimarron	Between Cimarron and Cerro Summit.
2298	Aug. 16	C. P. G	Denver	Taken at light.
2332	Sept 30	C. P. G	Fort Collins	Taken at light.
2333	Oct. 2	C. P. G	Fort Collins	At light.
2336	Oct. 5	C. P. G	Fort Collins	At light.
2337	Oct. 7	C. P. G	Fort Collins	At light.
2338	Oct. 5	E. G. T	Fort Collins	Taken at light.

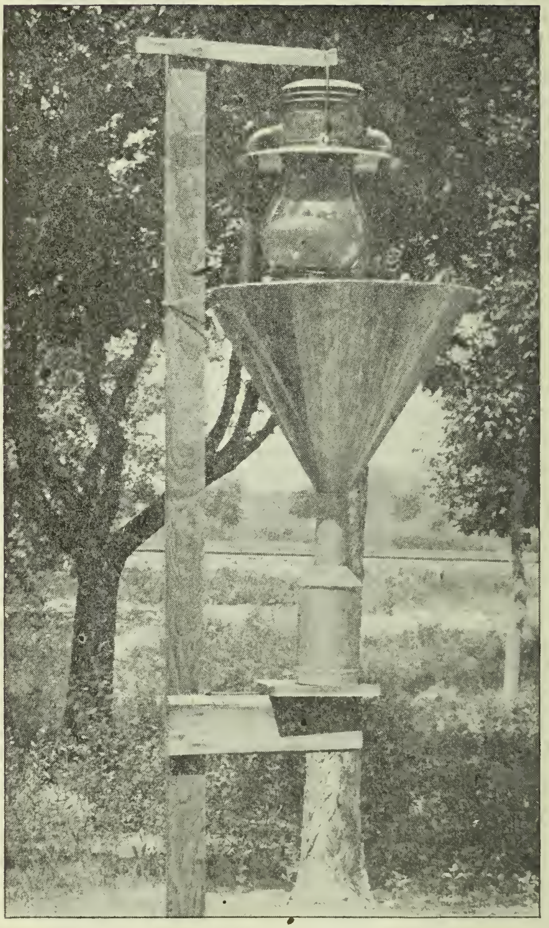
* W. T. Park.
† J. H. Cowen.

Cat. Nos.	Dates of Captures.	Collectors.	Localities.	Remarks.
2347	May 21	C. P. G	Fort Collins	About tomatoes.
2348	Nov. 1	C. P. G	Fort Collins	Larvæ taken June 2-5.
2423	April 28	C. P. G	Delta	Cocoon taken from plum.
2462	May 17	E. A. G.*	Fort Collins	Taken on lawn.
2463	June 16	E. A. G	Bellvue	General collecting.
2465	May 15	C. P. G	Near Fort Collins	Miscellaneous collecting.
2469	May 17	C. P. G	Fort Collins	Taken on window
2471	June 18	C. P. G	Fort Collins	In lantern trap.
2473	May 20	E. A. G	Fort Collins	Taken on window.
2475	June 19	C. P. G	Fort Collins	At light.
2476	June 21	E. A. G	Fort Collins	At light, one female full of eggs.
2480	May 20	C. P. G	Fort Collins	In lantern trap.
2486	May 22	C. P. G	Denver	At electric light.
2487	May 23	C. P. G	Fort Collins	At light.
2499	May 23	E. G. T	Fort Collins	Larvæ taken May 3. Fed on alfalfa and box elder.
2508	May 27	E. G. T	Fort Collins	From larvæ under boards, April 20.
2509	May 26	C. P. G	Fort Collins	Taken in foothills.
2524	May 28	C. P. G	Fort Collins	General collecting.
2526	May 31	C. P. G	Fort Collins	Taken at light.
2527	June 1	C. P. G	Fort Collins	Taken at light.
2528	May 28	C. P. G	Fort Collins	Taken at light.
2550	June 8	E. G. T	Fort Collins	Taken at light.
2553	June 9	C. P. G	Fort Collins	Taken at light.
2560	June 11	E. G. T	Fort Collins	Taken at light.
2564	May 14	C. P. G	Fort Collins	Taken in foothills.
2565	June 12	C. P. G	Rist Canon	General collecting.
2567	June 14	E. G. T	Fort Collins	Taken at light.
2570	June 16	E. G. T	Fort Collins	Taken at light.
2571	June 17	E. G. T	Fort Collins	Taken at light.
2573	June 18	E. G. T	Fort Collins	Ta en at light.
2576	June 20	E. G. T	Fort Collins	Taken at light.
2578	June 21	E. G T	Fort Collins	Taken at light.
2586	June 22	E. G. T	Fort Collins	Taken at light.
2587	June 23	E. G. T	Fort Collins	Taken on plum.
2603	June 25	E. G. T	Fort Collins	Taken at light.
2604	June 26	E. G. T	Fort Collins	At light.
2610	June 30	E. G. T	Fort Collins	Taken at light.
2612	July 1	E. G. T	Fort Collins	Taken under boards in larvæ state.
2613	July 1	E. T. G	Fort Collins	Taken at light.
2614	July 2	E. G. T	Fort Collins	Taken at light.
2615	July 2	E. G. T	Fort Collins	Taken under ground near cabbage, June 18
2617	July 3	E. G. T	Fort Collins	Taken in foothills.
2620	July 7	E. G. T	Fort Collins	Taken at light.
2621	July 6	E. G. T	Fort Collins	Taken at light.
2622	July 4	E. G. T	Fort Collins	Under bark of cottonwood, June 7.
2625	July 5	E. G. T	Fort Collins	Taken at light.
2633	July 9	E. G. T	Fort Collins	Larvæ from flower bed, May 25. Fed alfalfa.
2634	July 7	C. P. G	Fort Collins	On leaves of plum, June 25.
2637	July 10	E. G. T	Fort Collins	Taken at light.
2645	July 4	E. G. T	Fort Collins	Under bark of cottonwood, June 7.
2647	July 14	E. G. T	Fort Collins	Taken at light.
2648	July 15	E. G. T	Fort Collins	From larvæ under boards, May 4. Fed cottonwood.
2650	July 14	E. G. T	Fort Collins	Taken under bands on cottonwood, in pupa state.
2651	July 15	E. G. T	Fort Collins	Taken at light.
2652	July 16	E. G. T	Fort Collins	Taken at light.
2653	July 17	E. G. T	Fort Collins	Taken at sugar.
2654	July 17	E. G. T	Fort Collins	Taken at light.

* Emma A. Gillette.

Cat. Nos.	Dates of Captures.	Collectors.	Localities.	Remarks.
2657	July 14	E. G. T	Fort Collins	Larvæ under cottonwood bark, June 11.
2659	July 20	E. G. T	Fort Collins	Taken at light.
2661	July 21	E. G. T	Fort Collins	Taken at sugar.
2662	July 21	E. G. T	Fort Collins	Taken at light.
2663	July 22	E. G. T	Fort Collins	Taken at light.
2664	July 22	E. G. T	Fort Collins	Taken on sidewalk.
2666	July 24	E. G. T	Fort Collins	Taken at light.
2670	July 26	E. G. T	Fort Collins	Taken at light.
2674	July 26	E. G. T	Fort Collins	Larvæ on ash, June 26.
2676	July 27	E. G. T	Fort Collins	Taken at light.
2679	July 29	E. G. T	Fort Collins	Taken at light.
2682	July 15	C. P. G	Estes Park	Taken at Gem Lake, altitude 9,000 feet.
2683	July 12	C. P. G	Estes Park	Taken at Gem Lake, altitude 9,000 feet.
2684	July 15	E. A. G	Estes Park	Taken at Gem Lake, altitude 9,000 feet.
2685	July 20	E. G. T	Fort Collins	Taken at light.
2686	July 23	E. A. G	Estes Park	Taken in Devil's Gulch.
2688	July 30	C. P. G	Fort Collins	Taken on window.
2689	July 31	E. G. T	Fort Collins	Taken at light.
2691	Aug. 2	E. G. T	Fort Collins	Taken at light.
2692	Aug. 2	E. G. T	Fort Collins	Taken at sugar.
2693	———	W. T. P	Estes Park	
2694	———	J. H.*	Pinewood	
2695	July —	Mrs. T.†	Laporte	
2696	July 3	E. G. T	Fort Collins	Taken at light.
2699	Aug. 5	E. G. T	Fort Collins	Taken at light.
2700	Aug. 5	E. G. T	Fort Collins	Taken at sugar.
2708	Aug. 6	E. G. T	Fort Collins	Taken at light.
2709	Aug. 7	E. G. T	Fort Collins	Taken at light.
2710	July 25	R. N. U.‡	Fort Collins	General collecting.
2713	July 11	E. G. T	Fort Collins	Taken at light
2715	Aug. 13	E. G. T	Fort Collins	Taken at light.
2719	Aug. 14	E. G. T	Fort Collins	Taken at light.
2721	Aug. 10	C. P. G	Rocky Ford	General collecting.
2722	Aug. 16	E. G. T	Fort Collins	At light.
2730	Aug. 18	E. G. T	Fort Collins	At light.
2731	Aug. 19	E. G. T	Fort Collins	At light.
2733	Aug. 20	E. G. T	Fort Collins	At light.
2734	Aug. 21	E. G. T	Fort Collins	At light.
2737	Aug. 24	E. G. T	Fort Collins	At light.
2738	———	P. S	Loveland	General collecting.
2743	July 26	E. G. T	Fort Collins	At light.
2748	Aug. 27	E. G. T	Fort Collins	At light.
2750	Aug. 28	E. G. T	Fort Collins	At light.
2751	Aug. 30	E. G. T	Fort Collins	At light.
2752	Aug. 31	E. G. T	Fort Collins	At light.
2753	Sept. 1	E. G. T	Fort Collins	At light.
2754	July 12	E. A. G	Estes Park	Altitude 8,000 feet.
2755	July 20	C. P. G	Estes Park	Altitude 8,000 feet.
2756	July 17	E. A. G	Estes Park	Altitude 8,000 feet.
2758	Aug. 2	E. G. T	Fort Collins	At light.
2759	Aug. 3	E. G. T	Fort Collins	At light.
2763	Sept. 4	E. G. T	Fort Collins	At light.
2764	Sept. 7	E. G. T	Fort Collins	At light.
2765	July 15	E. A. G	Estes Park	
2768	Sept. 15	C. P. G	Fort Collins	Miscellaneous collecting.
2787	Sept. 25	C. P. G	Greeeley	On nursery stock—apple.
2806	———	———	Colorado	Specimens from David Bruce, and credited by him to Colorado.

* James Heukaufer.
† Mrs. Taft.
‡ R. N. Underwood.



LANTERN TRAP.

This lantern trap was used to collect many of the moths reported in this bulletin.

For a description of the trap see "Proceedings of the Ninth Annual Meeting of the Association of Economic Entomologists," p. 75.

II.

A Few New Species of Deltocephalus and Athysanus from Colorado.

Clarence P. Gillette.

DELTOCEPHALUS PARVULUS, n. sp.

Color greenish yellow, vertex strongly produced and acute, length $2\frac{1}{2}$ to 3 m. m.

Vertex strongly produced, acute, angle at the apex about eighty degrees, surface nearly flat but not depressed, length somewhat exceeding the distance between the eyes; color whitish, with two irregular, diverging, infuscate bands extending from the apex to the posterior margin, median line black and sharply defined on the posterior two-thirds. Front slightly infuscate, with about six interrupted, transverse, pale yellow arcs; clypeus pale yellow or slightly infuscate, broadest at base and gradually narrowing to the rounded apex; genæ greenish yellow throughout with a black spot just outside the middle of the loral suture, in some examples the upper part of the suture is also black. Entire length of the face slightly exceeding the width. Pronotum pale yellowish green, deeper yellow on the anterior margin, in some examples with two longitudinal black dashes above; the length hardly equal to one-half of the width, but slightly exceeding that of the vertex. Scutellum pale yellowish. Elytra deep yellowish green, subhyaline, considerably exceeding the abdomen; nervures very distinct and deeper yellowish green. Tergum black, with the lateral margins of the segments pale yellow. Venter yellowish green with little or no dark shading, last ventral segment broadly produced and oval at the tip. Pygofers and ovipositor yellowish white, the latter bordered with black beneath in some specimens. Legs pale yellowish white throughout.

Male genitalia: Valve rather small, triangular, the apex blunt, the base extending from one-half to two-thirds of the distance across the hind margin of the preceding ventral segment; plates long and rather slender, extending beyond the valve a distance about equal to twice the length of the latter, and possessing a single row of rather stout, pale yellow spines along the outer margins; color pale greenish yellow. [See fig. 1.]

Described from fifteen females and five males taken by the writer sweeping native plants, in most cases short prairie grass, between August 16th and October 7th, and on May 28th. The points from which specimens were taken are Fort Collins, Colorado Springs,

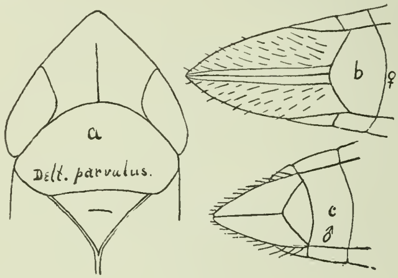


FIG. 1.

Deltocephalus parvulus: (a) upper surface of vertex, pronotum and scutellum; (b) female genitalia from beneath; (c) male genitalia from beneath. Grealty enlarged (original).

New Windsor, and Horsetooth Gulch. This species is a rival of *minimus* O. & B. in minuteness, which species it closely resembles. It is readily distinguished, however, by the broadly rounded, unicolorous, entire last ventral segment of the female, and the smaller, more acute valve in the male.

DELTOCEPHALUS COOKEI, n. sp.

Color cinereous to grayish brown, vertex with dark markings, length 2¼ m. m.

Vertex broad, flat, not distinctly depressed nor strongly produced, rounded at the apex; color pale yellowish, variously flecked with dark brown, median line nearly obsolete, length barely equaling the distance between the eyes and less than one-half the width of the head. Front pale brown, with about six incomplete transverse bars, and nearly parallel sided, rather narrow, width at clypeus fully one-half the width at the ocelli; labrum sordid yellow, in most examples streaked with black on the middle, nearly parallel sided, broadest near the rounded apex; genæ sordid yellow streaked with black beneath the eyes, next the antennæ, and along the loral suture; the inferior angle of the loræ black in some examples, in others entirely yellow; genæ, below the loræ, very narrow. Pronotum on the anterior margin, concolorous with the vertex, darker posteriorly, in some examples nearly unicolorous and in others with a distinct longitudinal dark stripe back of the inner angle of the eye; still others are marked with a small black spot on the anterior margin against the middle of each eye and have from one to three smaller spots posterior to these and directly behind the inner angle of the eye; distinctly longer than the vertex and a little more than twice as wide as long, Scutellum of the same color as the pronotum, with or without yellow and dusky markings, transverse suture very close to the hind margin of the pronotum. Elytra slightly exceeding the abdomen, pale cinereous, with a few dusky or black dashes within the cells, the heaviest one on the clavus near the suture, rather near the base. In some examples this is the only dark coloration present. Tergum black on basal half, mostly yellow on the last two segments. Pectus and venter almost entirely black; last ventral segment of the female black, short, distinctly inflated, posterior angles, produced and with a short, blunt median lobe; ovipositor yellow on the middle and basal portion, darker towards the tip, slightly exceeding the pygofers. Legs smoky yellow, femora and coxæ mostly black.

Male: With the valve large and broad, with a slight tooth at the apex; plates stout at the base, suddenly constricted before the apex and exceeding the valve by nearly its own length.

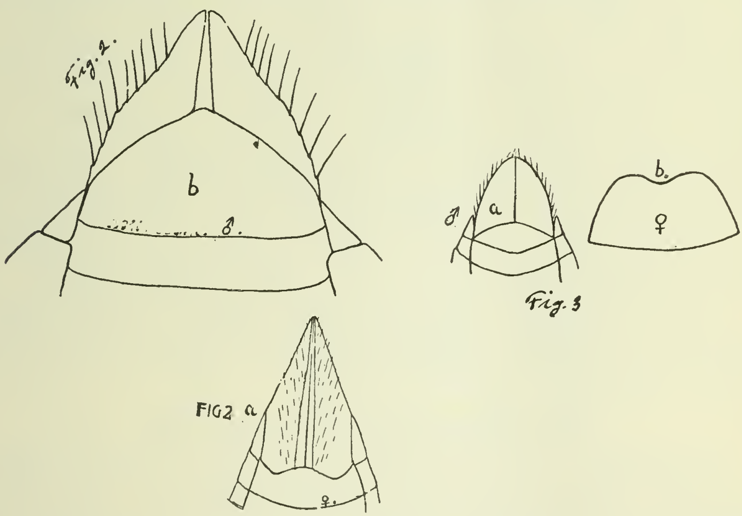


Fig. 2.—*Deltocephalus cookei:* (a) female genitalia from beneath; (b) male genitalia from beneath. Greatly enlarged (original).

Fig. 3.—*Deltocephalus vanduzei:* (a) genitalia of the male from beneath; (b) last ventral segment of the female from beneath. Greatly enlarged (original).

Described from seven males and five females taken at Manhattan, Colo., October 7th, by Prof. W. W. Cooke, to whom I take pleasure in dedicating this species. It is closely related to *vanduzei* G. & B., but is readily separated from the latter by the markings upon the vertex and the genital characters, as well as its usual lighter color. In venation this species is an *Athysanus*, but the vertex and face, especially the latter, are Deltocephaloid in form. [See figs. 2 and 3.]

DELTOCEPHALUS BLANDUS, n. sp.

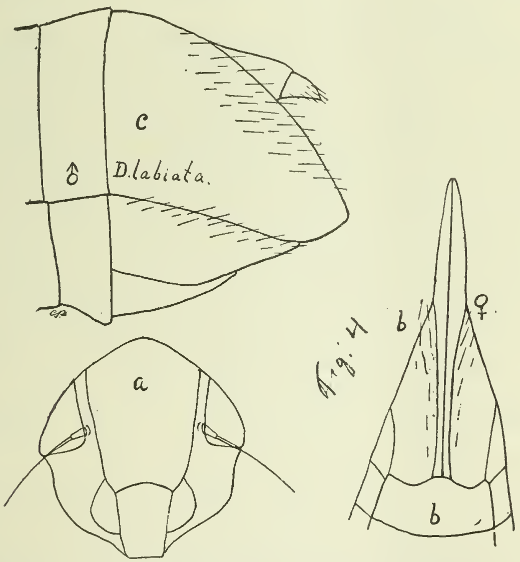
Pearl gray, marked with cinnamon brown. Length 2½ m. m. Vertex with a broad white median stripe divided by a brown line on the posterior two-thirds and bordered either side by a broader band of brown in which are two whitish spots, giving the brown color somewhat the shape or the letter B. Near the base of the vertex, either side of the white stripe, are two small deeply colored chocolate spots; ocelli black. Face light cinnamon brown in color with about six irregular transverse pale lines, and about one-sixth longer than broad; clypeus broadest at base and gradually narrowing to a rounded apex; loræ whitish with a large central dark spot; genæ whitish, black beneath the antennæ and moderately broad at the clypeus. Pronotum pale yellowish green, faintly stained with chocolate, slightly concave behind, lateral margins broadly rounded and two and one-fourth times as broad as long. Scutellum concolorous with pronotum, with the basal angles and two longitudinal parallel lines on the disc pale chocolate in color, transverse suture straight. Elytra attaining the posterior margin of the last abdominal segment, pale ashy in color with a few of the nervures bordered with pale brown. The tergum light brown, mottled with white along the median line, the basal portion of the pygofers above deeper brown than the rest, shading into black on the anterior margin. Venter black on the middle and yellow at sides; pygofers pale yellow stained with brown below; ovipositor black, scarcely exceeding the pygofers; last ventral segment with posterior angles produced and rounded and with a short blunt median tooth, the tooth and broad lateral margins of the segment white, the remaining portion black; feet pale yellow spotted and annulate with cinnamon brown.

A very handsome species described from two females taken by the writer, one at Fort Collins, September 21st, and one at Calhan, October 7th, while sweeping native grass.

DELTOCEPHALUS LABIATA, n. sp.

Somewhat closely resembling *D. argenteolus* Uhl., but differing in having a narrow and more acute vertex that is not at all depressed above. Length 3½ m. m.

Female: Vertex nearly flat but not depressed between the eyes, slightly sloping forward, conical at the apex, about one-fourth longer than the distance between the eyes, whitish to light lemon yellow in color, with light and brown pencilings on anterior third, ocelli fuscous or black. Front concolorous with vertex with about six more or less distinct dark cross lines, which are interrupted on the middle; clypeus long, lateral sutures straight, a little broadest at base, truncate at apex, extending about one-third of its length beyond the loræ; genæ ivory white with a black spot beneath the antennæ, another beneath the middle of the eye, and a third very small one on the middle of the loral suture, narrow below the loræ but, on meeting the clypeus, suddenly expanding and extending to its apex ; loræ and clypeus entirely yellow, or with their lower ends blackened ; entire length of face distinctly greater than the width. Pronotum colored like the vertex on the anterior margin but shading into greenish posteriorly, rather indistinctly transversely wrinkled on the posterior half, nearly three times as wide as long. Scutellum small, greenish or yellowish without markings, transverse groove rather faint. Elytra of same color as the vertex, about as broad as long, barely reaching the third abdominal segment. First two abdominal segments black above, the following ones light yellow, each having a transverse row of from six to eight light brown spots, except the last segment, which usually has no dark markings. One example has two spots, as in *D. argenteolus* Uhl., and also has black lateral margins at the penultimate segment. Venter black on the middle, yellow at the sides, posterior angles of last segment slightly



Deltocephalus labiata: (a) face; (b) genitalia of female from beneath; (c) genitalia of male from the side. All greatly enlarged (original).

produced, the middle lobe occupying more than half of the hind margin. Pygofers pale yellow, ovipositor about three-eights of the entire length of the body and strongly exserted. Legs pale yellow, in dark specimens tinged with brown.

Males: The males differ from the females in being only 2½ m. m. long and being much darker in color; the lower half of clypeus and loræ, the venter, and the tergum, except the last segment, which is white, black. The elytra are darker than in the females, with the nervures near the posterior margin conspicuously white. The ground color of the vertex is more reddish and the light markings are more distinct on account of darker brown colors bordering them. The valve of the genital pieces is triangular, narrow at the base, with the apex slender and acute; the plates are short and stout and exceed the valve but little. [See fig. 4.]

Described from numerous examples of both sexes taken by the writer during the months of April, May, September and October, sweeping native plants and in the following localities in the state: Fort Collins, Bellvue, Manhattan and Calhan.

Variety *rufus*.—Of this species I have three females that differ from the others in being of a salmon color throughout, with the markings indistinct.

DELTOCEPHALUS ATROPUNCTA, n. sp.

Pale yellow in color, vertex strongly produced with a black spot at apex. Length $3\frac{1}{3}$ m. m.

Vertex strongly produced, acute, slightly elevated towards the apex, disc slightly convex between the eyes, not at all depressed, length equal to one and one-half times the distance between the eyes. Color light yellow shaded with brown towards the apex, paler between the eyes, median stripe and two cross bars whitish, median dark line obsolete except at the base; ocelli black. Front long and narrow, nearly parallel sided, pale yellow in color with fuscous cross lines rather indistinct in one specimen and nearly black in another. Clypeus rather long, sides parallel, tip truncate and strongly produced beyond the loræ, pale yellow in color, infuscate towards the tip; loræ and genæ pale yellow, except that the latter have a black streak under either eye near the antenna, a smaller black spot beneath the middle of the eye and a black coloration in the very narrow portion below the loræ; entire length of the face fully one-fourth greater than the breadth.

Pronotum light yellow, feebly striated posteriorly, length a little more than one-third of the width. Scutellum pale yellow. Elytra pale yellow without markings, reaching the middle of the third abdominal segment. Tergum yellow with a black spot midway on the sides of the first segment and indistinct transverse rows of brown spots on the succeeding segments. Venter yellow, with the last segment, only, brownish in one example, and in another the middle of the hind margin is nearly black. The last ventral segment is large, posterior angles somewhat acute and hind margin somewhat produced, and very similar to that of the preceding species. It is readily separated from *labiata* by the greater length of the face, the more produced vertex and the black spot at the tip of the latter.

Described from two females, one taken by Emma A. Gillette at

Laporte, Colorado, May 17th, and one taken by the writer at Fort Collins, Sept. 27th. Both obtained by sweeping native plants.

It is not improbable that this species and the preceding may have to be taken out of the genus *Deltocephalus*. A study of long-winged forms, which probably exist, would help to settle the matter. The short elytra and greatly exserted ovipositors are strikingly similar to those parts in *Deltocephalus argenteolus* Uhl., and *Athysanus curtipennis* G. & B., but the conical shape of the vertex and the strongly produced clypeus is in contrast with those species and also with the species of the genus *Doratura*, J. Sahlb.

ATHYSANUS ORNATUS, n. sp.

A shining black species with posterior portion of the pronotum and the elytra, except three transverse black lines, white. Length 3 m. m. Vertex very broadly rounded, the length a little less than the distance between the eyes and almost exactly equaling the length of the pronotum; color polished black. Face of the same color as the vertex, except that there are two spots on the base of the clypeus, one near the angle of each cheek, and about eight interrupted cross lines on the front that are of a yellowish brown color. Front short and broad, rapidly narrowing to the clypeus; clypeus rounding at the base, parallel sided, truncate at the tip. Entire width of the face once and one-fifth the length. Pronotum shining black on anterior third, pale yellow on posterior two-thirds, and two and one-half times as wide as long. Scutellum black with the apex white. Elytra short, just covering the last segment of the tergum, the corium but little exceeding the clavus; in color glaucus white, with the extreme base, the tip, and a transverse band on the middle of each, shining black. Tergum deep shining black; venter mostly yellow, the bases of the segments more or less black, the last segment entirely black and a little concave on the hind margin; pygofers and ovipositor glossy black and short. Legs blue black with considerable yellowish brown coloration.

Described from a single female, example taken by the writer at Fort Collins, May 28th, sweeping native plants.

This is a very handsome species, and is readily recognized by the black head and white wing covers with the three tranverse black lines.

III.

LIST OF ORIGINAL TYPES OF SPECIES IN THE SUPERFAMILY JASSOIDEA

Now in the Collections of The Colorado Agricultural College and Agricultural Experiment Station.

CLARENCE P. GILLETTE.

The list given below is for the information of students in entomology and also for the purpose of correcting a statement in regard to "true type specimens" made by Mr. C. F. Baker in an article headed "Notes on the Genus Deltocephalus" and published in the current volume of "Psyche," p. 114.

I must also add that our missing types mentioned in that article, along with numerous other specimens that seem to have accompanied them, were "removed" without permission of anyone in authority, from the cabinets of this institution, where they still belong. Most of my own species, given below in the sub-family *Typhlocybinæ,* are unpublished at this writing but the descriptions are all in type and will soon appear in a paper from the United States National Museum, entitled "American Leaf-Hoppers of the Sub-family Typhlocybinæ."

Family BYTHOSCOPIDAE.

Pediopsis erythrocephalus G. & B.—1 female.
Pediopsis sordida V. D.—2 females and 1 male.
Idiocerus amœnus V. D —1 female.
Idiocerus perplexus G. & B.—2 females.
Idiocerus productus G. & B.—1 male.
Idiocerus snowi G. & B.—1 male.
Idiocerus rufus G. & B.—1 female.
Agallia cinerea O. & B.—4 females and 4 males.
Agallia gillettei O. & B.—12 females and 5 males.

Family JASSIDAE.

Acocephalus maculatus G. & B.—1 female.
Deltocephalus auratus G. & B.—3 males.
Deltocephalus bilineatus G. & B.—2 females.
Deltocephalus albidus O. & B.—2 females and 2 males.
Deltocephalus reflexus O. & B.—2 females and 2 males.
Deltocephalus pectinatus O. & B.—2 females and 2 males.
Deltocephalus abbreviatus O. & B.—2 females and 2 males.
Deltocephalus compactus O. & B.—2 females and 2 males.
Deltocephalus sylvestris O. & B.—2 females and 2 males.
Deltocephalus oculatus O. & B.—2 females and 2 males.
Deltocephalus minimus O. & B.—2 females and 2 males.
Deltocephalus monticola G. & B.—1 female.
Deltocephalus parvulus Gill.—12 females and 3 males.
Deltocephalus blanda Gill.—2 females.
Deltocephalus vanduzei G. & B.—1 male.
Deltocephalus cookii Gill.—5 females and 5 males.
Deltocephalus nigrifrons Forbes—1 female.
Deltocephalus bimaculatus G. & B.—2 males.
Deltocephalus flavovirens G. & B —1 male.
Deltocephalus labiata Gill.—22 females and 14 males.
Deltocephalus atropuncta Gill.—2 females.
Allygus coloradensis G. & B.—1 male.
Athysanus curtipennis G. & B —1 female.
Athysanus artemisiæ G. & B.—1 female.
Athysanus relativus G. & B.—2 females.
Athysanus dentatus O. & B.—2 females and 1 male.
Athysanus colon O. & B.—2 females and 2 males.
Athysanus punctatus O. & B.—2 females.
Athysanus ornatus Gill.—1 female.
Driotura robusta O. & B.—2 females and 1 male.
Eutettix querci G. & B.—1 male and 1 female.
Eutettix clarivida V. D.—1 female.
Phlepsius altus O. & B.—2 females and 2 males.
Thamnotettix caricis G. & B.—1 male.
Thamnotettix sonoræ G. & B. –1 female.
Neocœlidea tumidifrons G. & B.—2 males.
Gnathodus confusus G. & B.—2 females.
Gnathodus manitou G. & B.—1 male.
Cicadula arcuata G. & B.—1 female and 1 male.
Alebra fumida Gill.—1 male.
Dicraneura cockerellii Gill.—3 females and 3 males.
Dicraneura cruentata Gill —3 females and 2 males.
Dicraneura communis Gill.—2 females and 1 male.
Dicraneura kunzei Gill.—1 female and 2 males.
Dicraneura unipuncta Gill.—1 female.
Empoasca trifasciata Gill.—5 females and 2 males.
Empoasca clypeata G. & B.—3 males.
Empoasca nigra G. & B.—2 males.
Empoasca pulchella G. & B.—1 female.
Empoasca albolinea Gill.—7 females.
Empoasca denticula Gill.—1 female.
Empoasca unicolor Gill.—18 females and 2 males.
Empoasca atrolabes Gill.—20 females.
Empoasca pallida Gill.—2 females.
Empoasca alboneura Gill.—12 female and 8 males.
Empoasca aspersa G. & B. (tessellata Leth.)—4 females and 2 males.
Empoasca flavescens Fab., var. birdii Godg.—2 females and 1 male.
Empoasca robusta Gill.—2 females.
Empoasca nigroscuta G. & B.—2 females.
Empoasca nigroscuta, var. typhlocyboids G. & B. —2 males.
Eupteryx flavoscuta Gill.—2 females.
Eupteryx vanduzei Gill.—3 females.
Typhlocyba sanguinea G. & B.—1 female.
Typhlocyba hartii Gill.—2 males.
Typhlocyba rubroscuta Gill —12 females and 4 males.
Typhlocyba crevecœuri Gill.—8 females and 4 males.
Typhlocyba obliqua, Say, var. dorsalis Gill.—2 females and 1 male.
Typhlocyba obliqua, Say, var. nævus Gill.—1 female and 1 male.
Typhlocyba obliqua, Say, var. fumida Gill.—4 females and 2 males.
Typhlocyba comes, Say, var. illinoiensis Gill.—8 females and 4 males.
Typhlocyba comes, Say, var. coloradensis Gill.—5 females and 2 males.
Typhlocyba comes, Say, var. maculata Gill.—3 females and 1 male.
Typhlocyba comes, Say, var. scutelleris Gill.—2 females.
Typhlocyba comes, Say, var. rubra Gill.—11 females and 1 male.
Typhlocyba comes, Say, var. infuscata Gill.—4 females and 1 male.
Typhlocyba vulnerata, Fitch, var. niger Gill.—2 females and 4 males.
Typhlocyba dentata Gill.—1 female.
Typhlocyba flavomarginata G. & B.—1 female.

The State Agricultural College

THE AGRICULTURAL EXPERIMENT STATION

BULLETIN No. 44

TECHNICAL SERIES No. 4

FURTHER NOTES

ON THE

Birds of Colorado

An Appendix to Bulletin No. 37, on the Birds of Colorado

BY

W. W. COOKE

APPROVED BY THE STATION COUNCIL

ALSTON ELLIS, President

FORT COLLINS, COLORADO

MARCH, 1898

THE SMITH-BROOKS PRINTING COMPANY
DENVER

THE

Agricultural Experiment Station

FORT COLLINS, COLORADO

FURTHER NOTES

ON

THE BIRDS OF COLORADO.

BY W. W. COOKE.

On the publication in March, 1897, of Bulletin No. 37 of this Station, entitled "The Birds of Colorado," the author received many letters containing additional notes. These led to quite an extensive correspondence and in several cases the examination or re-examination of large series of specimens. In addition the present writer has had a chance to personally examine several small collections not before accessible to him.

The results of this investigation are presented in the following pages. Even with these additions it is practically certain that the Colorado list will yet receive many new species.

All references are to the pages of the original edition to which this bulletin is to be considered as an appendix. On page 3, the total number of species and varieties known to occur in Colorado should be changed to 374, of which 236 are known to breed.

CLASSIFICATION OF COLORADO BIRDS.

Changes to be made, including those already made in the Addenda on page 128.

Page 8. **1. Residents:** Add

Phasianus torquatus.

Page 10. **4. Species that have been taken in Colorado in winter, either as rare or accidental visitors.** Add

Somateria dresseri.
Nyctala tengmalmi richardsoni.
Acanthis linaria rostrata.

Page 11. *B. Species that breed on the plains, but only to the foot-hills of the mountains.* Add

Philohela minor.
Phasianus torquatus.
Phalænoptilus nuttallii nitidus.
Habia ludoviciana.
Helminthophila peregrina.
Harporhynchus bendirei.

Page 12. *D. Species that breed principally in the mountains.* Add

Empidonax hammondi.

Page 13. *E. Species that breed regularly only in Southern Colorado.* Add

Plegadis guarauna.

Page 13. **6. Species taken in the State during the summer, but not known to breed.** Omit

Plegadis guarauna.
Philohela minor.
Phalænoptilus nuttallii nitidus.

Add

Tympanuchus americanus.
Stellula calliope.
Melospiza georgiana.

Page 13. **7. Migrants.** Add

Urinator adamsii.
Porzana jamaicensis.
Piranga erythromelas.
Dendroica palmarun.

Omit

Helminthophila peregrina.
Harporhynchus bendirei.

Page 14. **8. Stragglers or doubtful species.** Add

Urinator adamsii.
Somateria dresseri.
Porzana jamaicensis.
Nyctala tengmalmi richardsoni.
Bubo virginianus articus.
Coccyzus americanus.
Dryobates pubescens.
Stellula calliope.
Acanthis linaria rostrata.
Melospiza georgiana.
Piranga erythromelas.
Dendroica palmarum.

Omit

Harporhynchus bendirei.

Page 15. **10. Rare or irregular visitants, from the east or southeast.** Add

Tympanuchus americanus.
Melospiza georgiana.

Habia ludoviciana.
Piranga erythromelas.
Dendroica palmarum.

Page 16. **12. Rare or irregular visitants from the west or southwest.** Add

Stellula calliope.

Add the star (*) to denote breeding, to
Plegadis guarauna.

Page 16. **SUMMARY.**

	Total species in Colorado	374
1.	Residents	88
2.	Regular winter visitants from the north	24
3.	Regular breeders that sometimes occur in winter	17
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5.	Summer residents	236
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7.	Migrants	60
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11.	Regular visitants from west and southwest	20
12.	Rare visitants from west and southwest	13

BIBLIOGRAPHY OF COLORADO ORNITHOLOGY.

Page 25. Add. BERTHOUD, E. L. Birds, their Geological History, Migration and Uses. By E. L. Berthoud, A. M., Member Phila. Academy and N. Y. Academy of Sciences. *Transcript Print*, Golden, Colo. [Issued in 1887.]

Short notes on twenty-four species of Colorado birds with reference to their distribution and migration. Includes the Wild Turkey and the Carolina Paroquet.

Page 27. Add. COCKERELL, T. D. A. The Food of Some Colorado Birds. *Am. Nat. XXV.* 1896, *p. 329.*

Examinations of the stomach contents of eleven species, taken by W. P. Lowe in various places in southern Colorado.

Page 27. Add. W. W. COOKE. The State Agricultural College, The Agricultural Experiment Station, Bulletin No. 37, Technical Series No. 2, The Birds of Colorado. By W. W. Cooke. Approved by the Station Council. Alston Ellis, President. Fort Collins, Colorado, March, 1897. The Smith-Brooks Printing Company, Denver, *pp. 144.* [Date of distribution, March 14, 1897.]

Contains an introduction on the general bird life of the State; Classification; giving lists of the birds with reference to their distribution and breeding. Dates of migration; a comparison of migration in different parts of Colorado with dates of arrival of the same species at St. Louis. Bibliography of Colorado ornithology; references to 182 books and articles. History of Colorado ornithology; giving the authority, date and place of publication for the introduction of each species into the list of Colorado birds. Birds of Colorado; being a list with brief annotations of the 363 species known to occur in the State.

COOKE, W. W. The Scarlet Ibis in Colorado. *Auk, XIV.* 1897, *p. 316.*

Note on the alleged occurrence of this species in the Arkansas Valley. The article is based on a mis-identification, the birds taken being really the White-faced Glossy Ibis.

COOKE, W. W. Bendire's Thrasher in Colorado. *Osprey, II.* 1897, *p. 7.*

Nests and eggs taken by Mr. N. R. Christie at Rouse Junction.

COOKE, W. W. A New Bird for Colorado. *Oregon Naturalist, IV.* 1897-8, *p. 65.*

A specimen of the Calliope Hummingbird found at Colorado Springs, July 25, 1897.

Page 29. Add. COUES, ELLIOTT. The Expeditions of Zebulon Montgomery Pike, To Headwaters of the Mississippi River, Through Louisiana Territory and in New Spain, During the Years 1805-6-7. A New Edition . . . . . by Elliott Coues . . . . In Three Volumes. Vol. II. Arkansas Journey—Mexican Tour. New York, Francis P. Harper, 1895, pp. 955.

Contains the same bird notes as the original edition with the addition of a specific name to the description of the Carolina Paroquet.

Page 30. Add. Editorial. *The Republican*, April 29, 1897. [Local newspaper, published at Rocky Ford, Colo.]

Note of a Scarlet Ibis killed in that vicinity a few days before and mounted by Bert Beymer. [Specimen was really the White-faced Glossy Ibis.]

Editorial. *The Republican*, June 3, 1897.

Further notes on the capture of the birds mentioned in a previous issue with the same error of identification.

EVERMANN, B. W. and Jenkins, O. P. Ornithology from a Railroad Train. *O. & O. XIII.* 1888, *pp. 65.*

Notes on twenty-one species of birds seen on a trip through the Arkansas Valley and up the Las Animas River to Trinidad.

Page 33. Add. INGRAHAM, D. P. Additional Records of the Flammulated Owl (*Megascops flammeola*) in Colorado. *Auk, XIV.* 1897, *p. 403.*

Two sets of eggs taken in May, 1897, near Beulah.

Page 34. Add. MORRISON. C. F. The Tricolored Blackbird in Colorado. *O. & O. XII.* 1887, *p. 107.*

Birds supposed to have been seen near Fort Lewis, February 3, 1887.

Page 35. Add. PIKE, Z. M. Exploratory Travels through the Western Territories of North America: comprising a Voyage from St. Louis, on the Mississippi, to the Source of that River, and a Journey through the Interior of Louisiana and the north-eastern Provinces of New Spain. Performed in the years 1805, 1806, 1807, by Order of the Government of the United States. By Zebulon Montgomery Pike, Major 6th Regt. United States Infantry. London: Paternoster Row. 1811. Denver: W. H. Lawrence & Co. 1889.

This is a reprint of the second edition. The book lays no claim to scientific ornithology, but it is interesting as being the first book that makes specific references to Colorado birds. Five species are mentioned or described.

Page 36. Add. RIDGWAY, ROBERT. A Monograph of the Genus *Leucosticte*, Swainson: or, Gray-crowned Purple

Finches. *Bull. Geol. and Geog. Surv. Ter. No. 2. Second Series.* May 11, 1875. *pp. 51-82.*

A full discussion of the three species and two varieties that inhabit the United States. Four of these forms are found in Colorado and three-fourths of the specimens that form the basis of the monograph came from Colorado.

Page 38. Add. SPRAGUE, U. [=W.] A. The Dwarf Thrush in Colorado. *Auk, XIII.* 1896, *p. 85.*

One taken at Magnolia, October 6, 1895, and identified by Ridgway.

THE HISTORY OF COLORADO ORNITHOLOGY.

Page 48. Add.

1898. **Cooke.** *Oregon Naturalist, IV.* 1897-8, *p. 65.* *Stellula calliope* taken at Colorado Springs and reported by C. E. Aiken.

1898. **Cooke.** *Colorado Experiment Station Bulletin No. 44.* The present publication contains the first records for Colorado of ten species as follows: *Phasianus torquatus* and *Melospiza georgiana* by Aiken; *Habia ludoviciana* by Mrs. Bacon; *Porzana jamaicensis* by Bruce; *Piranga erythromelas* by Cooke; *Nyctala tengmalmi richardsoni* by Doertenbach; *Urinator adamsii* by Hardy; *Tympanuchus americanus* by Robertson; *Dendroica palmarun* by H. G. Smith, and *Acanthis linaria rostrata* by Sprague.

Page 48. **RECAPITULATION.** Add.

1898	W. W. Cooke	1	364
1898	W. W. Cooke	10	374

THE BIRDS OF COLORADO.

Page 49. 1. **Æchmophorus occidentalis.** WESTERN GREBE.

In a collection of beautifully mounted birds at the High School building at Cheyenne, Wyo., is a fine specimen of this species, that was brought to Mr. F. Bond in the flesh and mounted by him, as were the other birds in this collection. Mr. Bond writes that years when he has been collecting he has seen a few in autumn on the lakes near Cheyenne. This record, taken in connection with that already published, would indicate that this species was quite regular in visiting the eastern slope of the range, though never common.

Page 49. 2. **Colymbus holbœllii.** HOLBŒLL'S GREBE.

The same collection contains one of these birds, shot in the vicinity by Mr. Bond, who has also seen several others in autumn on the lakes. As Cheyenne is only just over the Colorado line, these records make it probable that this species will eventually be taken in Colorado east of the range.

Page 49. 3. **Colymbus auritus.** HORNED GREBE.

Mr. E. L. Berthoud writes that he has seen two specimens that were killed on the lakes northeast of Golden.

Page 50. Add. 8. **Urinator adamsii.** YELLOW-BILLED LOON.

Migratory; rare or accidental. In the collection of Mr. Manly Hardy, Brewer, Me., there is a young male of this species taken May 25, 1885, at Loveland, Colo., by W. G. Smith. Mr. Hardy writes that there can be no question whatever of the identity of the specimen. This is the first record for Colorado, and a very strange record, since the species inhabits Arctic America and is rarely found anywhere in the United States.

Page 51. 60. **Larus philadelphia.** BONAPARTE'S GULL.

To previous records add one taken November 15, 1895, at Pueblo by Mr. H. W. Nash; also one taken and several others seen by Mr. F. Bond at Cheyenne.

Page 51. 62. **Xema sabinii.** SABINE'S GULL.

Near Golden in the early days of the settlement of that country Mr. E. L. Berthoud says that these gulls were not uncommon, but have disappeared of late years.

Page 52. 120. **Phalacrocorax dilophus.** DOUBLE-CRESTED CORMORANT.

In the summer of 1897, the Cormorant was found breeding by Prof. Knight, near Buffalo, Wyo. This is quite a long distance north of Colorado, but yet it increases the probability of the bird's occurring as a breeder in this State.

Page 53. 133. **Anas obscura.** BLACK DUCK.

A third specimen can now be recorded. According to Mr. H. G. Smith one was purchased by a local taxidermist in the Denver market December 12, 1894. It is presumed that the bird was shot in Colorado.

Page 53. 135. **Anas strepera.** GADWALL.

Found by Mr. C. E. Aiken as an abundant breeder at the San Luis Lakes.

Page 55. 144. **Aix sponsa.** WOOD DUCK.

A mounted specimen is now in the possession of Mr. E. J. Oslar of Denver, that was taken at Littleton about May 1, 1892.

Page 57. Add. 160. **Somateria dresseri.** AMERICAN EIDER.

One was taken by W. G. Smith at Loveland sometime previous to 1892. Prof. Wm. Osburn writes that he saw the specimen in Mr. Smith's collection.

There is a mounted bird of this species at the rooms of the Society of Natural History in Denver. There is no record accompanying it, but it was presumably taken in Colorado nearly twenty years ago.

Page 58. 172. **Branta canadensis.** CANADA GOOSE.

During the summer of 1897, this species was noted by the present writer as nesting five miles west of NiWot at about 5,500 feet. This is several thousand feet lower than previous records.

Page 60. [185.] **Guara rubra.** SCARLET IBIS.

In the third line, the word "Texas" should be New Mexico, the reference being to the record of Dr. Coues at Albuquerque. The birds reported by Mr. Beymer in the Rocky Ford Republican and by the present writer on his authority in the Auk were really the White-faced Glossy Ibis (*Plegadis guarauna*).

Page 60. 187. **Plegadis guarauna.** WHITE-FACED GLOSSY IBIS.

Summer resident; rare. The number of known occurences is now double what is was a year ago. As stated above the birds seen at Rocky Ford were really this species instead of the Scarlet Ibis. A flock of six were seen there on the Arkansas

River, April 23, 1897, and three of them were secured and have been mounted by Mr. Beymer. A young female, presumably of this species, was taken September 10, 1897, twenty miles east of Pueblo on the Arkansas and reported by W. F. Doertenback of Pueblo. It was not young enough to prove that it had been raised in the vicinity.

In September, 1872, Mr. C. E. Aiken saw one on the South Platte River in South Park at nearly 7,000 feet altitude. On July 1, 1875, Mr. Aiken found this species breeding at the San Luis Lakes at about 7,500 feet altitude, so that it stands at present in the Colorado list as a summer resident.

The known northern range of this species is much extended by the following record. In the spring of 1893, Mr. R. A. Wallen shot one at Red Bank, Wyo., about two hundred miles north of Laramie City.

Page 61. 191. **Ardetta exilis.** LEAST BITTERN.

About August 5, 1897, Mr. W. A. Sprague of Boulder, saw a Least Bittern on a branch of the Grand River in Middle Park eight miles from Buchanan Pass. This is the first and only record for Colorado west of the range. Mr. H. G. Smith has one record of this species for the vicinity of Denver.

Page 61. 194. **Ardea herodias.** GREAT BLUE HERON.

A very late migrant and also at a much higher altitude than the former records is the one reported by Mr. C. E. Aiken at over 9,000 feet on the divide between Colorado Springs and South Park, November 27, 1897.

Page 61. 197. **Ardea candidissima.** SNOWY HERON.

This is probably not so rare a bird as was formerly believed. In addition to the seven records already noted, three specimens of this species were mounted by Mr. W. F. Doertenbach of Pueblo, during the past eight years; he also saw one on the Arkansas near Pueblo, May 9, 1897, and two young birds were sent him October 4, 1897, that were taken within six miles of Pueblo.

Mr. C. E. Aiken adds five more records, two near Leadville, in 1886, one near Denver and two from Pueblo. The Leadville specimens at about 10,000 feet are several thousand feet higher than previous records.

Page 61. 198. **Ardea rufescens.** REDDISH EGRET.

A second record for Colorado comes from Mr. E. L. Berthoud, who shot one near Golden eight years ago.

Page 63. 212. **Rallus virginianus.** VIRGINIA RAIL.

Mr. C. E. Aiken took the nest mentioned near Fountain, El Paso County.

Page 63. Add. 216. **Porzana jamaicensis.** BLACK RAIL.

Migratory; rare. Mr. David Bruce of Brockport, N. Y., who has done a large amount of collecting in Colorado, writes that he has one that he shot in May several years ago at a pond near Denver. He thinks he has seen similar birds several times, but this is the only one he has secured. The Black Rail is a southern species coming north regularly almost to Colorado.

Page 63. 219. **Gallinula galeata.** FLORIDA GALLINULE.

A second record is added by Mr. E. L. Berthoud, who saw one in 1883 at Lathrop's Lake, twelve miles from Golden.

Page 63. [222. **Crymophilus fulicarius.** RED PHALAROPE.

According to the distribution of this species as given in the A. O. U. Check List, it should be found in Colorado, but no specimen has yet been reported. There is one in the collection of the Wyoming State University at Laramie City, that was taken September 14, 1897, at Seven Mile Lakes, Albany County, not far from the Colorado line.]

Page 64. 228. **Philohela minor.** AMERICAN WOODCOCK.

The classification can now be changed to—summer resident; rare. On July 3, 1897, Mr. Harry Horner of Timnath, found near his home a pair of Woodcock and three young. One of the young was caught. They could not have been more than a week old. In addition to the records already published, Mr. E. L. Berthoud writes that he has seen them occasionally in Jefferson and Park Counties, while once he saw them on the Arkansas.

Page 64. 230. **Gallinago delicata.** WILSON'S SNIPE.

Seen twice in the summer of 1897 in Middle Park at about 9,000 feet by Mr. W. A. Sprague of Boulder. Mr. C. E. Aiken found them breeding July 1, 1875, at the San Luis Lakes at an altitude of 7,500 feet. On January 16, 1898, Mr. Aiken saw five of these birds near Colorado Springs, and the same day two men shot fifteen along the banks of the Fountain Creek.

Page 65. 240. **Tringa fuscicollis.** WHITE-RUMPED SANDPIPER.

To previous records add one taken by Mr. Aiken at Colorado Springs and identified by Mr. Ridgway.

Page 66. 248. **Calidris arenaria.** SANDERLING.

One was taken October 1, 1897, by Mr. H. W. Nash near Pueblo. Mr. C. E. Aiken writes that he has known of several taken near Colorado Springs.

Page 70. 300b. **Bonasa umbellus umbelloides.** GRAY RUFFED GROUSE.

One was shot about eighteen miles south of Denver the latter part of December, 1894. It was with several others and they were seen on several occasions. Mr. L. D. Gilmore reports seeing five January 3, 1898, and more on the following week near Sweet Water Lake in Eagle County at 8,000 feet. An old hunter there told him that they are never seen in summer, but come in the winter and are sometimes quite common.

Page 71. Add. 305. **Tympanuchus americanus.** PRAIRIE HEN.

Summer visitant; rare and local. There have been many reports of true "Prairie Chickens" in Colorado, but all reported previous to 1897 have proved on investigation to be Sharp-tailed Grouse. During last October the present writer saw some Prairie Chickens at Ogallala, Neb., some twenty-five miles east of the Colorado line. Diligent inquiry has revealed the fact that they are quite common a little east of Ogallala and decrease suddenly to the westward. More than half of those questioned had never seen one west of that place. They do, however, extend occasionally into Colorado, for Mr. J. S. Robertson of Barton, has seen them twice at his place, which is about two miles within the Colorado line. Though this species has for years been moving westward, its further extension will be slow and probably not for any great distance. From Ogallala westward for the next hundred and fifty miles the native country is entirely unsuited to their wants, and the only grain fields occur as isolated patches of small extent under the ditches near the South Platte River. There is little to induce the birds to enter this country, and any that did migrate there would soon be exterminated by hunters and coyotes.

Page 71. 308b. **Pediocætes phasianellus campestris.** PRAIRIE SHARP-TAILED GROUSE.

Reports from two hunting parties that visited northwestern Colorado during the fall of 1897 indicate that in some of the wilder regions these birds are still not uncommon. The only specimen that was brought back was typical *campestris.*

Page 71. Add. 000. **Phasianus torquatus.** RING PHEASANT.

Resident; not common and local. This is the commonly called Mongolian Pheasant that has been introduced south of Denver. Mr. Aiken also saw one in the fall of 1897 near Colorado Springs, though this may have been a bird escaped from captivity.

Page 72. 312. **Columba fasciata.** BAND-TAILED PIGEON.

Quite common and breeds in the mountains near Glenwood Springs, showing that its regular extension west of the range is rather further to the north than on the eastern slope.

Page 73. 319. **Melopelia leucoptera.** WHITE-WINGED DOVE.

Under a late date, Mr. E. L. Berthoud writes concerning his record of this species, "Besides the record of 1869, when we shot one or two, I have seen two small flocks since. There was no mistaking this bird."

Page 73. 327. **Elanoides forficatus.** SWALLOW-TAILED KITE.

In August, 1877, two were brought in the flesh to Mr. C. E. Aiken, one had been shot at Colorado Springs and the other at Manitou Park. One was also shot in August, 1883. These were probably all wanderers that had nested outside of Colorado.

Page 73. 329. **Ictinia mississippiensis.** MISSISSIPPI KITE.

Mr. C. E. Aiken has seen one near Colorado Springs.

Page 76. 356. **Falco peregrinus anatum.** DUCK HAWK.

According to Mr. C. E. Aiken a pair nested for five consecutive years in the Garden of the Gods. He secured one of the old birds in 1885.

Page 77. 364. **Pandion haliaëtus carolinensis.** AMERICAN OSPREY.

They are very common spring and summer at Sweet Water Lake in the mountains east of Glenwood Springs at 8,000 feet, writes Mr. L. D. Gilmore.

Page 77. 365. **Strix pratincola.** AMERICAN BARN OWL.

Three more records near Pueblo are added by Mr. W. F Doertenbach—a fine male killed and mounted by him August 12, 1897, one other in 1889 and a third in 1891.

Page 77. Add. 371. **Nyctala tengmalmi richardsoni.** RICHARDSON'S OWL.

Winter visitant; rare. The only certain record for Colorado is the male taken by Mr. H. C. Lee Meyer at Crested Butte, October 14, 1896. Through the courtesy of Mr. W. F. Doertenbach of Pueblo, the present writer had the pleasure a few days ago of examining this specimen and there can be no question of the identification.

Page 78. 373e. **Megascops asio maxwelliæ.** ROCKY MOUNTAIN SCREECH OWL.

Mr. Aiken writes that this form occurs at Colorado Springs in winter, but not in summer.

Page 78. 373g. **Megascops asio aikeni.** AIKEN'S SCREECH OWL.

According to Mr. Aiken, none of these Owls are found at Colorado Springs in the winter, indicating that this and the preceding species perform a slight migration.

Page 78. 374. **Megascops flammeola.** FLAMMULATED SCREECH OWL.

The seventh, eighth and ninth specimens taken in the United States outside of Colorado are noted by Mr. Manly Hardy, Brewer, Me., who writes: "I have an adult female and a fully grown young Flammulated Screech Owl taken in 1883 at Santa Fé, New Mexico, by Chas. H. Marsh. Also an adult male taken in the Huachuca Mountains of Arizona by a Mr. Lusk, August 24, 1895."

The twelfth and thirteenth specimens for Colorado are recorded by Capt. D. B. Ingraham, who took a set of two fresh eggs at Beulah, May 27, 1897, and on May 29 a set of three eggs slightly incubated. The females were secured in both cases and identified by Prof. Allen. (Auk, XIV. 1897, p. 403). A female Flammulated Owl was shot by Mr. W. A. Sprague near Boulder, September 22, 1897. The skin was sent to the present writer for identification. This makes the fourteenth specimen for Colorado and the twenty-third for the United States. There are six known cases of breeding, all in Colorado.

Page 79. 375a. **Bubo virginianus pallescens.** WESTERN HORNED OWL.

This is the present recognized name for this variety instead of *subarcticus* (Stone., Am. Nat. XXXI. 1897, p. 236). To settle the exact name of the common Horned Owl of Colorado, Mr. C. E. Aiken lately sent eight specimens to the Smithsonian Institution. They embraced dark and paler examples from both the plains and mountain. They were pronounced by Mr. Ridgway as all of them *pallescens*, saying, "some of them are darker than the normal average style and incline toward *saturatus*, in fact they may be fairly considered intermediate between the two, though still nearer *pallescens* than *saturatus*."

Page 80. 376. **Nyctea nyctea.** SNOWY OWL.

Two specimens shot near Colorado Springs and reported by Mr. Aiken represent about the extreme southern range of the species in Colorado.

Page 81. 379. **Glaucidium gnoma.** PYGMY OWL.

Mr. Aiken adds three records to those previously published; one on the plains at Pueblo November 1, 1871; one in the winter of 1877-8 on Cheyenne Mountain, and one breeding in 1884 at Ute Pass.

Page 81. 382. **Conurus carolinensis.** CAROLINA PAROQUET.

The record of this species made by Pike in 1807 on the Arkansas River (1895 Edition by Dr. Coues, Vol. II. p. 474) is the earliest allusion to this species in Colorado, but as Pike does not mention it by name, only describes it, its proper place in the Colorado list is that already given it (p. 45) as introduced by Dr. Coues in 1877.

Page 83. 396. **Dryobates scalaris bairdi.** TEXAN WOODPECKER.

In the summer of 1897 Mr. W. P. Lowe saw a pair in company with young and feels sure that they were reared in St. Charles Cañon, Pueblo County. He saw a pair of old birds at the same place in 1896.

Page 84. 408. **Melanerpes torquatus.** LEWIS'S WOODPECKER.

Fresh eggs have been found by Mr. N. R. Christie at Rouse Junction, in southern Colorado, as early as the middle of May.

Page 85. 412. **Colaptes auratus.** FLICKER.

Noted by Evermann and Jenkins in the Arkansas Valley in Colorado. (*O. & O., XIII.* 1888, *p. 66.*)

Page 85. 413. **Colaptes cafer.** RED-SHAFTED FLICKER.

Some early eggs were found by Mr. W. A. Sprague at Magnolia, altitude 7,500 feet, on May 17, 1896, and May 20, 1897.

Page 85. 418a. **Phalænoptilus nuttallii nitidus.** FROSTED POOR-WILL.

Two specimens taken by Mr. Aiken at Colorado Springs have been identified as belonging to this variety and thus extending its range to the eastern foothills.

Page 86. No. 455 is a misprint for No. 425.

Page 86. 433. **Selasphorus rufus.** RUFOUS HUMMINGBIRD.

To the records east of the range add one taken about the middle of July, 1897, by Mr. Aiken, at Ramah, on the Divide south of Denver, at about 8,000 feet. The known northward range of this species has been greatly extended by the capture of a specimen July 24, 1897, in Carbon County, Wyo., a hundred and fifty miles northwest of Laramie City.

Page 87. Add. 436. **Stellula calliope.** CALLIOPE HUMMINGBIRD.

Summer visitant; rare or accidental. An adult male was found dead July 25, 1897, in Cheyenne Cañon, near Colorado Springs. The skin is now in the collection of Mr. C. E. Aiken.

Page 87. 447. **Tyrannus verticalis.** ARKANSAS KINGBIRD.

448. **Tyrannus vociferans.** CASSIN'S KINGBIRD.

During a collecting trip on the Divide south of Denver, in 1897, Mr. Aiken took careful notes of the relative abundance of these two species in the breeding season, at Ramah, altitude 8,000 feet. In quite a small area he found about a hundred and fifty pairs of the Arkansas Kingbird and only about twenty-five pairs of Cassin's.

Page 89. 474a. **Otocoris alpestris leucolæma.** PALLID HORNED LARK.

The determinations of Mr. Ridgway, mentioned below, make it probable that most of the winter birds of northern Colorado should be referred to *arenicola* instead of *leucolæma.*

Page 89. 474c. **Otocoris alpestris arenicola.** DESERT HORNED LARK.

A series of ten Horned Larks from Colorado were sent by Mr. Aiken to Washington. They embraced winter and summer specimens selected from a large number to show all phases of plumage, some even having the throat white without trace of yellow. They are all referred by Mr. Ridgway to *arenicola.*

Page 91. 487. **Corvus cryptoleucus.** WHITE-NECKED RAVEN.

A nest with eggs was found by Mr. Aiken in May, 1878, on Horse Creek, seventy-five miles east of Colorado Springs.

Page 92. 491. **Nucifraga columbiana.** CLARKE'S NUTCRACKER.

The first sentence should read: "The first eggs known to science from Colorado, etc." Maj. Bendire had previously taken the nest and eggs in Oregon.

Page 93. 494. **Dolichonyx oryzivorus.** BOBOLINK.

Several more records can be added to the five previously known. Mr. H. G. Smith saw a male in a garden in the city of Denver in June several years ago. Mr. C. E. Aiken took one in fall plumage at Colorado Springs September 5, 1897. There is a mounted bird at Cheyenne taken by Mr. F. Bond, who writes: "The Bobolink is not uncommon with us. I have taken them yearly for some years; sometimes within the city limits."

Page 94. 506. **Icterus spurius.** ORCHARD ORIOLE.

Three were seen by Mr. Aiken in Beaver Creek Valley, Fremont County, in May, 1875.

Page 95. 507. **Icterus galbula.** BALTIMORE ORIOLE.

Mr. E. L. Berthoud writes that he has seen the Baltimore Oriole occasionally at Golden.

Page 95. 514a. **Coccothraustes vespertinus montanus.** WESTERN EVENING GROSBEAK.

Five of these birds were seen by Mr. P. L. Jones at Beulah, August 3, 1897. They remained in that vicinity for over two weeks, being seen almost every day. As Mr. Jones has also seen them late in May, it is almost certain that they breed in Colorado.

Page 97. 524. **Leucosticte tephrocotis.** GRAY-CROWNED LEUCOSTICTE.

According to Mr. Aiken this species is somewhat irregular in its appearance at Colorado Springs, but winters almost every year in considerable numbers and some years becomes abundant. A male and a female were taken by Mr. W. A. Sprague on November 27, 1895, at Magnolia at 7,500 feet.

Page 98. 525. **Leucosticte atrata.** BLACK LEUCOSTICTE.

A few days ago the present writer had the pleasure of examining Mr. C. E. Aiken's large collection of the *Leucosticte*. Mr. Aiken probably has more specimens of *atrata* than all other collections together. They have been taken near Colorado Springs during the winter season and as late as April 4. They have been taken during the winters 1875, 1876, 1877, 1879 and 1883. During the fall of 1894 Mr. Aiken saw them in the Uintah Mountains in Utah near where Dr. F. V. Hayden took his specimen in 1870.

This Hayden specimen has been given the credit of being the first known to science (Ridgway, Bull. Geol. and Geog. Surv. Ter. Second Series No. 2, p. 53). Mr. Aiken however calls attention to the fact that there is an earlier specimen. He says: "It was shot in March, 1870, at Sherman, Wyo., [just over the Colorado line] by J. Denchman and sent by express to Mr. Holden in Chicago, together with about sixty specimens of *L. tephrocotis*—all in the flesh. Mr. Holden and myself examined this specimen carefully on the arrival of the shipment and as it was apparently an immature bird, we concluded that it was the young of *tephrocotis*, though the probability of its being an example of melanism was entertained. I think this specimen is still in Mr. Holden's collection. On securing my four specimens at Cañon City in April, 1874, I knew they were identical with the Holden bird and was confident that they represented an undescribed race." Mr. Holden has recorded this specimen as follows: "In one specimen, a young male, I think, the plumage is almost black, in fact it is black, except the wings and after half of the body. It is an interesting specimen." (Holden and Aiken, Proc. Bost. Soc. Nat. Hist., XV. 1872, p. 200.)

This specimen was not taken in Colorado and the first specimen for this State is the one already accredited to Mr. Aiken in 1874.

Page 98. Add. 528b. **Acanthis linaria rostrata.** GREATER REDPOLL.

Winter visitant rare or accidental. There is only one Colorado record for this northern species. Mr. W. A. Sprague shot one December 9, 1895, near Magnolia, at an altitude of 7,500 feet. Of this specimen, Mr. Ridgway says that it is not typical but near enough to be called this variety.

Page 99. **Passer domesticus.** EUROPEAN HOUSE SPARROW.

A wonderful increase has taken place with these birds during the last twelve months. They reached Fort Collins in the fall of 1896. So that now they occur along the eastern base of the foothills for nearly two hundred miles. Mr. E. L. Berthoud notes a short visit from them a few years ago at Golden, well up in the foothills, but they did not remain and none have since been seen.

Page 100. 534. **Plectrophenax nivalis.** SNOWFLAKE.

A pair were shot by Mr. Aiken at Colorado Springs the winter of 1877-8. This is the most southern record for Colorado.

Page 101. 542b. **Ammodramus sandwichensis alaudinus.** WESTERN SAVANNA SPARROW.

The question having been raised as to whether all of the Savanna Sparrows of Colorado belong to the western race, a large series was submitted by Mr. Aiken to the Smithsonian. They were all pronounced *alaudinus.* Another series sent by the present writer to Prof. Allen received the same identification. Nevertheless Mr. Aiken is quite sure that in the field he can see a difference between the breeding birds and the migrants. The latter is the larger and moves earlier, arriving at Colorado Springs the last of July to the first of August and leaves the first of October.

Page 101. 546a. **Ammodramus savannarum perpallidus.** WESTERN GRASSHOPPER SPARROW.

A large series of this Sparrow submitted to Prof. Allen and Mr. Ridgway are all considered as true *perpallidus*.

Page 103. 558. **Zonotrichia albicollis.** WHITE-THROATED SPARROW.

One taken by Mr. H. W. Nash at Pueblo, October 18, 1893. This is the third record for Colorado.

Page 103. 560. **Spizella socialis.** CHIPPING SPARROW.

The more the Chipping Sparrows of Colorado are investigated the more evident it becomes that the eastern form is far less common in the State than had formerly been supposed. There is need of much more work in the matter on the plains of eastern Colorado, before the distribution of the two varieties can be determined.

Page 104. 566. **Junco aikeni.** WHITE-WINGED JUNCO.

In the fifth line the "5th of October" was a misprint in the original article for the "5th of November." Mr. Aiken writes that the earliest he has seen the birds at Colorado Springs is October 26, 1897.

Page 105. 569. **Junco caniceps.** GRAY-HEADED JUNCO.

At Magnolia, Boulder County, at 7,500 feet, Mr. W. A. Sprague found eggs May 25, 1896, and young birds a week old May 29, 1897. On July 6, 1897, he also found young birds newly hatched showing that two broods are reared in northern Colorado. Mr. Aiken thinks that these Juncos winter in the mountains as far north as Colorado Springs, coming to the plains during storms and returning to the mountains as soon as the weather moderates.

Page 106. 574a. **Amphispiza belli nevadensis.** SAGE SPARROW.

The known northeastern extension of this species has been largely increased by a specimen taken just over the Colorado line in Wyoming, near Cheyenne, by Mr. F. Bond. The specimen is now mounted in his collection. This is apparently the first record east of the Front Range.

Page 107. Add. 584. **Melospiza georgiana.** SWAMP SPARROW.

Summer visitant; rare or accidental. Only one instance known, seen by Mr. Aiken, at Colorado Springs, the latter part of August, 1897. Regularly comes west only to the plains, but has been once taken in Utah.

Page 107. 585c. **Passerella iliaca schistacea.** Slate-colored Sparrow.

An adult male was taken in July, 1889, at Florissant, by Dr. J. L. Goodale, now of Boston, Mass The specimen is still in his collection, but its capture has not before been recorded. Mr. David Bruce of Brockport, N. Y., took one on the Grand River, near Glenwood Springs, during June, 1897. The bird was seen several times and was evidently breeding.

The above records are the only unquestionable ones that this species has for Colorado. They confirm the previously accepted belief that the bird is a summer resident in Colorado.

Page 108. 593. **Cardinalis cardinalis.** Cardinal.

A second record for Colorado is that of Mr. H. W. Nash who saw one at Pueblo about November 28, 1895.

Page 108. Add. 595. **Habia ludoviciana.** Rose-breasted Grosbeak.

Summer resident; rare, if not accidental. It is with some hesitation that the present species is given a place in the Colorado list and yet after most careful investigation there seems scant possibility of error. In the summer of 1894 a pair nested near the house of Mrs. J. W. Bacon, Longmont. The male was several times seen at a distance of less than twenty-five feet and the rose color distinctly noted. Later the same bird was seen on the lawn feeding the newly fledged young. One of the latter was caught.

Page 109. 597a. **Guiraca cærulea eurhyncha.** Western Blue Grosbeak.

Not an uncommon bird as far north as Pueblo and breeds in the foothills as far up as Beulah where Mr. P. L. Jones took four nests in 1897. Farther north at Colorado Springs it still occurs regularly though not common. North of there, the only record is that of one taken by Mr. H. G. Smith east of Morrison.

Page 109. 604. **Spiza americana.** Dickcissel.

One taken by Mr. C. E. Aiken at Colorado Springs August 29, 1897.

Page 110. 607. **Piranga ludoviciana.** Louisiana Tanager.

There are no records of this bird breeding in Colorado below 6,000 feet, but in northeastern Wyoming at Sundance, Prof. Knight found it in 1897 breeding at 4,500 feet.

Page 110. 608. **Piranga erythromelas.** Scarlet Tanager.

Migratory; rare. The brackets can now be removed from this species and it be entered as a Colorado bird. A few weeks ago the present writer saw at Glenwood Springs two mounted males that were taken near Newcastle the spring of 1892. Mr. E. L. Berthoud writes that he took one on Bear Creek near Golden in 1867 and also saw one in the Del Norte Valley, in September, 1883. That it should appear at the edge of the the plains is not wonderful, but the two records west of the range were entirely unexpected.

Page 112. 624. **Vireo olivaceus.** RED-EYED VIREO.

To previous records add one seen by H. G. Smith at Denver May 22, 1892.

Page 112. 629a. **Vireo solitarius cassinii.** CASSIN'S VIREO.

One was taken by Mr. W. F. Doertenbach, near Pueblo, September 6, 1897. Two were seen and one secured.

Page 113. Add. [645a. **Helminthophila ruficapilla gutturalis.** CALAVERAS WARBLER.

One adult and one young-of-the-year were taken on Teepee Creek, Carbon County, Wyo., July 19, 1897, and one young-of-the-year near Reed's Ranch, Albany County, Wyo., August 3, 1897. These specimens are now in the museum of the State University at Laramie City. All of these birds were taken near the Colorado line, making it practically certain that this species will yet be found in western Colorado. It is certain that these birds are *ruficapilla* of either the eastern or western form, but the above reference to the western form is given merely on geographical grounds. When the present writer examined the specimens he had no means of determining the exact variety.]

Page 113. 647. **Helminthophila peregrina.** TENNESSEE WARBLER.

Summer resident; rare. This species is brought among the breeders of Colorado on the strength of two nests found by Mr. C. E. Aiken, one in Colorado Springs and one near there. Mr. F. Bond writes that he has seen these birds several times at Cheyenne during migration.

Page 115. 657. **Dendroica maculosa.** MAGNOLIA WARBLER.

One taken by Mr. H. G. Smith, near Denver, May 17, 1888.

Page 116. 665. **Dendroica nigrescens.** BLACK-THROATED GRAY WARBLER.

According to Mr. Aiken this Warbler is not an uncommon breeder in the piñon hills north and east of Cañon City. It arrives early in May.

Page 116. Add. 672. **Dendroica palmarum.** PALM WARBLER.

Migratory; rare or accidental. One was seen by Mr. H. G. Smith in Denver, June 20, 1891. The specimen was not secured, but was seen so close at hand and so carefully identified that there is undoubtedly no mistake in the matter. This is an eastern species and comes regularly so near to Colorado that it is strange there are no more records of its occurrence here.

Page 116. 675a. **Seiurus noveboracensis notabilis.** GRINNELL'S WATER-THRUSH.

Several seen by Mr. C. E. Aiken at Cañon City in May, 1873.

Page 118. 701. **Cinclus mexicanus.** AMERICAN DIPPER.

The Dipper nested in 1897 at Coburn's mill west of Boulder at 7,000 feet, according to Mr. W. A. Sprague, and probably on Middle Boulder Creek as low as 6,500 feet.

Up to December 15, 1897, Mr. L. D. Gilmore saw one frequently on the headwaters of Clear Creek at 10,500 feet. On October 3, 1897, he saw one just above timber line near Berthoud's Pass at 11,500 feet.

Page 120. 708. **Harporhynchus bendirei.** BENDIRE'S THRASHER.

Summer resident; rare and local. Mr. N. R. Christie writes that it breeds at Rouse Junction, in south central Colorado, at 6,000 feet. On June 6, 1896, he found two sets of three eggs each; June 2, a set of two eggs almost hatched; June 13, nest and four young. In 1897 one pair was noticed in May but no nests found.

Page 120. 719b. **Thryothorus bewickii leucogaster.** BAIRD'S WREN.

These Wrens are found by Mr. Christie as not uncommon at Rouse Junction, nesting about the first of June. Mr. Aiken shot one at Colorado Springs, May 1, 1879.

Page 122. 733a. **Parus inornatus griseus.** GRAY TITMOUSE.

Found by Mr. Aiken as a common winter resident in the foothills, northeast of Cañon City, where a few remain to breed.

Page 124. 751. **Polioptila cærulea.** BLUE-GRAY GNATCATCHER.

Mr. H. G. Smith has seen one at Denver.

Page 124. 754. **Myadestes townsendii.** TOWNSEND'S SOLITAIRE.

A nest with four eggs heavily incubated was taken by the present writer July 25, 1897, in Estes Park at 8,500 feet.

Page 125. 759. **Turdus aonalaschkæ.** DWARF HERMIT THRUSH.

One was taken by Mr. W. A. Sprague at Magnolia, altitude 7,500 feet, October 6, 1895.

Page 126. 766. **Sialia sialis.** BLUEBIRD.

Mr. H. W. Nash took one at Pueblo April 5, 1883.

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THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 45.

THE LOSS OF WATER FROM RESERVOIRS BY SEEPAGE AND EVAPORATION.

Approved by the Station Council.

ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

MAY, 1898.

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THE LOSS OF WATER FROM RESERVOIRS BY SEEPAGE AND EVAPORATION.

By L. G. CARPENTER.

For convenience of reference the principal paragraphs are numbered. A summary and conclusions are given on the last pages of the bulletin.

§ 1. This bulletin was intended to give the results of a series of observations made to determine the loss from seepage on reservoirs near Fort Collins, during the winters of 1895-6 and 1896-7, and to give such of the related observations on evaporation as were necessary to throw light on the measurements from the lakes. As the losses from seepage were less than expected, the losses from evaporation were correspondingly more important. Without intending, or desiring, in this place, to enter upon a discussion of the mass of evaporation observations, this fact has led to a fuller statement of the observations of evaporation than were at first thought necessary or desirable.

§ 2. The loss from the lakes may be due to evaporation from the water surface, and seepage or filtration through the dam and bottom of the reservoir. The leakage through imperfectly fitting gates can be prevented or remedied by better construction. Gain may come from rainfall on the lake, the drainage from the water shed tributary to the lake and the seepage from irrigated lands above the lakes. The aggregate of these gains and losses is desired by the companies as much, or more, than a knowledge of each, but the aggregate can best be told when a knowlege of the amount of loss or gain from each cause is determined. The losses from seepage in many cases deserve most attention, as they may vary between wide limits, and to some extent are preventable. The amount of loss from evaporation may be estimated with considerable certainty. The loss from seepage is more uncertain, as it must vary with the conditions of each basin, and the amount is peculiar to that particular site. Its determination is surrounded with difficulty, and requires accessory investigations, so that attempts to determine the loss by seepage from reservoirs seem not to have been made, or if so, I have been unable to find any records of the attempt or of the results. But while evaporation depends upon various circumstances some of which can be controlled, the amount of evaporation cannot be materially modified at any practicable cost.

§ 3. Generally the scarcity of sites for reservoirs makes the selection depend on their availability, nevertheless the possibility of an undue loss from seepage needs to be borne in mind in making the selection. In most of the sites found in Colorado, the strata form a natural basin from which the loss by seepage is small. There are places in which the strata of rock incline both ways from the reservoir, an anticlinal in the term of the geologist. This condition or when the strata dip in one direction from the site should be avoided, although when the rocks are deeply covered with soil undesirable effects may be small. I have seen reservoirs in Algeria with the strata inclining from the reservoir, where all the exposed rock has been cemented in order to prevent the loss of water through the strata. With a bottom of sand, the loss may be large for a time, but the action rapidly grows less after the sand layers are once saturated.

EVAPORATION.

§ 4. The general conditions of evaporation are well known. The amount of evaporation depends upon the temperature of the water, upon the dryness of the air (not directly upon the temperature of the air), upon the wind. The wind brings fresh, unsaturated air in contact with the water surface and gives opportunity for more vapor to be absorbed. Unless the temperature of the water surface is warmer than the dew point of the air, evaporation cannot proceed; if lower, condensation may take place. The wind also causes waves and increases the area subject to evaporation.

§ 5. The temperature of the water affects the evaporation much more than is usually realized. A shallow lake evaporates faster than a deep one, because its temperature is higher. Likewise the evaporation from the shallow parts of a lake is greater than from the deep portions. I have often found the temperature of the water in the shallow areas much higher than at the deep places. The temperature of the water, and the wind exposure, may differ so much between bodies of water in the same neighborhood that a general statement must be accepted with reserve. It is entirely possible for two tanks side by side to have very different losses from evaporation. In the evaporation tank, which has now been maintained for eleven years, the loss from evaporation averages 41 inches per annum. From lakes during the summer months the evaporation has been fouud to be as much as twice that from the tanks, an increase of temperature of ten degrees, or enough to change the temperature from 70° to 80°, may be sufficient to double the amount.

§ 6. Evaporation proceeds from ice, but at a diminished rate. When our tanks are frozen they show a loss of from 1 to 1½ inches per month, solely from the frozen surface.

The evaporation at night, contrary to common opinion, is almost the same as during the day, and this is nearer equality as the body of water is larger. Even in our tanks, the evaporation during the nights of a month is often found to be more than during the days for the same period.

THE LOSS FROM SEEPAGE.

§ 7. For two winters observations were made to determine the loss from reservoirs by seepage. In many cases water runs into the reservoirs until late in the fall and the filling begins early in the spring, hence the period during which the losses can be found without measurements of inflow and outflow is short. Nearly a dozen reservoirs were visited. Bench marks were established, and levels run to the surface of the water. Some of those selected were filled during the winter, and the record was of no value. Perhaps half a dozen gave some basis for estimating the loss.

Most of the reservoirs under observation are natural basins situated within twelve miles of Fort Collins, and at an elevation from 5,000 to 5,500 feet above sea level. The sites have been ponds in wet weather, and the extreme bottom is covered with thin silt, which when soaked is nearly impervious to water. On the sloping sides the soil consists of a gravelly loam or sandy clay, but lacking the natural impervious coating.

METHOD OF OBSERVATION.

§ 8. At the first visit of the season, some well marked and permanent object was selected as a reference point. If none was convenient, a stake was driven where it would remain undisturbed through the winter; the top was used as a reference point. The elevation of the water surface was compared with the height of the top of the stake by an engineer's level. In case of ripples or waves, the observer was instructed to take the mean water level as near as it could be estimated. Any heaping of the water on one side of the lake from wind was not eliminated. Such cause may effect some of the observations, but the effect has been slight, and can affect but few. April 17, 1897, was windy, and the greatest effect is thought to have been on that day. As the reservoirs were filled immediatly thereafter, this was the last observation that could be made, and has been used.

For a portion of the winter the lakes were covered with ice. When this was the case, holes were cut, and the elevation of the water surface taken. In almost no case did the water rise to the surface of the ice.

DESCRIPTION OF THE LAKES.

§ 9. Loomis lake is one and one half miles west of the Agricultural College. It is a shallow natural basin, which by the construction of an embankment on the north side has been converted into a reservoir. The Larimer County Canal No. 2 runs close to the west side of the lake, and for rods the embankment of the canal forms the only separation between the two. The basin is but little below the plain. Trees and brush on the ditch embankment protect the lake to some extent from west winds. The lake may receive water by seepage from lands to the west, principally lands irrigated from the Pleasant Valley and Lake Canal. Any surface drainage is intercepted by the New Mercer and the Larimer Co. No. 2 Canals, with the exception of that from a strip on the south and east covering but a couple of acres. The lake receives the waste water from some of the neighboring farms. The lake showed a gain in the winter of 1895–6, and a loss in the winter of 1896–7. It is probable that some water wasted into the lake the first winter.

No Name lake is a lake of about an acre, to the east of the reservoir of the Larimer and Weld Reservoir Company, about two miles north of Fort Collins. It has but a small drainage area. It is filled from the Larimer County Canal.

The Rocky Ridge reservoir is situated several miles farther north, on the east side of the Larimer County Canal, which here passes on a ridge on the west and south side of the lake. To the east of the lake is a cliff of sandstone several hundred feet high. The outlet of the reservoir is by a short tunnel under the canal, through a ridge to the west of the lake. The reservoir was being filled during the second winter of observation, so that a record was not taken.

The North Poudre Canal reservoirs, of which three were observed in the winter of 1895–6 and four in the winter of 1896–7, are natural basins, most of which have an embankment thrown up on one side. These lakes are of considerable size, some having an area of several hundred acres. Before they were converted into reservoirs, they held storm waters and collected some flood water, so that the bottoms were covered with silt. There are no trees to shield them from the wind.

Rigden lake is a natural basin one mile east and two miles south of the Agricultural College. It has neither inlet nor outlet. Some seepage shows on the inclined sides of the basin during the summer season, and the ground is soft in places. The lake collects the waste and seepage waters from irrigated land to the west. The nearest ditch that is more than a small lateral, is over a mile away. The lake is not fully exposed to the wind, being below the surface of the plain, and protected by a grove of cottonwoods a few rods to the west, and another a short distance to the east.

Warren lake lies a mile and one half south of Rigden lake, and is used as a reservoir. It has an embankment on the northeast side. Some seepage water enters at the west side, and also waste water from irrigation. Observations on evaporation were carried on in this lake for several years. The observations on loss by seepage were of no result, as the company found it convenient to fill the lake, and the filling, together with the seepage inflow, made the observations inconclusive.

TABLE I.—SUMMARY OF OBSERVATIONS ON LOSSES FROM RESERVOIRS.

1896.

Name of Lake.	Period.	No. of days.	Net loss—inches.	Rain during period—inches.	Total loss—evaporation and seepage—inches.	NOTES.
Rigden Lake	Feb. 18—Mar. 20.	31	3.24	1.21	4.45	Feb. 18, little ice in lake. Water 46° 4 p. m. No water running in.
	Mar. 20—April 11.	22	3.36	.67	4.03	Mar. 20, no ice. April 11, water 63° at 11 a. m.
Loomis Lake	Feb. 18—Mar. 20.	31	3.40 g	1.21	2.19 g	Feb. 18, no water running in.
	Mar. 20—April 11.	30	8.84 g	.67	8.17 g	Mar. 20 no ice. April 11, water running in adjacent canal; water in canal April 5.
No Name Lake	Feb. 19—Mar. 12.	21	2.04	.66	2.70	Small drainage area.
	Mar. 12—April 14.	33	4.08	1.22	5.30	April 14, temperature 62° at 9 a. m. Soil moist for 4 in.
Rocky Ridge Lake	Feb. 20—Mar. 12.	21	....	.66	....	Filled in this interval. March 12, ice mostly gone.
	Mar 12—April 14.	33	2.65	1.22	3.87	April 14, temperature water 54° at 10 a. m. Waves cause change of level of ⅛ in. during measurement. Ground moist 3 in. deep.
Reservoir No. 1, North Poudre Canal	Feb. 20—Mar. 12.	21	1.33	.66	1.99	Drainage area about 2 square miles.
	Mar. 12—April 14.	34	.76	1.22	1.98	April 14, temperature water 59° at 11 a. m. Level affected by waves.
Reservoir No. 2, North Poudre Canal (Demmel Lake)	Feb. 20—Mar. 12.	21	1.64	.66	2.30	Drainage of about 2 square miles.
	Mar. 12—April 14.	34	3.31	1.22	4.56	April 14, temperature 53° at 12 m.
	Dec. 5, '95—April 10.	127	4.00	2.19	6.19	From record of Mr. E. J. Gregory, Supt.
Reservoir No. 3, North Poudre Canal (Tenney Lake).	Feb. 20—Mar. 12.	21	9.90	.66	10.56	April 14, water running in lake.
	Dec. 5, '95—April 10.	127	4.00	2.19	6.19	From Mr. Gregory, Supt.
Reservoir No. 4, North Poudre Canal	Dec. 5, '95—April 10.	127	6.00	2.19	8.19	From Mr. Gregory, Supt.

TABLE II.—SUMMARY OF OBSERVATIONS ON LOSSES FROM RESERVOIRS.

1897.

NAME OF LAKE.	Period.	No. of days.	Net loss—inches.	Rain during period—inches.	Total loss—evaporation and seepage—inches.	NOTES.
Loomis Lake	Feb. 3—Mar. 6.	31	.64	.72	1.36	Feb. 3, ice covered. Little snow on ice. Ice 5 in. thick.
	Mar. 6—Mar. 17.	11	.96	.08	1.04	March 6, ice covered.
	Mar. 17—April 17.	31	.92	2.90	3.82	March 17, most ice gone Sides of basin wet from frost coming out of ground.
No Name Lake	Feb. 2—Mar. 5.	31	.49 g	.72	.23	Ice 5 in. thick. About 1 in. snow on ice. Water rises same height as ice.
	Mar. 5—Mar. 17.	12	.70	.08	.78	March 5, ice 6 in. thick. No appearance of water having run in. Little crusted snow on ice—about ½ or ¾ in. March 12, some open water.
	Mar. 17—April 17.	31	1.54	2.90	4.44	April 12, windy, poor measurement and not used. April 17, measurement all right.
Reservoir No. 1, North Poudre Canal	Feb. 2—Mar. 5.	31	.62	.72	1.34	Feb. 2, ice 6 in. thick. Some snow. Water rises above ice in hole.
	Mar. 5—Mar. 17.	12	.96 g	.08	.88 g	March 5, little open water. Ice 6 in. thick. No appearance of water having run in.
	Mar. 17—April 12.	26	4.88 g	2.74	2.14 g	March 17, snow all gone. April 12, heavy wind from northwest.
Reservoir No. 2, North Poudre Canal (Demmel Lake.)	Feb. 2—Mar. 5.	31	.43	.72	1.15	Feb. 2, thin layer of snow on some parts of ice.
	Mar. 5—Mar. 17.	12	.48	.08	.56	March 5, ice 8 in. thick. Very little open water. Think no water entering from any source.
	Mar. 17—April 12.	26	3.20 g	2.74	.46 g	March 17, considerable open water. Drove stake to level of water for measurement. April 12, windy, measure uncertain.
Reservoir No. 3, North Poudre Canal	Feb. 2—Mar. 5.	31	.18	.72	.90	Feb. 2, strip open water near edge.
	Mar. 5—Mar. 17.	12	....	....	....	March 17, filling lake. Small amount running out of lake.
Reservoir No. 4, North Poudre Canal	Feb. 2—Mar. 5.	31	.41	.72	1.13	Feb 2, ice about 5 in. thick. About 1 in. snow on ice. Water rises same level as ice.
	Mar. 5—Mar. 17.	12	.48	.08	.56	March 5, some crusted snow on ice.
	Mar. 17—April 12.	26	3.82 g	2.74	1.08 g	March 17, snow gone. April 12, ground around lake moist and muddy. Small amount of water running in from snowbank.

§ 10. The total loss given in Table 2 is the combined loss from seepage and evaporation. The records, given later in the bulletin, form the basis of the estimated evaporation given in the column so headed in the following table. The difference, unaccounted for by evaporation, is the loss due to filtration or seepage. In forming this table, only those cases where a loss was shown have been taken. It is noticeable that there are many cases in which the total loss was less than the amount of evaporation; in other words, the reservoirs were gaining water from the run-off of the water sheds running into the lake, or from seepage entering the lakes, or perhaps, in a few cases, from water in the supplying ditches, which had been reported dry. This is shown in the following table:

TABLE III.—LOSSES DUE TO SEEPAGE ALONE.

Name of Lake.	Total Loss—Inches.	Evaporation (estimated)—Inches.	Remainder (seepage) —Inches.	No. Days.	Seepage per Day—Inches	Per Year, at Same Rate.
Rigden Lake, 1896	4.45	2.39	2.06	31	.067	24.25
	4.03	2.58	1.45	22	.066	24 06
Loomis Lake, 1897	1.36	2 43	1.07 gain	31	Gain	Gain
	1.04	.85	.19	11	.017	6.30
	3.82	2.97	.85	31	.027	10.01
No Name Lake, 1896	2.70	1.70	1.00	21	.048	17.38
	5.30	3.66	1.64	33	.050	18.16
	.23	2.43	2.20 gain	31	Gain	Gain
	.78	.93	.15 gain	12	Gain	Gain
1897	4.44	2.97	1.47	31	.0475	17.31
Rocky Ridge Lake	3.87	3.66	.21	33	.006	2.32
Res. No. 2, North Poudre Canal 1896	1.99	1.63	.36	21	.016	6.26
	1.98	3.66	1.68 gain	34	Gain	Gain
1897	1.34	2.20	.86 gain	31	Gain	Gain
Demmel Lake, 1896	2 30	1.63	.67	21	.032	13.21
	4.56	3.66	.90	34	.0265	9.67
1897	1.15	2.20	1.05 gain	31	Gain	....
	.56	.93	.37 gain	12	Gain	....
Res. No. 3, North Poudre Canal. 1896	10.56	1.63	8.93	21	.42	155.00
1897	.90 gain	....	....	....	....	....
Res. No. 4, North Poudre Canal, 1897	1.13	2.43	1.30 gain	....	Gain	....
	.56	.93	37 gain	....	Gain	....
	1.08 gain	2.97	4.05 gain	....	....	....
For the whole winter, from the records of the Canal company, there must have been gain from inflow.						
Demmel Lake	6.19	10.26	4.07 gain	127	Gain	....
Res. No. 3, North Poudre Canal	6.19	10.26	4.07 gain	127	Gain	....
Res. No. 4, North Poudre Canal	8.19	10.26	2.07 gain	127	Gain	....

§ 11. It appears that the leakage from these particular reservoirs is very small. After allowing for evaporation, we find that several lakes must have gained water from outside sources, either by some water coming through the supply ditches, or from the water sheds. The three lakes, Rigden lake, Loomis lake and No Name lake, where the loss is most evident, are cases where the water sheds are small. In the other cases, it was not thought that water could have come from the water shed, but it may be possible.

§ 12. The loss from seepage during the months the lakes were measured, is evidently small. During the remainder of the year the loss will not be much more rapid, but the greater depth of water usually in spring increases the rate. When the lakes are nearly full, the water then covers some ground less completely protected by silt, but in the course of repeated fillings the whole lake bottom will reach much the same condition.

§ 13. In the Rigden lake, the loss from seepage appears to be about 2 feet per year; in the case of the No Name lake not quite so much; in reservoir No. 2, during the period when gain was not noticed, at the rate of 13 feet per year. The loss from the last lake is looked upon with doubt, but no cause other than seepage has been established.

§ 14. As a whole, the losses from the lakes under observation have been small; less than the evaporation, and less than expected. In some other places that have not been subjected to careful observations, the loss has been much greater than found in these reservoirs. Numerous small reservoirs known to the writer have been abandoned for storage purposes, because the loss was so great. In the southern part of the state, one instance was found where a depth of 27 feet is reported to have disappeared between October and the following March. Yet in these cases much of the loss has doubtless been due to filling the adjacent subsoil, as well as to seepage proper.

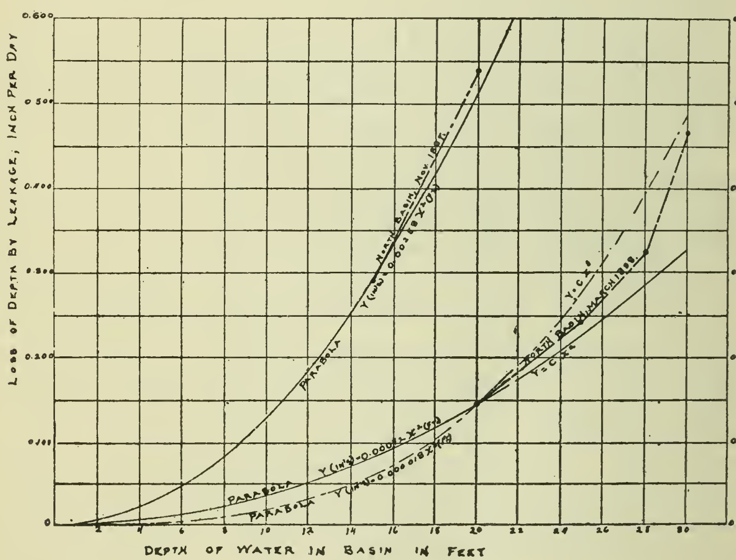
§ 15. In most of such cases, though the loss is so large at first, it may grow less with succeeding years after the adjacent subsoil is once filled. This may be expected to be the case where there are extensive beds of sand under and surrounding the reservoir. These beds absorb about one third of their volume of water, and continue to absorb as long as there are connected bodies of sand into which it can flow, or other outlets. Where the reservoir is small and the sand bed is large, the amount of water taken up in this way may be large and cause the loss from the lake to be excessive. When, however, the sand is filled, the draft on the lake is much less, the loss is reduced, and the sand holds water with success, as is shown by the lakes in sand hills, or by the holding power of sand embankments.

§ 16. In these and other cases the losses may be lessened. For since clay or fine material offers great resistance to the passage of water, only a thin layer of clay or fine sediment is required to greatly diminish the loss of water. One of the most efficient means, therefore, of lessening the loss is to change the character of the surface of the lake bottom by the deposit of a thin stratum of fine material. Since flood waters often contain a large percentage of silt, their use and the deposit of such silt, seals the bottom and may make the basin nearly water tight.

The success of the silting process may be expected to be greater with small reservoirs than with large ones. Much of the silt is deposited where the speed of the water is checked, or near the inlet. Near the outlet, where the seepage is usually the greater, less silt is deposited. Yet if the sediment is fine much benefit may be expected by application of this process.

In many cases the water may be made artificially muddy by throwing clay into the inflowing stream, taking pains that it is finely subdivided and is carried in suspension.

§ 17. The loss by seepage from sites, for reasons already mentioned, may be expected to increase with an increase of depth of water in the reservoirs, and to become less with the lapse of time.



Effect of Depth and of Sediment on Loss cf Water from Reservoirs.
Observations under J. C. Trautwine, Jr., 1897–98.

The observations reported were during the winter, with the surface of the lakes nearly stationary, and do not show the effect of variation in depth. Several cases, where the loss has been measured from canals, show that the loss increases with the depth of water in the canal, but the loss seems to be greater than shown from theoretical considerations. From Darcy's experiments the writer deduces an expression for the leakage through embankments, which seems to be proportional to the square root of the cube of the depth. Much of the loss may take place through the bottom, and this would tend to make the leakage increase at a higher rate.

Through the courtesy of John C. Trautwine, Jr., Chief of the Bureau of Water, Philadelphia, I am enabled to quote some recent and valuable observations on one of the reservoirs belonging to that city, and which clearly show the effect of increased depth. The Queen Lane reservoir has considerable trouble on account of leakage, and during the summer of 1897 had been lined with asphalt, the lining being completed August 16th.

The diagram shows the observations at different depths, the two curves representing the losses before and after partially silting the reservoir by pumping into the reservoir water laden with anthracite coal dust.

November, 1897. (Before Silting.)		March, 1898. (After Silting.)	
Depth.	Loss per Day.	Depth.	Loss per Day.
15 feet.	.29 inches.	20 feet.	.15 inches.
20 feet.	.54 inches.	25 feet.	.24 inches.
....	....	28 feet.	.32 inches.
....	....	30 feet.	.46 inches.

These observations show in both cases a more rapid increase in the leakage with depth than would seem to be indicated by the uncertain theory.

That a portion of the rapid increase is due to some change in the conditions is shown by still more recent observations. Under date of April 7th, Mr. Trautwine adds that observations, extending over ten days, with a nearly constant head of about 30 feet, have shown an increase in the daily loss to .55 inch.

Since that date the reservoir has been drawn down to 20 feet, and under date of April 16th, Mr. Trautwine writes that the average daily loss at that depth for eleven days was .28 inch, or about double the amount shown in March.

These interesting facts would seem to show that the conditions remaining the same, the effect of an increase in leakage due to an increase in depth, would be at a much less rapid rate than indicated in the curve shown.

As an explanation of the increase in rate with increased depth, and the continued increase after the depth is reduced, Mr. Trautwine suggests that there may be a velocity of percolation at which the sediment-bearing water ceases to deposit its sediment in the pores and begins to carry away that which has already been deposited, thus permitting an increase under large heads with time.

EVAPORATION.

§ 18. The following table shows the amount of evaporation that has been observed from our standard tank during the past eleven years. The tank is of galvanized iron, three feet square, originally two feet deep, but since 1889, three feet deep. During the summer months, the height of the water is measured by the hook gage to the nearest thousandth of a foot, twice daily. After September, darkness interferes with the observation at 7 p. m. and readings are made only at 7 a. m. After ice forms the tank is undisturbed except at the beginning of the month. The ice is then loosened from the sides of the tank, and the elevation of the water surface, which is then the same as if the floating ice were melted, is measured. Ice sometimes forms of considerable thickness, and punctures in separating it from the sides have caused the loss of the record for several months. The rainfall is measured by standard gages near the tank. The amount given as the evaporation, is the loss from the water surface after allowing for the rainfall, or is the fall of the surface plus the rainfall. The amounts here given are subject to slight corrections, as critical examination may cause the rejection of some days of heavy showers.

TABLE IV.—EVAPORATION FROM WATER SURFACE.

Tank 3x3x3 feet, flush with ground, at Fort Collins, Colorado. Elevation 4,990 feet above sea level: latitude 40° 34', longitude 105°. Amounts are given in inches.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1887........	2.46	3.23	4.60	5.55	5.19	5.75	5.23	4.24	4.12	3.26	1.48	1.60	46.71
1888........	....	....	....	....	4.45	7.70†	7.00†	4.06	3.94	2.17	1.35	.99	.....
1889........	1.08	1 03	2.75	4.06	3.72	4.34	5.20	5.15	5.19	3.28	.62	1.42	37.84
1890........	.86	2.36	3.48	3.50	4.32	5.71	5.44	5.76	3.69	2.71	1.32	1.10	40.25
1891........	1.89†	1.90	2.23	2.24	5.03	4.97	5.72	4.91	4.12	3 62	1.74	.75	39.12
1892........	2 51	2.15‡	2.78	3.58	3.49	4.20	4.69	5.64	5.11	3.33	1.93	1.13	40.54
1893........	p.	1.52*	3.79	5.40	5.12	6.12	6.41	4.73	5.04	3.79	1 05	1.38	.....
1894........	1.14†	1.15†	1.95	4.61	4.66	5.01	5.74	4.88	3.77	3.75	1.64	1.22	39.52
1895........	1.19†	1.19†	p	4.91	4.27	4.13	4.57	4.52	4.06	2.24	1.53	1.68	.....
1896........	2.64	2.25	2.39	4.71	5.91	5.09	5.23	5 80	3.34	2.94	1.62	1.25	43.17
1897........	1.80	2.20	p.	3.33	4.13	4.26	4.64	4.76	3.97	2.88	1.47	.94	.....
Average....	1.73	1.90	3.00	4.19	4.57	5.21	5.44	4.95	4.21	3.09	1.43	1.22	40.94

* Record from part of month.
† Deduced from loss in two months.
‡ From record from February 17.
p. Tank punctured, record lacking.

§ 19. As the temperature of the water is an important factor in the amount of evaporation, the average temperature of the water for the corresponding time is given in Table 5. The temperature given is the mean of the surface temperatures at 7 a. m. and 7 p. m. The maximum and minimum temperatures at the surface have also been taken by self-recording instruments in the water in early spring or late fall. Their record is not so complete and is not given here. The average derived from the 7 a. m. and 7 p. m. observations, as shown by hourly readings, is lower than the average temperature of the tank by about 3.5°. The difference is due to the fact that while heating, the surface heats rapidly and the lower layers slowly. But in cooling, the whole mass of water cools. The mean of the maximum and minimum temperatures is much closer to the true average temperature.

TABLE V.—MEAN TEMPERATURE OF WATER IN EVAPORATION TANK.

Surface temperatures. Average of 7 a. m. and 7 p. m.

NOTE—The means thus found are less than the true average by 3 or 4 degrees.

Year.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1887	....	....	46.6	49.5	62.3	69.8	73.0	71.5	64.7	59.0	38.9	....
1888	....	....	....	....	....	....	....	....	....	....	...	....
1889	....	....	....	....	....	66.6	72.0	70.5	61.1	52.7	....	....
1890	....	....	....	....	58 9	68.4	75 1	69.9	62.0	49.0	....	....
1891	....	....	....	....	59.4	68.5	74.1	70.5	64.3	50.8	43.1*	....
1892	....	....	....	46.7	54.4	66.9	71.8	70.0	63.2	49.5	....	....
1893	....	....	....	47.0	55.5	68.9	73.9	70.3	63.2	49.0	....	....
1894	....	....	....	49.9	59.8	67.7	73.0	71.8	63.1	51.1	42 8†	....
1895	....	....	....	50.4	59.4	65 6	69.4	70.7	62.8	48.1	....	....
1896	....	....	....	51.1	58.9	69.6	74.1	71.4	63.3	50.9	....	....
1897	....	....	....	48.2	61.4	66.6	70.9	71.4	66.4	51.5	....	....
Average	....	....	....	49.0	58.9	67.9	72.7	70.8	63.4	51.2	41.6	

* First fifteen days.
† First thirteen days.

§ 20. Observations have also been made on the evaporation from reservoirs. Tanks one foot square and eighteen inches high were used and floated by pontoons, and filled with water to 3 or 4 inches from the top. It was intended to maintain the water in the tank at the same level as the water on the outside. In order to break the waves the whole was surrounded by a triangular float of boards, which was anchored so that the angle would face the waves and prevent them washing into the tank. The device was not always completely successful in this respect. At times boys interfered with the tanks. Observations were carried on for several years in Warren's lake, but the interference was so great the observations at that place were abandoned. For the last two years tanks were placed in other lakes, convenient of access, and chosen because the lakes were partially closed to the public and the observations less likely to be interfered with.

§ 21. The lakes used in 1896 and 1897 were Lee's lake, Loomis lake and Claymore lake.

The Lee lake is a small reservoir owned by Dr. E. A. Lee of Fort Collins, and situated about four miles from the College. The lake is shallow and exposed to the wind. Weeds grow freely in the lake, and late in summer form a mass which is difficult to pass through, and greatly hinders the formation of waves. The water has varied from about six to ten feet in depth during the season.

Loomis or Sheldon lake is the same as previously mentioned in the observations on loss from seepage. It is a little over a mile west of the College. The depth has varied from five to ten feet. This lake is free from weeds.

Claymore lake is situated six miles northwest of the College and close to the ridge of Dakota sandstone which rises immediately from the water on the west side. The lake is a reservoir connected with the Pleasant Valley and Lake Canal. The ridge of sandstone to the west rises at an angle of about 20° and to the height of 400 feet. This ridge interferes with the wind slightly, but because of the downward movement of most of the west winds, it lessens the evaporation very little, if any. This lake is the largest of the three on which observations were taken. The depth of water has varied from 6 to 15 feet. There have been few or no weeds observed, but floating plant life has been abundant.

METHODS OF OBSERVATION.

§ 22. The observations were made weekly in 1896 and semi-weekly in 1897. The distance to the surface of the water in the tank was measured by placing a rule across the top of the tank and measuring down to the surface of the water by a rule graduated to tenths of inches, a rule such as is used in rain gages being used. In order to eliminate the effect of tipping the tank when grasped by the observer, the readings were made at two opposite sides or at the center of the tank. The tanks were filled to two or three inches from the rim and evaporation allowed to proceed until the water had fallen to three to five inches, then again filled from the lake. The measurements cannot be considered as exact, but the error is nearly eliminated in the differences.

RAINFALL.

§ 23. The rainfall as given in the table is that observed at the Agricultural College. The lakes are several miles distant. At times the rainfall is undoubtedly greater or less than that observed at the College. Gages were placed on the floats, but as they could be read only once or twice weekly, the rain record at the College, where the observations are made twice daily, is used instead. The greatest difference is found on days of local thunder storms in July and August, but in only a few cases is there any material difference.

§ 24. The temperature of the surface of the water in the tank, of the surface of the lake, and of the bottom of the lake, was taken. To obtain the temperature at the lake bottom, a sampling instrument was used. This consisted of a brass cylinder with valves at top and bottom, arranged to open as the cylinder descended in the water, and open as it rose. By churning the instrument up and down in the water it was easy to fill it with a sample of water from any desired depth, and bringing the instrument rapidly to the surface, the temperature was immediately taken. It will be noticed that the bottom of the lake is cooler than the surface, as was to be expected. Table 6 shows the changes during the day at the bottom and surface of Lee lake, the measurements being made at fifteen minute intervals for eight hours. From hourly observations on the smaller evaporation tanks at the College, there is reason to believe that late at night the bottom and surface become of the same temperature, and that at times the bottom is warmer than the surface.

To show the changes in the temperature of a lake during the day the following observations are given. They were made Aug. 6, 1896, on the Lee lake, by Mr. R. E. Trimble:

TABLE VI.

Hour of Observation.	Clouds, in Tenths.	Wind.	Temperature of Water.		
			Tank.	Lake Surface.	Lake Bottom.
9 : 00 a. m.	....	....	71.0	70.2	68.8
9 : 15 a. m.	Few	....	72.0	70.5	68.2
9 : 30 a. m.	Few	Light S. E.	72.0	70.7	68.0
9 : 45 a. m.	Few	Light S E.	72.0	71.2	67.7
10 : 00 a. m.	Few	East.	72.0	71.0	68.0
10 : 15 a. m.	1	....	72 8	71.7	68.8
10 : 30 a. m.	1	Light S. E.	73.3	72.2	69.0
10 : 45 a. m.	2	Light S. E.	74.0	72.9	68.6
11 : 00 a. m.	2	Light S. E.	74.0	73 0	68.5
11 : 15 a. m.	3	Light S. E.	74.0	73.0	68.2
11 : 30 a. m.	3	Light S. E.	73.2	72 9	68.5
11 : 45 a. m	3	Light S. E.	74.0	73.1	69.1
12 : 00 p. m.	2	Light S. E.	74.2	73.2	69.2
12 : 15 p. m.	2	Light S. E.	74.8	74.0	68.8
12 : 30 p. m.	2	Light S. E.	74.4	74 0	68.8
12 : 45 p. m.	3	Light S. E.	74.5	74.2	69.1
1 : 00 p. m.	4	Light S. E.	74.0	73.9	68.3
1 : 15 p. m.	6	... .	74.2	74.2	68.7
1 : 30 p. m.	7	Brisk N.	73.8	73.8	69.1
1 : 45 p. m.	5	Light E.	74.0	74.0	69.4
2 : 00 p. m.	4	Light S.	74.9	74.7	69.8
2 : 15 p. m.	3	W.	75.7	76.0	69.4
2 : 30 p. m.	2	W.	75.5	76.0	69.5
2 : 45 p. m.	2	....	76.0	77.0	70.0
3 : 00 p. m	1	S. E.	76.6	77.2	69 3
3 : 15 p. m.	2	S. E.	76.2	76.4	69.8
3 : 30 p. m.	2	S. E.	76.2	76.0	69.0
3 : 45 p. m.	2	S. E.	76.0	76.0	69.3
4 : 00 p. m.	1	S. E.	76.0	76.0	68.8
4 : 15 p. m.	2	E.	75.8	76.0	68.2
4 : 30 p. m.	3	None	76.0	76.2	69.0
4 : 45 p. m.	5	N.	75.6	76.7	68.7
5 : 00 p. m.	....	....	75.5	76.8	68.6

The temperature of the surrounding lake was taken to detect whether the tank caused any material change in the temperature of the water in the tank. The difference is slight, and in that respect, the small tanks seem to affect the temperature less than larger tanks. The water in the tank was sometimes warmer than the surrounding lake, occasionally as much as 3° to 5°, but usually less than 1°. The consequence of this increase in temperature is to increase the evaporation, and therefore the amounts measured may be considered slightly greater than evaporation from the lake itself.

§ 25. The wind record is from the anemometer at the Experiment Station of the Agricultural College. The anemometer at that point is exposed on a tower sixty feet from the ground, but with trees, not in all directions, at a moderate distance. The supposition that this record represents the wind at the lakes is subject to the same uncertainties as the similar use of the rain record. The error cannot be great. In the present discussion the wind is not used in the comparison, but is given to exhibit the conditions. The effect of the wind is to increase the amount of evaporation by bringing unsaturated air in contact with the water, and to give opportunity for the diffusion of the water vapor. From the working formula derived from the observations in 1889, each mile of wind increased the evaporation by about 2 per cent. Mr. Fitzgerald's experiments at Boston, indicate an increase of 2 per cent for each mile of wind. The amounts are to be taken subject to investigations since made. A reduction of the observations made at this place during the past ten years should give a more satisfactory and useful formula than that mentioned in the Annual Report of the Experiment Station for 1891. High winds may affect the record by blowing spray into the tank, notwithstanding the protecting shelter. The greatest velocity between the different observations is given. Heavy rainfalls may introduce uncertainties also.

The observations on Claymore lake for three months in the summer of 1897 have not been used, because it was found that a leak existed in the tank, and the record involving nearly thirty trips to the lake is rejected. The record from August 21 to November, after the tank was repaired, is given, as also a few weeks in May.

EXPLANATION OF THE TABLES.

§ 26. The column giving the net loss gives the depression of the water surface observed in the period given in the second column. The rain during the same period as measured at the Agricultural College at Fort Collins, is given in the next column. The total loss is the sum of the loss observed in the lake, increased by the amount of rainfall which has fallen in the meantime, or is the sum of the two preceding columns.

TABLE VII.—EVAPORATION OBSERVATIONS, LEE'S LAKE.—1896.

Date.	No. of Days Interval.	Temperature of Water. Degrees, Fahrenheit. In Tank.	At Surface of Lake.	At Bottom of Lake.	Wind—Miles. Av. Movement per 24 hrs.	Maximum hourly Velocity.	Fall of Water Surface since Previous Obs.	Rainfall at College since Previous Obs.	Total Loss since Previous Obs.	Average Loss per Day.	Remarks.
——— June 15.....	..	76.0	76.0	....	....	....	....	....	....	....	Put tank in lake.
9 : 20 a. m. June 17.....	2	75.5	73.7	....	113*	48	.50	T	.50	.250	
4 : 10 p. m. June 20.....	3	75.8	75.8	....	160	30	1.60	T	1.60	.533	
1 : 15 p. m. June 24....	4	73.5	73.5	70.0	166	30	.20	.70	.90	.225	Rain gage at lake, 0.65 inches.
9 : 05 a. m. June 30.....	6	72.5	72.5	69.0	126	40	−.20	.36	.18	.030	Rain gage at lake, 0.62 inches.
3 : 45 p. m. July 3....	3	75.3	75.3	71.0	151	16	.90	T	.90	.300	Rain gage at lake, 0.02 inches.
9 : 30 a. m. July 7.....	4	76.0	....	72.0	122	12	1.00	.03	1.03	.258	Rain gage at lake, 0.02 inches.
9 : 30 a. m. July 8.....	1	76.0	75.8	72.0	105	7	.20	T	.20	.200	Rain gage at lake, 0.02 inches.
4 : 00 p. m. July 11.....	3	83.0	83.5	76.0	113	13	1.30	0	1.30	.433	
9 : 20 a. m. July 14.....	3	75.0	74.8	73.0	146	17	.90	0	.90	.300	
10 : 40 a. m. July 18.....	4	74.0	73.7	71.0	156	17	1.05	.28	1.33	.332	Rain gage at lake, 0.10 inches.
9 : 00 a. m. July 21.....	3	73.0	73.0	70.5	152	14	.70	.37	1.07	.357	Rain gage at lake, 0.13 inches.
9 : 50 a. m. July 28.....	7	74.0	71.0	68.8	126	21	−.60	2.30	1.70	.243	Rain gage at lake, 3.84 inches.
3 : 25 p. m. August 1..	4	79.0	79.0	70.0?	126	20	.90	.07	.97	.242	
9 : 30 a. m. August 4..	3	72.0	70.8	69.0	136	15	.80	0	.80	.267	
5 : 00 p. m. August 6..	2	75.5	76.8	68.6	147	24	.85	T	.85	.425	
3 : 15 p. m. August 8..	2	74.0	74.2	71.2	176	15	.25	0	.25	.125	Rain gage at lake, T.
9 : 00 a. m. August 11..	3	65.8	66.2	64.2	202	22	1.45	0	1.45	.483	
4 : 45 p. m. August 15..	4	71.5	72.0	67.2	150	17	.85	.02	.87	.217	Rain gage at lake, 0.02 inches.
9 : 00 a. m. August 18..	3	....	....	....	139	17	.40	0	.40	.133	Rain gage at lake, 0.20 inches.
3 : 45 p. m. August 22..	4	67.2	67.5	65.9	136*	17*	−1.35	2.02	.67	.168	Rain gage at lake, 1.90 inches.
9 : 40 a. m. August 25..	3	65.8	66.0	64.2	124	18*	.60	.02	.62	.207	
3 : 00 p. m. August 29..	4	74.6	74.8	65.8	119	17	.60	0	.60	.150	
9 : 30 a. m. Sept. 1....	3	70.2	70.8	66.2	111	16	.60	.14	.74	.247	
3 : 35 p. m. Sept. 5....	4	74.0	74.2	65.6	157	15	.90	.04	.94	.235	Rain gage at lake, 0.06 inches.
9 : 35 p. m. Sept. 8....	3	65.0	65.2	63.9	148	20	1.30	0	1.30	.433	From this on the rain gage at lake was so near the water that waves washed water in.
3 : 30 p. m. Sept. 12....	4	69.8	69.0	59.6	124	14*	−.10	.48	.38	.095	
10 : 00 a. m. Sept. 15....	3	67.6	66.8	61.8	112	....	.40	0	.40	.133	It seemed to rain more west of town.
9 : 15 a. m. Sept 22....	7	60.2	60.2	58.0	140	19*	.20	.55	.75	.107	
3 : 00 p. m. Sept. 26....	4	58.0	58.0	55.0	195	24	.30	.47	.77	.192	
9 : 50 a. m. Sept. 29....	3	58.0	57.8	56.0	118	10	.30	.01	.31	.103	
3 : 30 p. m. Oct. 3.....	4	56.0	55.8	59.8	113	9	.70	0	.70	.175	
9 : 00 a. m. Oct. 5.....	2	57.7	57.5	56.0	144	13	.20	0	.20	.100	
12 : 00 m. Oct. 13. ...	8	54.8	54.8	52.0	149	19*	1.30	.02	1.32	.165	Wind blowing.
3 : 30 p. m. Oct. 17.....	4	57.5	56.3	54.2	140	15*	1.20	0	1.20	.300	
10 : 45 a. m. Oct. 20.....	3	55.2	54.0	52.2	133	12	.20	0	.20	.067	
3 : 05 p. m. Oct. 24.....	4	52.0	52.0	51.8	133	12	.30	.28	.58	.145	
10 : 15 a. m. Oct. 27.....	3	49.0	48.8	48.2	124	15	.30	0	.30	.100	
3 : 00 p. m. Oct. 31.....	4	44.8	44.2	42.2	256	26	−.10	.19	.09	.023	

* Days when electrical recorder was out of order. Some estimates included.

TABLE VIII.—EVAPORATION OBSERVATIONS, LEE'S LAKE.—1897.

DATE.	No. of Days' Interval.	Temperature of Water. Degrees, Fahrenheit. In Tank.	At Surface of Lake.	At Bottom of Lake.	Wind—Miles. Av. Movement per 24 hrs.	Maximum hourly Velocity.	Fall of Water Surface since Previous Obs.	Rainfall at College since Previous Obs.	Total Loss since Previous Obs.	Average Loss per Day.	REMARKS.
11:30 a. m. May 8.....	..	57.0	57.0	....	....	....	....	....	....	....	Put tank in lake.
9:20 a. m. May 11.....	3	60.8	59.7	59.2	188	30*	0	.10	.10	.033	
9:15 a. m. May 18.....	7	67.8	66 8	65.7	148	20*	1.50	.04	1.54	.220	Shower before measuring.
3:45 p. m. May 22.....	4	71.4	71.2	69 8	143*	22*	-1.10	1.50	.40	.100	
9:30 a. m. May 25.....	3	74.0	68.6	66.8	161*	19*	.60	.04	.64	.213	A few waves.
3:20 p. m. May 28.....	3	68 8	67.4	64.6	136*	18*	.20	.21	.41	.137	
9:00 a. m. June 1....	4	....	....	....	142*	17*	-.10	.35	.25	.062	No thermometer.
3:40 p. m. June 4....	3	64.0	63.8	64.0	144	14	3.00	.63	(3.63)	....	A few waves.
9:45 a. m. June 8....	4	72.8	65.2	64.5	121	11	.30	.39	.69	.172	
10:00 a. m. June 11....	3	64.5	64.5	64.6	184	29	1.90	.10	2.00	.067	
9:25 a. m. June 15....	4	72.0	71.2	70.6	114*	11*	4.70	0	(4.70)	....	
9:15 a. m. June 18....	3	66.5	66.3	65.8	233*	27*	1.00	0	1.00	.330	Pulled ashore and nailed on boards so would
9:00 a. m. June 22....	4	72.5	72.5	72.0	119	20	.70	.11	.81	.202	float higher.
10:00 a. m. June 25....	3	68.5	69.9	69.4	149	14	.90	.28	1.18	.393	A few waves.
9:35 a. m. June 29....	4	73.5	71.5	71.7	185	14	1.00	T	1.00	.250	
9:40 a. m. July 2.....	3	75.0	73.5	73.0	129	16	-.10	.05	-.05	....	
9:40 a. m. July 6.....	4	70.5	69.5	69.8	193	25	1.30	0	1.30	.325	A few waves.
2:10 p. m. July 9.....	3	71.8	71.3	71.0	136*	19*	-.40	1.18	.78	.260	
9:50 a. m. July 13.....	4	80.0	75.5	76.0	109*	10*	2.00	.32	(2 32)	....	
4:25 p. m. July 16.....	3	75.0	74.8	73.5	138	12	.90	0	.90	.300	Put rain gage on float.
10:25 a. m. July 20.....	4	68.5	67.0	66.3	141*	16*	.10	.89	.99	.247	Rain record at lake, .74 inches.
9:35 a. m. July 23.....	3	72.5	71.3	71.3	122*	9*	.70	0	.70	.233	Rain record at lake, 0.
9:45 a. m. July 27.....	4	73.1	71.2	71.6	133	18	.90	.21	1.11	.278	Rain record at lake, .19 inches.
9:30 a. m. July 30.....	3	75.0	73.0	72.1	121	22	-.90	0	-.90	....	
10:05 a. m. Aug. 3....	4	73.1	71.6	72.0	142	24*	.80	.06	.86	.215	Rain record at lake, .33 inches.
9:25 a. m. Aug. 6....	3	73.8	71.6	70.3	97	9*	.20	.37	.57	.190	Rain record at lake, .43 inches.
9:50 a. m. Aug. 10....	4	75.0	72.5	71.1	107	8*	.40	.53	.93	.233	Rain record at lake, .34 inches.
11:30 a. m. Aug. 13....	3	74.8	73.7	72.5	100	14	.85	.03	.88	.293	Rain record at lake, T.
10:00 a. m. Aug. 17....	4	74.0	72.9	71.0	103	13	1.00	T	1.00	.250	
9:30 a. m. Aug. 20....	3	69.8	69.2	68.2	116	10	.85	.67	1.52	.507	Rain record at lake, .13 inches.
9:30 a. m. Aug. 24....	4	69.9	68.8	68.0	120	11	1.20	0	1.20	.300	Rain record at lake, 0.
9:40 a. m. Aug. 27....	3	69.9	68.7	67.7	131	11	.85	T	.85	.283	Rain record at lake, 0.
9:30 a. m. Aug. 31....	4	71.5	69.0	67.2	138	22	.95	.13	1.08	.270	Rain record at lake, .08 inches.
10:30 a. m. Sept. 6....	6	71.0	70.8	67.0	99*	12*	1.10	0	1.10	.183	Rain record at lake, 0.
9:30 a. m. Sept. 11....	5	65.0	66.0	....	129*	16*	1.70	.01	1.71	.342	
4:30 p. m. Sept. 22....	{ 11	71.0	72.4	60.0	115*	19*	....	.74	{	{	Rain gage full of water.
9:45 a. m. Oct. 1.....	{ 9	63.6	63.9	62.0	97	12*	4.85	T	5.59	.280	
10:00 a. m. Oct. 19.....	18	49.0	47.5	45.8	131*	28*	2.50	.49	2.99	.166	
1:35 p. m. Oct. 27.....	8	46.7	46.5	....	182*	27*	.20	.26	.46	.058	
9:30 a. m. Nov. 2.....	5	47.0	45.0	43.2	193	19*	1.30	0	1.30	.260	
9:45 a. m. Nov. 11.....	....	....	....	....	....	....	....	....	....	....	Hole shot into pontoon.

* Electrical register out of order for portion of period.

TABLE IX.—EVAPORATION OBSERVATIONS, LOOMIS LAKE.—1897.

Date.	No. of Days Interval.	Temperature of Water. Degrees, Fahrenheit. In Tank.	At Surface of Lake.	At Bottom of Lake.	Wind—Miles. Av. Movement per 24 hrs.	Maximum hourly Velocity.	Fall of Water Surface since Previous Obs.	Rainfall at College since Previous Obs.	Total Loss since Previous Obs.	Average Loss per Day.	Remarks.
11 : 00 a. m. May 12.....	..	61.0	61 0	58.2	....	....	....	....	....	....	Put tank in lake.
9 : 45 a. m. May 19.....	7	67.8	65.0	62.8	146	22*	1.65	.04	1.69	.241	
2 : 25 p. m. May 22.....	3	67.5	69.0	66.0	141*	22*	-.60	1.50	.90	.300	
3 : 00 p. m. May 25.....	3	68.8	68.7	68.0	159*	19*	.80	.04	.84	.280	
2 : 30 p. m. May 28.....	3	57.2	57.0	62.5	148*	18*	.50	.21	.71	.237	
2 . 30 p. m. June 1....	4	....	....	....	132*	17*	.60	.35	.95	.238	
2 : 15 p. m. June 4....	3	63.3	63.2	63.0	138	14	.20	.63	.83	.277	
3 : 30 p. m. June 8....	4	69.8	69.0	63.7	121	11	.30	.39	.69	.172	
9 : 50 a. m. June 11....	3	63.0	63.0	62.2	172	29	2.30	.10	(2.40)	(.800)	
4 : 00 p. m. June 15....	4	71.0	71.0	65.5	119*	11*	1.10	0	1.10	.275	
2 : 45 p. m. June 18....	3	67.3	67.0	66.2	238*	27*	2.20	0	(2.20)	(.733)	
3 : 00 p m. June 22....	4	76.5	75.0	69.0	114	20	1.10	.11	1.21	.302	
9 : 05 a. m. June 25....	3	67.3	67.5	68.6	150	11	.60	.28	.88	.393	
4 : 10 p. m. June 29....	4	75.0	75.5	71.5	138	14	1.40	T	1.40	.367	
12 : 00 m. July 2.....	3	72.0	71.5	71.0	133	19	.70	.05	.75	.250	
3 : 25 p. m. July 6.....	4	....	.. .	....	192	25	....	0	....	...	
11 : 00 a. m. July 9.....	3	....	....	...	167*	19*	....	1.18	....	....	
10 : 00 a. m. July 14.....	5	....	72.0	71.0	116*	12*	....	.32	....	....	
8 : 45 a. m. July 16.....	2	72.5	71.3	69.0	126	12	.90	0	.90	.450	
3 : 20 p. m. July 16.....	½	75.5	74.5	69.3	165	10	.20	0	.20	.400	
9 : 00 a. m. July 20.....	3½	66.8	65.2	66.0	142*	16*	.30	.89	1.19	.297	Rain record at lake, .69 inches.
8 : 45 a. m. July 23.....	3	69.5	69.0	67.0	123*	7*	.70	0	.70	.233	
8 : 50 a. m. July 27.....	4	69.5	69.3	69.1	133	18	1.40	.21	1.61	.402	Rain record at lake, .15 inches.
8 : 40 a. m. July 30.....	3	70.5	70.2	70.3	122	22	1.80	0	1.80	.600	
9 : 10 a. m. Aug. 3....	4	71.5	71.0	69.8	143	24	1.20	.06	1.26	.315	Rain record at lake, .08 inches.
8 : 40 a. m. Aug. 6....	3	72.3	71.2	69.8	97	9*	.10	.37	.47	.157	Rain record at lake, .22 inches.
9 : 00 a. m. Aug. 10....	4	72.5	71.7	70.1	108	11*	.50	.53	1.03	.258	Rain record at lake, .49 inches.
12 : 45 p. m. Aug. 13....	3	73.3	73.6	72.8	108	14	1.00	.03	1.03	.343	Rain record at lake, .02 inches.
9 : 15 a. m. Aug. 17....	4	71.8	70.7	70.3	119	13	1.15	T	1.15	.288	Rain record at lake, T.
8 : 45 a. m. Aug. 20....	3	70.0	68.8	67.2	117	11	.60	.67	1.27	.423	Rain record at lake, .22 inches.
8 : 40 a. m. Aug. 24....	4	69.3	69.2	68.2	119	11	1.20	0	1.20	.300	Rain record at lake, 0.
8 : 45 a. m. Aug. 27....	3	68.0	68.1	67.9	131	11	.90	T	.90	.300	Rain record at lake, .04 inches.
8 : 45 a. m. Aug. 31....	4	68.8	68.2	67.2	138	22	1.00	.13	1.13	.282	Rain record at lake, .09 inches.
5 : 30 p. m. Sept. 22....	22	68.0	68.2	68.9	120	19*	....	.73	....	....	Rain gage, considerable water in.
6 : 00 p. m. Sept. 26....	4	66.4	66.2	62.7	110*	9*	-.75	0	-.75	-.187	Rain record at lake, .01 inches.
8 : 50 a. m. Oct. 1.....	5	63.5	64.0	63.2	101*	12*	2.20	T	2.20	.440	Rain record at lake, T.
9 : 10 a. m. Oct. 19.....	18	47.0	47.3	46.8	136*	28*	2.80	.49	3.29	.183	Rain record at lake, .46 inches.
1 : 55 p. m. Oct. 27.....	8	46.5	45.5	....	181*	27*	- 20	.26	.06	.008	Rain record at lake, .32 inches.
1 : 30 p. m. Nov. 2....	6	50.0	45.5	45.5	161	19*	1.70	0	1.70	.283	
4 : 00 p. m. Nov. 11....	9	42.5	42.5	41.6	244	75	....	.04	....	....	Storm drove ashore and upset; put out again.
3 : 35 p. m. Nov. 18....	7	42.0	41.0	40.0	130	19	.05	.34	.39	.056	

* Electrical recorder out of order for portion of period.

TABLE X.—EVAPORATION OBSERVATIONS, CLAYMORE LAKE.—1897.

DATE.	No. of Days Interval.	Temperature of Water. Degrees, Fahrenheit. In Tank.	At Surface of Lake.	At Bottom of Lake.	Wind—Miles. Av. Movement per 24 hrs.	Maximum hourly Velocity.	Fall of Water Surface since Previous Obs.	Rainfall at College since Previous Obs.	Total Loss since Previous Obs.	Average Loss per Day.	REMARKS.
12 : 00 m. May 1.....	.	59 2	59.2	....	....	....	....	....	....	....	Tank put in lake.
9 : 55 a. m. May 4.....	3	63.0	58.0	....	206	26	.63	0	.63	.210	
1 : 10 p. m. May 11.....	7	62.0	60 4	58.2	181	30*	1.52	.10	1.62	.231	
1 : 25 p. m. May 18.....	7	67.5	65.5	63.3	150	20*	–.10	.04	(–.06)	–.009	
3 : 45 p. m. May 22.....	4	71.4	71.2	69.8	131*	22*	–1.30	1.50	.20	.050	Waves on lake. Shower before measuring.
10 : 00 a. m. Aug. 21....	..	68.2	68.2	....	....	....	....	0	....	....	
12 : 30 p. m. Aug. 24....	3	74.8	70.3	69.3	123	11	1 15	0	1.15	.383	Rain record at lake, .14 inches.
10 : 20 a. m. Aug. 27....	3	72.0	69.0	67.6	131	11	.60	T.	.60	.200	Rain record at lake, .01 inches.
1 : 00 p m. Aug. 31....	4	74 0	70.0	68 8	137	22	1.00	.13	1.13	.282	Rain record at lake, .16 inches.
11 : 30 a. m. Sept. 6....	6	73.0	70.0	67.3	121*	12*	1.00	0	1.00	.167	
5 : 45 p. m. Sept. 11....	5	71.0	71.0	67.0	129*	16*	1.25	.01	1.26	.252	Rain record at lake, .04 inches.
2 : 40 p. m. Sept. 21....	10	65.0	67 0	62.0	119*	19*	–1.05	.74	(–.31)	....	Rain gage filled by water from lake
10 : 40 a. m. Oct. 1.....	10	64.2	64.6	61.9	105	8*	.90	T.	.90	.090	Rain record at lake, .06 inches.
1 : 20 p. m. Oct. 19.....	18	54.0	51.0	50.8	143*	28*	.03	.48	.52	.029	Rain gage full of water.
1 : 00 p. m. Oct. 27.....	8	45.0	45.0	....	182*	27*	–1 10	.26	(–.84)	....	Rain gage full of water.
12 : 15 p. m. Nov. 2.....	5	54.0	47.0	45.2	190	19*	....	0	.70	.140	
2 : 30 p. m. Nov 11.....	..	....	....	....	....	....	....	....	....	....	Tank damaged and brought in.

* Days when electrical register was out of order. Some estimates included.

§ 27. A tank similar to those used as a basis of measurement in the lakes already mentioned, was placed in Warren's lake, four miles southeast of the College, floated by pontoons and observed weekly during 1889 and 1890. The lake was a resort for fishing, and the tank was often interfered with, so that the observations were abandoned after the two years experience.

TABLE XI.

1889.	No. Days.	Temperature. Degrees, Fahrenheit.	Loss—Inches.	Rain at College—Inches.	Total Loss—Evaporation—Inches.	Loss per Day—Inches.
June 25 to July 11	16	72—74	2.65	.40	3.05	.19
July 11 to July 19	8	74—74	1.31	.39	1.70	.21
July 19 to July 27	8	74—73	2.50	.50	2.50	.31
July 27 to August 1	5	74—72	1.56	0	1.56	.31
September 4 to September 9	5	66—68	1.34	0	1.34	.27
September 9 to September 20	11	68—62	2.39	.28	2.67	.24
September 20 to September 28	8	62—60	1.86	.10	1.96	.25
September 28 to October 4	26	60—59	1.28	0	1.28	.21
October 4 to October 17	13	59—54	1.46	.44	2.00	.15
October 17 to October 25	8	54—52	1.92	.02	1.94	.24

TABLE XII.

1890.	No. of Days.	Temperature. Degrees, Fahrenheit.	Loss—Inches.	Rain at College—Inches.	Total Loss—Evaporation—Inches.	Loss per Day—Inches.
April 30 to May 6	6	57	.86	.40	1.26	.21
May 25 to June 1	7	62—66	1.98	0	1.98	.28
June 14 to June 21	7	74	1.90	0	1.96	.28
June 28 to July 5	7	76—74	.83	.42	1.25	.18
July 5 to July 12	7	74—78	1.52	.05	1.57	.22
July 19 to July 26	7	76—79	1.82	.42	2.24	.32
July 26 to August 2	7	79—77	.05	.35	2.40	.34
August 2 to August 9	7	77—72	2.15	.06	2.21	.32
August 9 to August 23	14	72—74	1.13	3.08	4.20	.30
August 23 to September 1	10	74—70	1.40	T	1 40	.14
September 22 to September 26	4	63—62	1.96	0	1.96	.49
September 26 to October 3	7	62	1.73	T	1.73	.25

The observations were taken in the afternoon between 2 and 5 p. m., generally about 3 p. m., or near the highest temperature of the day.

A similar tank was placed in the Arthur ditch where it passes through the College grounds. Observations were taken daily. While not the same as reservoir conditions, it gives data for comparison:

June, 1889	2.89 inches	Record	based on	16	days
July, 1889	4.13 "	"	"	31	"
August, 1889	3.94 "	"	"	21	

§ 28. From the above data we obtain the basis for estimating the evaporation at the same rate for the calendar months:

TABLE XIII.

Lee Lake—1896.			Lee Lake—1897.		
Month.	Evaporation —Inches.	No. Days Record.	Month.	Evaporation —Inches.	No. Days Record.
....	....	..	May	4.31	24
June	6.36	15	June	9.55	21
July	9.11	32	July	8.53	21
August	7.25	31	August	8.61	32
September	5.20	32	September	8.40	31
October	4.17	28	October	4.60	32

Loomis Lake—1897.			Claymore Lake—1897.		
May	7.89	20	May	5.22	14
June	7.91	26	June	....	..
July	11.87	20	July	....	..
August	9.02	32	August	8.93	10
September	....	..	September	4.81	21
October	4.89	32	October	1.62	23

Warren's Lake—1889.			Warren's Lake—1890.		
May	....	..	May	7.71	13
June	....	..	June	8.40	7
July	7.37	37	July	5.41	29
August	....	..	August	8.06	38
September	7.25	30	September	....	..
October	5.61	21	October	....	..

§ 29. It will be noticed that the evaporation from the tanks as given is much greater than the corresponding tank on the grounds of the Agricultural College. This difference is partially but not entirely due to temperature. The tanks in the lakes are more freely exposed to the wind than the standard tank, and this would therefore make a great difference. The tanks are more or less agitated by waves, and in consequence the water surface exposed to the air is larger than the cross section of the tank. A film of water is also left on the metal sides of the tank with every movement, and this is apt to be of higher temperature than the water in the lake or in the tank, and evaporates more rapidly. The influence has been noticed by Mr. Trimble, who made the observations in 1896 and some of those in 1897, and suggested as a cause of some of the excess of evaporation observed from the lakes. The effect may be considerable, but how much is uncertain. The wave action differs in the different lakes. In Lee lake the weeds extend so near the surface that there is little opportunity for wave formation. In the other two lakes the effect is greater. As the wave also increase the area of the surface of the lakes which is exposed to the air likewise, the result is possibly closer to the loss from a lake exposed to the wind than if the tank had been stationary.

§ 30. The effect of such increase of surface may be considerable. We have made no experiments to determine the possible effect. The only ones reported are some by Maurice Aymard, a French engineer stationed in Algeria, whose report on Irrigation in Spain as preliminary to the construction of a reservoir which has but recently been built, is classic in irrigation literature. The observations were carried on for less than four days in 1849. Tanks 20 inches (50cm) in diameter and 2 feet high were made. In one the water was still; in the other an iron disk nearly of the same diameter as the tank, with holes through it, was slowly raised and lowered in the tank. The water passing through the numerous small holes, kept the surface in agitation, something like the surface in small ditches with rapid fall. The loss under these conditions was more than a third more from agitated than from the quiet water, or a loss of 1.66 inches from the quiet water. and of 2.32 from the rough water.*

ESTIMATE OF EVAPORATION FROM RESERVOIR.

§ 31. From the preceding data we may estimate the amount of evaporation under reservoir conditions. Any such estimate is subject to the uncertainties already mentioned, and to the condition that the evaporation may vary much from year to year, and from one body of water to one immediately adjacent. Nevertheless we may make what may be considered a reasonable estimate from the observations.

	Evaporation.		Evaporation.
January	1.5 inches.	July	9.5 inches.
February	2.0 "	August	8.5 "
March	3.5 "	September	6.5 "
April	5.0 "	October	4.5 "
May	6.5 "	November	2.5 "
June	8.0 "	December	1.5 "
Total			59.5 inches.

§ 32. The following are other cases of evaporation which have been observed. On several lakes in California, observations were made in 1879 by J. D. Schuyler, now consulting engineer, of Los Angeles, Cal. They are reported in William Ham Hall's report as State Engineer of California in 1880, and in Physical Data and Statistics of California:

Reeder lake is a narrow lake with wooded shores, water 12 to 15 feet deep. Evaporation pans two by two feet square and one foot deep were used. They were protected from the wind but exposed to the sun. From June 25th to July 11th, a total of sixteen days, the loss was 1.21 inches, or an average of .24 inch per day. The temperature of the water from five observations taken late in the afternoon, varied from 82° to 92°, which would be higher than the average temperature.

In Panama Slough, California, July 9th to August 20th, 1879, a loss of 2.46 inches in a little over seventeen days, was noticed, or an average of .145 inch per day. The temperature of the water was from 64° to 72°.

* Debauve, Manuel de l'Ingenieur, Des Eaux en Agriculture, p. 170. Parrochetti, Manuale pratico di Idrometria, pp. 256-8.

In Kern lake, Mr. Schuyler also made observations from Aug. 4th to Sept. 29th. In a tank near the shore, the daily evaporation was .30 of an inch. In a tank near the shore in a depth of 5 feet of water, the daily loss during the same time was .21 of an inch per day. The temperature of the water as given was the same in each case, and varied from 78° to 88°. About noon the air was considerably warmer. From Oct. 2nd to Dec. 20th, a period of seventy-nine days, evaporation amounted to 9.66 inches from Kern river, Cal. This was determined from weekly observations. The temperature of the water in the pan varied from 55° to 80°. The average daily loss was .12.

At Sweetwater reservoir, near San Diego, California, an evaporation tank was put in place by J. D. Schuyler and has since been continued by and under the direction of H. N. Savage, C. E. The reservoir was visited by the writer in 1891. At that time a circular tank, floated in the lake, was used. A Piche evaporometer was used for comparison. When the pan gave out in 1892, it was not renewed, and the records were made from the Piche instrument until 1897, when Mr. Savage had the pan replaced. As the records with the Piche evaporometer do not show the evaporation from free water surface, they are not used in the table which follows, and only those depending on the records from the tank are given. Mr. Savage has furnished the record up to date.

TABLE XIV.—EVAPORATION FROM SWEETWATER RESERVOIR.

Near San Diego, California. Latitude, 32° 40'; longitude, 117°; elevation, 220 feet.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1889........	1.99	3.34	3.38	4.96	5.82	6.81	8.22	7.26	7.81	4.52	3.96	.95	59.02
1890........	1.59	2.21	3.28	4.14	6.14	7.30	7.38	9.02	6.48	4.92	5.54	1.84	59.84
1891........	3.61	1.35	3.08	3.71	5.60	6.03	6.50	8.89	6.15	6.31	4.10	2.75	58.08
1892........	2.54	1.39	3.08	5.82	4.67	6.48	8.81	6.54	6.27	6.56	4.77	2.61	59.54
1897........	2 12	1.64	2.91	5.99	5.69	7.90	6.25	6.61	5.53	6.27	4.24	3.75	58.90
Mean......	2.37	1.99	3.15	4.92	5 58	6.90	7.43	7.66	6.45	5.72	4.52	2.38	59.07

The water temperature ranged from an average of 80 to 82 degrees, in the warmest month, to 50 degrees, in the coolest.

§ 33. A valuable series of observations is being carried on by H. B. Hedges, C. E., of San Bernadino, Cal., at the Arrowhead reservoir in Little Bear valley. This is at an elevation of 5,160 feet above sea level, and near enough to San Diego to furnish some comparison between the evaporation at those two places and indicating the effect of elevation.

In this case the evaporation was measured in a three-foot pan floated in a concrete basin separate from the reservoir. Measurements are made twice daily at 6 a. m. and 6 p. m. in summer. It will be noticed that the evaporation is much less than at San Diego.

TABLE XV.—EVAPORATION FROM THE ARROWHEAD RESERVOIR.

Little Bear Valley, California. Latitude, 34° 16'; longitude, 117° 11'; elevation, 5,160 feet. By H. B. Hedges, C. E.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1895	....	....	1.12	1.84	5.30	6.60	6.30	6.20	5.05	2.80	1.20	.34	......
1896	.09	.81	.94	3.39	2.86	6.50	5.04	5.50	4.01	4.05	1.28	1.23	35.70
1897	.57	.24	....	3.01	4.75	6.17	7.62	5.17	5.00	4.01	1.24	1.21	......
Average	.33	.53	1.03	4.12	4.30	6.42	6.32	5.62	4.69	3.62	1.24	.93	39.15

§ 34. The following are records of the average evaporation from floating tanks made at Rochester, New York, and at Boston Mass. The former were made under the direction of Emil Kuichling, chief engineer of the water works, and were made in small indurated fiber tubs, about 10 inches in diameter and six inches deep. At Boston the observations were made under the direction of Desmond Fitz-Gerald on the Chestnut Hill reservoir. Those at Rochester are dependent on records from one to five years of the different months, at Boston upon a much longer period. Those at Boston are not the actual means of observation, but the smoothed values determined by the application of Bessell's formula to reduce periodic series:

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Rochester.	.45	.45	.91	2 67	4.05	4.93	5.65	5.28	4.07	3.13	1.50	1.22	34.31
Boston	1.12	1 20	1.81	3.01	4.48	5.55	5.98	5.50	4 20	3.14	2.22	1.50	39.71

THE EFFECT OF ELEVATION ON LOSSES.

§ 35. Are the losses more or less at high elevations? Is it more economical to store water at low or high elevations?

For increase of elevation the evaporation, if the wind conditions are the same, is greatly diminished. Practically the opportunities for storage are confined to basins not over 10,000 feet in elevation, and the question of the evaporation is of most importance for elevations below that height. Observational data are almost entirely lacking. Such observations as have been made are not under the same methods and not strictly comparable.

As far back as 1890, I made attempts to obtain such data and furnished evaporation tanks to several places, distributing some tanks coming from the U. S. Irrigation Survey of 1889–90 and also some new tanks. The highest point was at the U. S. Fish Hatchery near Leadville, at an elevation of nearly 10,000 feet. Few results were obtained except from the sub-stations connected with the College in the San Luis valley and on the Divide, at elevations of 7,600 and 7,200 feet respectively. The other observers were voluntary, and as there were no funds to replace the broken instruments or repair the damaged tanks, the observations were abandoned. In the absence of observations, we may consider the probable effects.

§ 36. We may dismiss the losses from seepage from consideration. They depend upon the character of the site and nothing in the mere elevation would increase or diminish the seepage, unless the lower temperature of the soil should lessen the rapidity of seepage, and this, as shown in Bulletin 33, may be considerable. In general the rock strata are nearer the surface in the mountains and more attention may well be given to the geological characteristics of the site.

§ 37. But elevation has an influence on evaporation, and as evaporation is shown to be of more importance in the cases examined, the effect of elevation on losses will be principally due to its effect on evaporation.

§ 38. The factors controlling evaporation, are:

First—The temperature of the surface of the water, which indicates the limit of the amount of vapor which the air in contact with the water will absorb.

Second—The amount of moisture present in the air. The difference between the moisture corresponding to the temperature of the water surface, and the moisture actually present, is a measure of the additional amount of vapor which the air will take up.

Third—The wind movement.

§ 39. The temperature of the air is decidedly lower at high elevations, though on individual days inversions may occur, and the air be warmer at the high elevations. This is often shown in comparing the observations taken at the College, with those taken by Mr. C. E. Lamb at the foot of Long's peak. This inversion occurs principally in the winter months, between November and April, and has less effect on evaporation than if occurring in the summer.

Taking the records from several places, we find the average temperatures as follows, where the lower temperature with increased altitude is to be noted:

	Latitude.	*Elevation.*	*Av. Temp.*
Agricultural College, Ft. Collins	40° 34′	5,000 ft.	47°.7
Denver	39° 45′	5,300 ft.	49°.5
Colorado Springs	38° 50′	6,100 ft.	47°.2
Lamb's, near Long's Peak	40° 20′	9,100 ft.	37°.0
Pike's Peak	38° 50′	14,147 ft.	19°.4

The difference of 8,000 feet in elevation between Colorado Springs and Pike's peak, causes a difference of 28° in mean annual temperature, equivalent to a difference of 1° for 300 feet rise.

§ 40. The temperature of bodies of water freely exposed to the air will not differ much from that of the air in contact with them. The temperature of the water surface averages higher than the whole body of water, because as the water warms, the heated layers remain on top for temperatures above 39°, while in cooling the water sinks as it cools and the whole mass cools together. Below 39° the colder water remains on the surface. In heating, therefore, above 39° the whole mass is heated, and the increase in temperature is slow, while in cooling the surface cools without the mass of water cooling materially. Hence for temperatures above 39° the surface averages of higher temperature than the body of water, and for temperatures between 32° and 39° it averages lower. In the one case it tends to make the surface warmer than the air, in the other cooler.

In our evaporation tank it is noticeable that the temperature of the surface shows an excess of from 6° to 7° above the air temperatures.

At higher elevations similar differences prevail, and in all probability the differences are nearly the same, though exact observation is lacking. But as the prevailing temperatures are lower, the water temperature is less than the critical temperature of 39° for a greater part of the year than at lower elevations. It seems probable, therefore, that the excess of the water temperature above the air temperature is less than at the lower elevations.

§ 41. But even if more, the evaporation, so far as this factor is concerned, may be less, for as the evaporation seems to vary directly with the difference of vapor pressure corresponding to the temperatures of the water surface and of the air, and as the vapor pressures decrease much faster than the temperatures, the same difference in degrees means a greater difference in vapor pressure, or a greater capacity for moisture at a high temperature than at a low. Thus the table shows the pressure of the water vapor corresponding to the ordinary air temperatures.

Temperature.	*Corresponding Vapor Pressure.*
100 degrees	1.91 inches.
90 "	1.40 "
80 "	1.02 "
70 "	.73 "
60 "	.52 "
50 "	.36 "
40 "	.25 "
30 "	.17 "
20 "	.11 "

From this table a difference of 10° would correspond to a difference of vapor pressure or capacity for moisture:

For 10 Degrees Difference.	*Difference of Vapor Pressure.*
Between 80 and 70 degrees	.29 inches.
" 70 and 60 "	.22 "
" 60 and 50 "	.16 "
" 50 and 40 "	.11 "
" 40 and 30 "	.08 "

Since the evaporation varies directly as this difference of vapor pressure, or, so far as this factor is involved, when the temperature of the water surface is 80°, the evaporation would be $3\frac{1}{2}$ times as fast as when the temperature is 40°, the excess above dew point being 10° in each case.

But at the low temperatures corresponding to high elevations, the dew points are nearer the air temperatures than at higher temperatures. In addition, there is reason to believe that the water temperature is not so much above the air temperatures as at higher temperatures. It is evident that the effect of these conditions is to make the difference of vapor pressures corresponding to the temperature of the water surface, and of the dew point to be less at high elevations than at low, and by so much to reduce the evaporation.

§ 42. On the other hand, the lessened air pressure at the higher elevations is favorable to increased evaporation, the increase in evaporation being proportional to the decreased pressure, and the influence of elevation being to increase the evaporation by the per cent given in the third column. This increase is due to the decreased barometric pressure alone.

Elevations.	*Pressures.*	*Increase in Evaporation Over Evap. at 5,000 Feet.*
5,000 feet	25 inches	00 per cent.
6,000 "	24 "	$3\frac{1}{2}$ "
7,000 "	23.2 "	7 "
8,000 "	22.3 "	11 "
9,000 "	21.4 "	14 "
10,000 "	20.6 "	18 "
11,000 "	19.9 "	20 "
12,000 "	19.1 "	24 "
13,000 "	18.4 "	26 "
14,000 "	17.7 "	29 "

§ 43. Confining these effects to elevations less than 10,000 feet, which is practically the limit of available storage sites, we find that the condition of air and water temperatures materially reduce the evaporation, the decreased barometric pressure increases, and the wind, if greater, would tend to increase it. The effect of lower temperatures is greater than the increasing effect of the barometric pressure and probably greater than the effect of the wind, except in exposed places. And when we take into account the fact that the water is frozen for a much longer period of the year, it is safe to conclude that the evaporation for the year is much less than at lower elevations.

§ 44. The amount of decrease cannot be stated with certainty. An increase in wind increases the evaporation, each mile of wind during the twenty-four hours, increasing the evaporation for that day by from 1 to 2 per cent.; 2 per cent. deduced from Fitz-Gerald's formula from Boston observations,† and nearly 2 per cent. for wind of 5 miles per hour, decreasing to 1 per cent. for each mile at 25 miles per hour, as deduced from Professor Russel's observations; ‡ 2 per cent. from Colorado observations of 1889, by L. G. Carpenter.*

§45. SUMMARY AND CONCLUSIONS.

1. The losses from reservoirs are from seepage and evaporation.

2. The seepage losses are dependent on the condition of the reservoir site, therefore different for different sites.

3. The seepage losses were determined on a series of reservoirs near Fort Collins, in the winter of 1895–6 and 1896–7.

4. The seepage losses may be great. In the lakes under measurement, the losses in some cases were less than from evaporation alone.

5. In some cases, lakes may gain from seepage from irrigated lands, and the gain may be more than the combined loss from seepage and evaporation.

6. In the cases where loss from seepage occurred, the loss was at the rate of about 2 feet in depth over the area of the lake, per year.

7. This amount does not necessarily apply to other sites, and other observations are needed before general statements respecting loss from this source can be made.

8. The seepage decreases after the lake is first filled, from the effect of silting, and from having filled the porous ground underneath and connected with the site.

9. Even in sand, there is a limit to the amount of seepage, and the time during which the loss is large.

10. After sand beds connected with the reservoir are saturated, the losses from seepage will decrease.

10 *a*. The loss increases with the depth, probably nearly as the square.

11. The losses may be lessened, though not entirely prevented, by silting.

12. The silting process is more efficient with small reservoirs, because of the better distribution of the silt.

13. If the loss from seepage is not more than 2 feet per annum, the sites may be considered as practically water tight. In the case of canals, the losses often average more than that in twenty-four hours.

EVAPORATION.

14. The losses from evaporation, in the cases examined, are greater than those from seepage.

15. The evaporation is not necessarily the same from adjacent bodies of water.

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† Trans. Am. Soc. C. E., 1883. ‡ U. S. Weather Bureau. * Report Exp. Sta., 1889.

16. The amount of evaporation increases with the temperature of the water, with the wind, and diminishes with increased moisture in the air.

17. From the standard evaporation tank at the Experiment Station, the average evaporation for 11 years, has been 41 inches.

18. Evaporation proceeds when the water is frozen, but at a diminished rate, averaging about 1 to 1½ inches per month.

19. The evaporation at night is the same as during the day, the difference being less with the increase of the size of the bodies of water.

20. The loss by evaporation from several lakes exceeded that from the standard tank.

21. The loss from the lakes was about 60 inches per year.

22. The increase is due to higher temperature of the water, and to freer exposure to the wind.

23. In some of the summer months, the lakes lost twice as much as the standard tank.

24. The lower temperature of water at high elevations, and the lower dew points, tend to decrease the evaporation.

25. The diminished barometric pressure tends to increase the evaporation, amounting to 14 per cent at 8,000 feet, and to 18 per cent at 10,000 feet, over the evaporation at 5,000 feet.

26. Every mile of wind movement in 24 hours increases the evaporation by from 1 to 2 per cent over the evaporation if calm.

27. The winter period is longer at the high elevations.

28. For the whole year, the evaporation in all probability is considerably less at the high elevations than at the low ones.

29. Evaporation is lessened by any influence which diminishes the wind or decreases the temperature of the water.

30. Protection of lakes by wind breaks is in many cases practicable, and in small lakes sometimes desirable. In the large lakes the benefit is by reducing the wind velocity; in small lakes both from effect on wind and by lessening action of sun.

31. The deeper the lake the cooler the water as a whole, the cooler the surface, consequently the less evaporation.

32. Assuming a loss of 5 feet in depth per annum, an area of 100 acres would require ⅝ cubic feet per second for the whole year to make good the losses from evaporation; one of 500 acres would require 3½ cubic feet per second, considerably more than would be used to irrigate an equal area.

33. The net loss to the reservoir would be the sum of the above losses from seepage and from evaporation, diminished by the rainfall, a combined loss which may be considered as a depth of 6 feet in one year.

34. As irrigation reservoirs are usually full for a few months only, the loss is much less than this for the high water area.

THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 46.

A SOIL STUDY:

PART I.

The Crop Grown: SUGAR BEETS.

Approved by the Station Council.

ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

JUNE, 1898.

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A Soil Study:

Part I. The Crop Grown: SUGAR BEETS.

By WILLIAM P. HEADDEN, A. M., Ph. D.

Among the many questions arising in the practice of irrigation, is the one in regard to the prevention of the alkalizing of low and poorly drained land.

The accumulation of water may not be so rapid that the land becomes waterlogged, though this, in many instances, actually occurs; yet the supply of water, laden with salts, dissolved out of the soil through which it has passed, is sufficient to cause, by its evaporation, a deposition of large quantities of these salts on, and in, the upper portion of the soil. This concentration of the salts is not always indicated by an efflorescence, though this frequently occurs.

The condition upon which the poor drainage depends, is usually the configuration of the surface, but the character of the land and of the strata underlying the soil contribute materially in bringing about this condition.

The difficulty is met with, mostly in limited areas, it is true, but so frequently, and that in otherwise good land, that it becomes a question whether we cannot ameliorate it in some way. Perfect drainage would answer all questions, but this is frequently difficult to obtain, or altogether impracticable. It is, however, not to be inferred that alkalized land is necessarily swampy land, or has such a supply of water that irrigation is unnecessary. Neither of these conditions obtain in general, or when they do, particularly the former, the land must simply be abandoned. The plot chosen for this study is representative of this class of land; it is neither so wet as to be untillable, nor so badly alkalized as to be hopeless.

I recognize that this, like every other agricultural problem, is an involved one, and that it is difficult to determine to which factor the greatest importance should be given. In the present case, there are several patent questions, such as: Does the alkali present produce any effect upon the plant? Is its action directly upon the plant itself or does it act indirectly upon the plant through its effects, mechanical or chemical, upon the soil? Is the starvation of the plants observed in this case, due to an actual deficiency of available plant food, or to the mechanical conditions which obtained? Which is to be taken as the alkali in any given case, the efflorescence, the leachings from the soil, or the salts in the ground water, etc.

I shall devote the subsequent portion of this study to the consideration of the soil and ground water. In this I shall consider the crop grown.

I have chosen to pursue this investigation in a comparative way, believing that this gives the most satisfactory method of checking both observations and results. For this purpose, I selected two plots planted to beets by the Agricultural Department. The beets were of different varieties, and the soils were both good and presumably free from alkali. The investigation was begun and carried on upon the assumption that the character and relative quantities of the soluble salts present have a direct and important bearing upon the amount and character of the mineral matters taken up.

The experiments made in California with sugar beets on alkali soil could not give results necessarily applicable to our case, because our alkali is quite different. The efflorescence, or alkali crusts, are the same, or essentially so, but the leachings of the soil are quite different; ours is much poorer in sodic carbonate and much richer in calcic sulphate. Our alkali crusts are correctly so called, but the salts held in solution in the ground waters, and the leachings of the soil, are both so rich in calcic sulphate that it seems a misnomer to speak of them as alkali, and it should be borne in mind that throughout this bulletin no distinction has been made between the incrustation forming on the soil and the soluble salts in the soil, though there is a great difference between them. The incrustations are sodic and magnesic sulphates, with small quantities of calcic sulphate and sodic chloride, together amounting to about six per cent., while the water residue is largely calcic sulphate, with sodic and magnesic sulphates in smaller quantities.

A brief description of the soil, and a statement of the general condition of alkalization, may be given in this place.

The soil varies from a loam, with some gravel, and having a clayey and somewhat calcareous subsoil, to a fine alluvium, which owes its origin partly to the washings from the immediately surrounding country, and partly to the action of former water courses. It can scarcely be said that there is a true hardpan underlying our experimental plot; but the whole soil, to a depth of five and a half feet, is very retentive of water, and there is a stratum of clay immediately above the gravel, which is quite as efficient in preventing a free passage of the water into the ground flow as a hardpan would be. The gravel below the clay is filled with water, and I believe that the ground water from the higher land to the west finds its way through this to the river.

The water in the alkalized basin and in the gravel stratum are quite independent of one another, so far as I have been able to discover by sinking holes or wells through the soil into the gravel and examining the water. Subsequent study may disprove this, but up to the present I have no reason to doubt it.

Portions of this plot are so rich in soluble salts that incrustations one-half inch in thickness form on the surface of the soil after irrigation, or other favorable conditions. Such are the general conditions of the soil in which I endeavored to grow a crop, in order to study, first, the effects of these conditions upon the crop, and, second, the effects of the cultivation and crop upon the soil.

It is my purpose to record, in this bulletin, the results obtained in regard to the first subject, reserving the further consideration of the second question for a future bulletin.

Several considerations led me to choose the sugar beet as the crop to be studied in this experiment: The whole crop is usable; the weight of the crop is fairly large; its culture has been made familiar to the public by numerous bulletins, and is commanding a large amount of public interest; but the most important one was that the beet is more tolerant of alkali than most of our culture crops. I shall follow the developement of the plant and its sugar content, but this is not the chief object had in view.

Directions for the cultivation of the crop form no part of my plan; besides, they have been given in great fullness by many others. The first question which suggests itself in this study, is: What is the effect of the alkalies on the germination of the seed?

GERMINATION EXPERIMENTS.

I had every reason to expect difficulty in getting a good, or indeed, any stand at all in parts of the plot. The character of the soil and the experience of others justified this expectation. As the general composition of our alkali had already been determined, a series of experiments was instituted to determine, beforehand, whether a failure to get a stand should be attributed to the alkali, to the seed, or to some other cause. I also endeavored to determine the maximum amount of the constituent compounds of the alkali which might be present and still permit the seed to germinate. The amount of sodic chloride present in our alkali is so inconsiderable that it was excluded from our experiments, which were made with the other salts composing the alkali, *i. e.*, sodic carbonate, which is present in small quantities only, sodic sulphate, and magnesic sulphate. There is a very large amount of calcic sulphate in the soil, but no germination experiments were made with it.

My object, as already stated, was to determine the vitality of the seed, the effect of these salts upon the germination of the seed and upon the young plants. The salts were used separately, and also in conjunction, in quantities varying from 0.01 per cent. to 1.0 per cent. of the air-dried soil; for instance, 99 grams of clean, washed, and ignited sand, and 1 gram of dry, neutral sodic carbonate, were taken. The seed used were carefully selected, only fresh, plump burs being taken. The vessels used as germinating cups were ordinary glass tumblers. By using these we avoided the evaporation from the sides of the vessels, which would have taken place had a porous retainer, such as a flower pot, been used, and also any drainage and consequent washing out of the alkali. Evaporation from the surface, and too strong a light, were guarded against by covering each glass with a close-fitting disk of paste board. After the salts had been added to the sand, distilled water was used to wet the mass, and subsequently to replace that lost by evaporation.

The experiment extended over a period of 37 days, from April 11 to May 17, inclusive. The temperature was observed at 7:00 a. m., 12:00 m., and 6:00 p. m. The lowest temperature at 7:00 a. m. was on the day of planting, 46° F.; the highest temperature at this hour was 63° F.; the average of all the readings, 51°. The average temperature at noon for the entire period was 61° F., and at 6:00 p. m., 70° F.

The experiment was divided into four series: The first with sodic carbonate, the second with sodic sulphate, the third with a mixture of these two salts, sodic carbonate and sulphate, and the fourth with magnesic sulphate. The general results of the experiments only are given, because a detail of the daily record would show but little of interest, and occupy a great deal of space. The chief thing which would be gained would be the easily demonstrated fact that the seed germinate more quickly in the solutions of the soda salts, and more slowly in the magnesium salt, than when they are absent, and that the corrosive action of the sodic carbonate made itself manifest when so much as .05 per cent. of it was present in the soil.

SODIC CARBONATE, OR BLACK ALKALI, ALONE.

Variety of Seed Planted.	Per Cent. Sodic Carbonate in the Soil.	Number of Burs Taken.	Number Sprouted.	Per Cent. Sprouted.
Vilmorin	0.00	20	18	90
Vilmorin	0 01	20	17	85
Vilmorin	0.02	20	17	85
Vilmorin	0.03	20	17	85
Vilmorin	0.04	20	18	90
Vilmorin	0.05	20	20	100
Vilmorin	0.06	20	18	90
Vilmorin	0.07	20	19	95
Vilmorin	0.08	20	19	95
Vilmorin	0.09	20	18	90
Vilmorin	0.10	20	15	75
Kleinwanzlebener	0.10	10	4	40
Imperial	0.10	10	9	90
White Imperial	0.20	10	2	20
Lion Brand	0.20	10	5	50
Kleinwanzlebener	0.40	10	0	00
Imperial	0.40	10	1	10
White Imperial	0.50	10	0	00
Lion Brand	0.50	10	0	00
Kleinwanzlebener	0.70	10	0	00
Imperial	0.70	10	0	00
Imperial	0.80	10	0	00
Lion Brand	0.80	10	0	00
Kleinwanzlebener	1.00	10	1	10
Imperial	1.00	10	0	00

SODIC SULPHATE, OR WHITE ALKALI, ALONE.

Variety of Seed Planted.	Per Cent. Sodic Sulphate in the Soil.	Number of Burs Taken.	Number Sprouted.	Per Cent. Sprouted.
Kleinwanzlebener	0.1	10	8	80
Imperial	0.1	10	10	100
White Imperial	0.2	10	10	100
Lion Brand	0.2	10	10	100
Vilmorin	0.4	10	5	50
Imperial	0.4	10	6	60
White Imperial	0.5	10	9	90
Lion Brand	0.5	10	8	80
Vilmorin	0.7	10	7	70
Imperial	0.7	10	7	70
White Imperial	0.8	10	5	50
Lion Brand	0.8	10	7	70
Vilmorin	1.0	10	1	10
Lion Brand	1.0	10	4	40

BLACK AND WHITE ALKALI—EQUAL PARTS.

VARIETY OF SEED PLANTED.	Per Cent. Sodic Carbonate in the Soil.	Per Cent. Sodic Sulphate in the Soil.	Number of Burs Taken.	Number Sprouted.	Per Cent. Sprouted.
Vilmorin	0.05	0.05	10	1	10
Imperial	0.05	0.05	10	9	90
White Imperial	0.10	0.10	10	6	60
Lion Brand	0.10	0.10	10	7	70
Vilmorin	0.20	0.20	10	1	10
Imperial	0.20	0.20	10	2	20
White Imperial	0.25	0.25	10	2	20
Lion Brand	0.25	0.25	10	2	20
Vilmorin	0.35	0.35	10	0	00
Imperial	0.35	0.35	10	1	10
White Imperial	0.40	0.40	10	0	00
Lion Brand	0.40	0.40	10	1	10
Vilmorin	0.50	0.50	10	0	00
Imperial	0.50	0.50	10	0	00

MAGNESIC SULPHATE (EPSOM SALTS).

VARIETY OF SEED PLANTED.	Per Cent. of Magnesic Sulphate in the Soil.	Number of Burs Taken.	Number Sprouted.	Per Cent. Sprouted.
Vilmorin	0.10	20	19	95
Vilmorin	0.20	20	17	85
Vilmorin	0.30	20	18	90
Vilmorin	0.40	20	20	100
Vilmorin	0.50	20	18	90
Vilmorin	0.60	20	17	85
Vilmorin	0.70	20	16	80
Vilmorin	0.80	20	18	90
Vilmorin	0.90	20	16	80
Vilmorin	1.00	20	19	90

The preceding experiments were conducted under identical conditions, and demonstrate that good beet seed will germinate freely in soil containing as much as 0.7 per cent. of white alkali, or sodic sulphate, but with as much as 0.1 per cent. of black alkali, or sodic carbonate, free germination of the seed is doubtful, and the action of the black alkali is scarcely, if at all, mitigated by the presence of an equal quantity of white alkali. The result obtained when 0.05 per cent. of black alkali was present is less favorable than was obtained in the first series, when twice this amount, or 0.1 per cent., was present. This difference might have been partly due to the varieties used. It seems that the Vilmorin is more sensitive to the action of the alkali than the other varieties, but the experiments are not numerous enough to really establish this point, and it must also be remembered that another lot of Vilmorin seed might prove much hardier.

The next series of experiments was conducted with the sodic carbonate, or black alkali, alone, at a somewhat higher temperature, the average being 73.76° F., and the young plants were allowed to remain in the soil to enable us to see how long they would endure the alkali. The quantity of alkali added varied from 0.1 to 1.00, the quantity increasing regularly by 0.1 per cent. The variety of seed used was the Vilmorin; a blank was run at the same time. In six days, 90 per cent. of the seeds in No. 1, containing 0.1 per cent. black alkali, had germinated, none of the others containing alkali germinated, though the experiment was continued for twenty days. The seeds in the glass to which no alkali had been added all germinated, and continued to grow in a normal manner so long as we continued to observe them.

The glass containing 0.1 per cent. of sodic carbonate was allowed to remain five days after germinating, when the seedlings were noticed to be drooping. They were carefully removed from the sand by washing, and seven out of the nine had the plumule corroded, and the rootlets of the other two were already blackened. The blank was allowed to remain exposed to the same conditions for nine days longer, and at the end of this period were still healthy and growing. There can be no doubt but that the alkali had caused the death of the plants in the other glass, proving that, while 0.1 per cent. of black alkali in the soil will not prevent the germination of beet seed, the young plants cannot endure this amount. If the plant had already been established, before this percentage of the alkali had been brought into the soil, it might endure it. I am, however, inclined, by what I have seen of the deportment of the beet plant toward alkali, to doubt whether, even under such conditions, it would survive, especially if, as is the case in Colorado, there should be a rapid evaporation from the surface of the soil.

The next and last series of sprouting experiments* was made to study the effects of still smaller quantities of sodic carbonate, as the maximum amount of sodic carbonate which can be present without any serious disadvantage, evidently lies below one tenth of one per cent.

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* The results have been incorporated in the table under the heading of sodic carbonate.

This last statement ought to be modified to some extent, because there is no humus, or other substance, to ameliorate the action of the alkali, in which respect our tests do not resemble the true soil conditions. The humus in our Colorado soils is so small that it would, under all conditions, be a question whether its influence would be great enough to be observable. The result of this experiment was that the beet seed germinate more quickly in soils containing less than 0.10 per cent. of sodic carbonate, than in soils containing no alkali, but that the young plants cannot survive in the presence of 0.05 per cent. of black alkali, or sodic carbonate.

THE CULTIVATION AND COST.

General instructions for the proper cultivation of the sugar beet have been furnished to every section adapted to its culture, so that a repetition of them here would be useless, and I shall confine my statements on the subject of cultivation to a brief account of our operations, which I make that our conditions may be more fully appreciated.

The ground was plowed and subsoiled to a depth of 14 inches; it was then harrowed, planked and replowed, and still its condition was not a desirable one.

The seeds were drilled in, with the rows two feet apart, and the varieties three feet apart. The depth to which the seeds were put in was between two and three inches, but owing to the uneven condition of the ground this varied greatly. The plots were all planted on May 18, 1897. A rain storm set in on this day and the weather continued rainy until June 11. The beets began to come up on June 6, but, notwithstanding the favorable weather, they did not come up well. This was not to be explained by there being too much rain on a poorly drained soil, for on those portions which were under water for from three to five days there were many more plants than on some of the higher portions. The weather being rainy until June 11, the ground did not bake badly before the first hoeing, which was begun on June 14; but from this time on the soil baked badly and was very difficult to keep in any sort of tilth.

THE APPEARANCE OF INSECTS.

On June the 16th, I noticed a striped beetle, *Systena tæniata*, attacking the leaves. These beetles seemed to come from an adjacent fallow plot, which was covered with poverty weed. By June 21, they had become quite abundant and done considerable damage.

While the plants were quite young they were attacked by the leaf hoppers, *Agallia uhleri*, *Agallia sanguineolenta* and *Agallia cinerea.* Prof. Gillette, who determined these insects for me, is of the opinion that these hoppers did no appreciable harm, except while the plants were small.

Insecticides were applied on June 24, with very unsatisfactory results, and during the next few days it looked as though our insect enemies would defeat us.

We had already observed an occasional individual much larger than the striped beetle, *Monoxia puncticollis.* This beetle had become plentiful by July 3, and was doing considerable damage. On this date we sprayed with paris green, suspended in water, one pound to 80 gallons. This gave us the best satisfaction of all the insecticides which we tried.

THE EFFECT OF ALKALI.

The first observed effect of alkali was on June 15 and 16, when we observed some plants, in spots, at the east end of the plot, drooping, just as some had done in our sprouting experiments. Examination showed that the roots of the plants had been attacked, and were already black and dead. This was not due to the evaporation from the surface and concentration of the salts about the stem at the surface; such action was not observed until June 21, and was the worst in those spots where the efflorescences were the most marked. The effect of the alkali upon the roots was observed in spots where no incrustation appeared at any time. The presence of enough alkali to actually destroy the young plants was confined to certain spots, which were small, and gave no other evidence of either greater abundance or variation in character than that of its effect upon the plants. In fact, it appeared to be less abundant in these spots where it was fatal to the plants, than in other spots, near by, where the plants did well in the midst of a thick incrustation. Local variations in the composition, and, consequently, in the character of the alkali, within such narrow limits, may seem improbable to some, but I see no other explanation for these local effects.

I was not able to detect any corrosive effect of the alkali after the plants had become established, and the ground had been tilled and irrigated.

IRRIGATION.

The plot was irrigated twice, June 29–July 1 and August 18–20. The total rainfall for May, June, July, August, and September, was 8.89 inches. The total time spent in raising the crop, exclusive of harvesting, was 330 hours, including man and team for 25 hours.

As the experiment was carried out on a piece of most refractory soil, the cost of raising the crop would be no criterion for the judging of the cost of raising another crop under favorable conditions, therefore the details of cost are not given. The time given suffices to indicate that this particular crop could not yield a profit unless we obtained a yield of upwards of 16 tons to the acre, and could sell it at four dollars a ton.

THE SUGAR IN THE CROP.

We began taking samples for the determination of the sugar content, and also for other purposes, on September 2, and took them weekly from that date until the crop was harvested, October 14.

The plot represents three well-marked soils; the extreme west end representing a fine loam, the middle a clay soil, with some gravel, and the east end a gumbo. The fine earth, or soil material, ranges between 91 and 95 per cent. It bakes badly, and the air-dried lumps require the use of a pestle to break them.

The varieties of beets planted were the Kleinwanzlebener, Vilmorin, Lion Brand, Lane's Imperial, and the Imperial—four rows each. We always took three samples of each variety, corresponding to the different kinds of soil. As a control, and for the sake of comparison, one sample each of the Kleinwanzlebener and Vilmorin was taken from the plots of the Farm Department.

Our object was to observe the time when the sugar is formed in the beet most rapidly; to study, in other words, the effect of the degree of maturity upon the sugar content, and to determine, if possible, what the effect of our bad soil conditions were upon both the formation and the amount of the sugar.

The soil is rich in potash and soda, with an ample supply of lime and a fair amount of phosphoric acid, but it is rather poor in nitrogen.

The sugar in this series of determinations was determined by means of Fehling's solution, and the percentages represent the total sugar. I have made no distinction between sucrose and the other sugars.

The numbers in the table represent the different soil conditions in our plot: Number one, for instance, always being taken along a line near the west end of the plot; number two along one across the middle, and number three near the east end. The stand in this, the east end, was very bad, and we could not adhere so strictly to a given line as at the other two points.

It must be acknowledged that the weekly average for the sugar content has but little value, still I have introduced it that a general view of the rate of increase may be more easily obtained.

TABLE SHOWING PERCENTAGE OF SUGAR.

Date.	Number.	Klein-wanzlebener.		Vilmorin.		Lion Brand.		Imperial.		Lane's Imperial.		Klein-wanzlebener.		Vilmorin.	
		Percentage of Sugar.	Purity.	Percentage of Sugar.	Purity.	Percentage of Sugar.	Purity.	Percentage of Sugar.	Purity.	Percentage of Sugar.	Purity.	Percentage of Sugar.	Purity.	Percentage of Sugar.	Purity.
September 2......	1	7.72	....	7.86	....	8.21	....	8.60	....	.....	....	8.36	....	7.24	....
	2	7.60	....	6.75	....	8.14	....	9.21	....	.....	....	.....	....	.....	....
	3	6.94	....	5.57	....	7.18	....	7.47	....	.....	....	.....	...	.....	....
Average	....	7.75	....	7.06	....	7.84	....	8.43	....	.....	....	8.36	....	7.24	....
September 8... ...	1	9.06	....	8.42	....	7.61	....	9.69	....	... .	....	10.60	....	9.98	....
	2	10.55	....	8.02	....	11.36	....	11.87	....	.....	....	.....	....	.....	....
	3	7.97	....	7.97	....	7.37	....	10.06	....	.....	....	.....	....	.....	....
Average	....	9.19	....	8.14	....	8.78	....	10.54	....	.....	....	10.60	....	9.98	....
September 15......	1	10.06	....	7.28	....	9.31	....	9.03	....	.....	....	8.55	....	9.73	....
	2	10.88	....	10.46	....	11.20	....	13.19	....	.....	....	... .	....	.. ..	....
	3	6.88	....	8.33	....	6.21	....	10.06	....	.....	....	.....	....	.....	....
Average	....	9.61	....	8.69	....	8.91	....	10.77	....	.....	....	8.55	....	9.73	...
September 22......	1	8.14	74	7.60	76	8.14	74	10.79	77	9.70	81	10.60	75	11.50	77
	2	10.73	76	10.73	83	10.02	77	10.85	72	10.73	77	.....	....	.....	....
	3	6.24	62	4.80	48	7.06	71	9.03	70	.....	....	.....	....	.....	....
Average	....	8.37	71	7.71	69	8.41	73	10.22	73	10.14	79	10.60	75	11.50	77
September 29......	1	9.91	76	8.69	72	12.49	89	10.36	74	.....	....	10.21	73	9.07	70
	2	10.42	80	9.03	70	10.36	....	11.42	71	.....	...	.....	....	.....	....
	3	8.07	58	6.85	49	7.86	60	7.24	66	.....	....	.....	....	.....	....
Average	....	9.47	71	7.86	64	10.27	75	9.67	70	.....	....	10.21	73	9.07	70
October 6..........	1	8.29	....	9.03	70	11.50	77	10.73	72	.....	....	12.15	81	10.02	72
	2	9.80	70	10.98	78	11.69	83	12.00	75	.....	....	.....	....	.....	....
	3	8.21	91	7.93	66	6.52	65	9.60	70	.....	....	.....	....	.....	....
Average	....	8.77	80	9.31	71	9.90	75	10.78	72	.....	....	12.15	81	10.02	72
October 13...	1	12.15	76	12.49	78	12.84	80	13.61	80	11.25	80	12.32	77	13.02	77
	2	14.70	82	10.13	72	13.61	76	15.20	84	9.91	....	.....	....	.....	....
	3	8.44	70	10.21	73	11.84	74	12.15	76	9.21	77	.....	....	.....	....
Average	....	11.76	76	10.94	74	12.76	77	13.65	80	10.12	78	12.32	77	13.02	77

The increase from September 2 to 15, inclusive, was positive in all cases. But the samples taken on September 22 show a falling off, which is not wholly regained by all the varieties until October 13. The cause of this is, I think, a rainfall amounting to .74 inch, which took place between September 10 and 14—mostly on the 14th. It did not produce a second growth. The beets were still in such condition that they could continue their development without putting out new leaves, but they increased quite markedly in size, and the condition of their roots indicated plainly that they had taken on greater activity and were feeding vigorously. I think that the apparent falling off of the sugar content indicated a relatively greater increase in the other constituents than any decrease in the sugar. The average weight of the beets during this period corroborates this view. In cases where a second growth has taken place the results are unquestionably different, for then new leaves are put forth, and the supply of food stored is begun to be used up.

By the beginning of the second week in October the leaves began to turn yellow, and the plants showed signs of ripening. My opinion is, that it was rather a case of starvation than of natural maturing. The outside rows, in the case of every one of the varieties, and especially the ends of the rows, were much slower in showing these signs than the inside rows; further, the other plots on the Farm did not show the same signs of maturity for more than two weeks after this. The beets were all pulled on October 14.

A comparison of those samples numbered three throughout the table, with the others, gives an exaggerated view of the effect of very unfavorable conditions. I avoid saying alkalized soil, because I am by no means convinced that the effect, so evident in this case, is a direct result of the action of the alkali upon the plant. I am rather of the opinion that the same soil conditions, in the absence of alkali, would be quite as pronounced in their effect as that observed in this case. There is no reason why just as unfavorable conditions should not exist without the alkali; but, the fact remains that we have both in this instance.

The observable effects were, a very poor stand and small beets, having, for the most part, an exceedingly bad shape. The plants did not scald as I expected that they would, and as they did do in some parts of the plot. Whether this was due to a partial adaptation on the part of the plants, or due to other causes, I am unable to state. The appearance of the beets indicated that it was the former. The Kleinwanzlebener and Vilmorin, given as the sixth and seventh varieties in the table, are samples grown on good soil by the Farm Department, the Kleinwanzlebener on alfalfa sod. They were taken in order to have some comparable standard. They seem to have responded more quickly than my less favorably conditioned plot to the rain of September 14, and also to have gained in their sugar content rather sooner than mine.

I have included my sample number three in all of the weekly averages. This is perfectly proper, as the value attached to these averages, and the purpose of their introduction into the table, have been stated; but, in trying to form a judgment of the effect of alkali upon the sugar content of the beets, this sample ought to be excluded, because the quantity of alkali was so excessive, or, as I believe, the other soil conditions were such that really no crop was grown. If it had been due to excessive alkali the samples numbered one ought to approach those numbered three much more nearly than they do, for the soil at this point carries much more soda, sulphuric acid and magnesia, with almost exactly the same amount of potash. In addition to these facts, the soil water in this portion of the field carries, at times, quite as much in solution as that from the east section, or section three, though the amount is usually less by from 10 to 80 grains per gallon. The water from the former carries from 150 to 200 grains per gallon, while that from the latter carries from 200 to 250. This subject of ground water will be treated of at another time.

The amount of alkali in the section represented by samples numbered one, being only slightly, if at all, less than in number three, but, the soil being in much better tilth, affords us better data on which to base our judgment.

The section represented by samples numbered one is in good condition and quite well drained, though it is on the western edge of this alkalized basin. Were it not for its proximity to the lower land it would be considered excellent, but an analysis shows it to contain more soda and sulphuric acid than the rest of the plot.

In order to judge of the effect of the alkali upon the sugar content in the beets, I think that we should take the Farm samples and numbers one and two, taken October 13. The crop had, at this date, reached its maturity—even the beets on the Farm plot, though remaining unharvested for a long time, showed only a moderate gain, not really large enough to positively place it beyond the differences in individual samples, after this date. In this case we observe that the Kleinwanzlebener, Vilmorin, Lion Brand, and Imperial, grown on my plot, and the Kleinwanzlebener and Vilmorin, grown on the Farm plots, are quite close, containing, in the order given, 12.15, 12.49, 12.84, 13.61, 12.32 and 13.02 per cent., while the samples from my plot numbered two, and taken in the same order, show 14.70, 10.13, 13.61, and 15.20 per cent. sugar. There is no room for question as to the character of the soils on which these samples grew. That on which the Farm samples grew, particularly in the case of the Kleinwanzlebener, is as free from alkali as any of our soil and was in good condition. The same is true in regard to the mechanical condition, though to a less extent, perhaps, of that on which my sample numbered one was grown, while that on which my sample number two grew was strongly alkalized, but the beets were richer in sugar than those grown on land practically free from alkali. This is true, also, of the samples taken on other dates, and of all the varieties, with few exceptions.

I conclude that the effect of white alkali, to the extent that it is present in this soil, is, of itself, not detrimental to the sugar beet, so far as its sugar content is concerned. This, though quite contrary to my preconceived notions, based upon previous but limited observations, is in harmony with the conclusions of Hilgard and Loughridge, who conclude, from their investigations made at Chino, California, that beets grown in soil carrying large amounts of alkali may be of good quality, both in regard to their purity and the percentage of sugar contained.

The causes of the low sugar content in the samples numbered three will be studied during the present season. It is evident from the uniformily low percentage of sugar and the low co-efficient of purity that there is some condition obtaining which is very harmful to the plant. Indeed, I am justified in making the statement, that in this section of the plot, the beets did not grow at all.

The table exhibits another interesting point, *i. e.*, the time of the most rapid increase of sugar in the crop, and how it may be influenced by the weather, and the condition of the crop at the time, for instance, of a rainfall. From September 2 to October 13 there is an increase of from three to five per cent., which is unevenly distributed throughout the six weeks, and much less evenly in my samples than in the Farm samples. Up to October 6, no marked increase in the percentage of the sugar had been observable. On the contrary, there had been fluctuations depending, as already pointed out, upon the weather and the condition of the crop. But, from October 6–13, there is a very marked rise in the percentage of sugar in five out of the six series, and a small increase in the sixth, which had shown an increase of about two per cent. during the preceding week. On October 6, the Kleinwanzlebener from the Farm plot, was the only variety yielding marketable beets, unless we include sample number two, of the Imperial. On October 13, however, there is only one sample falling materially below the standard of 12 per cent. This change, which we speak of as the maturing of the beet, makes a difference of from two to three per cent. My plot was harvested on October 14, and no opportunity was had to observe the deposition of the sugar subsequent to that time, but the Farm plots were not harvested until some days later, because they gave none of the accepted signs of ripening. I took another sample of the Kleinwanzlebener variety on October 21, and found 12.30 per cent., with a purity coefficient of 82.

This plot of beets had, according to our samples, been practically stationary in the percentage of sugar from October 6 to October 21, but the crop was increasing, at what rate I did not attempt to determine. Owing to the failure of this crop to ripen, *i. e.*, to show the usually accepted signs of ripening, a portion of it was allowed to remain in the ground, and was subsequently covered with straw to protect the beets against severe freezing. A sample taken December 19 showed 12.7 per cent. of sugar, and co-efficient of purity 81. Another sample taken at the same time, and sent to Grand Island, Nebraska, showed, sugar 13.7 per cent., purity 86. My check on this showed, sugar 13.12 per cent., and purity 81. This is as close as can be expected, when it is considered that the samples were not parts of the same beets, and both had dried out to some, but probably to different, degrees.

On December 30, I took another sample and obtained, sugar 12.54 per cent., purity 85. The last of the beets were dug January 7, 1898, and showed 12.92 per cent. sugar. This is the average of eight beets tested individually. We see that, in this case, in which the variety was Kleinwanzlebener, taken from the same plot, we have a difference of less than 1 per cent. in the increase of the sugar from October 6 to January 8, but there is a positive increase, and it is not to be accounted for by the shrinkage in the crop. It would not be just to take the result obtained at the Grand Island factory as the maximum, because these beets had dried out to some extent. There is no question but that the determination is correct, but the sample was no longer representative.

I believe that this plot of beets represents the average sugar beet grown in this section of the state, and, so far as my observation goes, it represents the beets of the state. The average found by this Station from 1887–1896, inclusive, is 12.8 per cent. sugar, which is essentially the same as shown by the crops grown at the Station this year, and analyzed within a few hours after being pulled.

The time elapsing between the pulling of the beets and the making of the sugar determination, together with the care of the sample, is of the utmost importance. Indeed, there is no difficulty at all in making a most excellent showing for a very poor crop of beets.

THE DISTRIBUTION OF THE SUGAR IN THE BEET.

This question was raised incidentally during our study of the feeding value of the trimmings of the beets—that is, the tops of the beet removed. It has been claimed, and experiments made to show, that the percentage of sugar present in the beet increases from the top downward.

My time did not admit of my extending the series of analyses too greatly, so I have taken the larger sections, thirds, by weight. If there is any difference of sufficient magnitude to be of any practical importance, we should find it between the first and third thirds, numbering from the top downward.

The beets used were of the Kleinwanzlebener variety, freshly dug, and of medium size. The crown was not removed.

The sugar beet, with us, grows almost wholly under ground, and the question of crowns is of much less importance than in some other places.

SUGAR IN THE RESPECTIVE THIRDS.

	Thirds.	Percentage Sugar in Juice.	Percentage Sugar in Beets.	Total Solids in Juice.	Co-eff. of Purity.
Beet No. 1	1	12.70	12 07	14.660	87
	2	12.50	11.88	14.356	87
	3	12.30	11.64	14.312	86
Beet No. 2	1	13.30	12.64	16.646	80
	2	13.70	13.02	17.396	79
	3	13.90	13.21	17.596	79
Beet No 3	1	13.40	12.73	15.437	87
	2	13.80	13.11	16.185	85
	3	14.00	13.30	15.934	88
Beet No. 4	1	14.00	13.30	16.236	86
	2	14.40	13.68	16.352	88
	3	14.10	13.40	16.213	87
Beet No. 5	1	14.60	13.87	16.701	87
	2	14.30	13.78	17.155	85
	3	14.60	13 87	16.608	88
Beet No. 6	1	14.60	13.87	16.701	87
	2	14.60	13.87	16.701	87
	3	14.50	13.78	16.440	88

The sugar was determined by means of the polariscope, but no sample was repeated less than four times; besides, I checked my readings from time to time by means of test plates.

The specific gravity was determined by means of the Westphal balance. This series does not show any pronounced difference between the thirds, taken by weight. There is, in three cases, less sugar by 0.60 per cent. in the first one-third than in the third one-third, but in the other cases there is practically no difference. In taking the thirds by weight, the first one-third includes that portion usually trimmed off as objectionable, but neither the sugar content nor the co-efficient of purity shows any marked inferiority of this portion of the beet. I will anticipate a subsequent paragraph to the extent of stating that neither the amount of dry matter nor the percentage of ash indicates any reason why the crown should be much inferior to the rest of the beet. The averages for all the respective thirds show a difference of less than two-tenths of one per cent. of sugar in favor of the lower two-thirds of the beet. This is of some interest to our farmers, as they can market practically the full weight of their crop.

SUGAR IN THE CROWNS.

I, unfortunately, did not make the determination of the sugar in the crowns from perfectly fresh beets, but used beets which had been stored for a few weeks in the root cellar. I, however, got beets which had been covered with fine soil, and which was still as moist as it was at the time the beets were harvested.

By crown, or neck, I mean that portion of the beet between the base of the leaves and the transverse line, showing in a vertical section of the beet, and transversing it from a point just below the outermost row of leaves.

The beets selected were, perhaps, rather above the average in size, and 14 in number. The average weight of the crowns, as determined from another similar lot of 22 beets, was 136.36 grams, or four and four-fifth ounces. This was about 13 per cent. of the beets. The sugar in the crowns was 15 1 per cent., with a co efficient of purity of 82.35; the sugar in the beets was 16.1, and the co-efficient of purity, 88. Six beets were u-ed in the sample for the sugar determination. The result, however, gives us a full answer to the question as to the sugar value of the crowns, *i. e.*, that it is about one per cent. less than that of the beet. While the statements in this paragraph agree with those made on this subject by others, in making both the percentage and purity somewhat lower than in the beets, my results make the difference much less than that given by others. Ware, in "The Sugar Beet," page 86, quotes Champignon and Pellet as making the difference 2.60 in the percentage of sugar. The Cornell University Agricultural Experiment Station Bulletin 143, makes the difference vary from 1.55 to 2.90 per cent. of sugar, and from 6 to 14 degrees in the purity. The crown, in this case, is really a structural portion of the beet, and not an indefinite part of the root, which has been exposed to the action of the light and air without protection, except that furnished by the foliage. The leaves being very heavy, furnish more protection to the beet grown here than is usual in other sections, but, aside from this, the sugar beet with us grows entirely under ground.

THE EFFECT OF FREEZING UPON THE SUGAR CONTENT.

I regret that my observations on this interesting point are not more extended. The samples in which the sugar was determined were frozen in the ground, but under a covering of straw or earth.

Sample No. 1—Upper third frozen; sugar in juice, 13.5 per cent.; sugar in beet, 12.82 per cent.;* purity, 78. The second third was not frozen; sugar in juice, 12.6 per cent.; sugar in beet, 11.98 per cent.; purity, 91. The bottom third not frozen; juice, 12.6; beet, 11.97 per cent. sugar; purity, 81.

Sample No. 2—Upper third frozen; sugar in the juice, 11.50 per cent.; sugar in the beet, 10.93 per cent.; purity, 73. Middle third frozen; juice, 11.7 per cent.; beet, 11.11 per cent. sugar; purity, 70. Bottom third not frozen; juice 15.1 per cent.; beet, 14.34 per cent. sugar; purity, 88.

Sample No. 3—Frozen solid; juice, 15.00 per cent.; beet, 14.25 per cent. sugar; purity, 84.

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* This solution being unsatisfactory, the sugar was redetermined by means of Fehling's solution, and showed 13.11 per cent. sugar in the beet.

Samples No. 1 and No. 2 were individual beets. No. 1 weighed 4½ pounds, No. 2 weighed 2 pounds. The sample of this plot, taken October 13, contained 12.32 per cent. sugar, and samples taken later ran as high as 12.9. The average of these beets is 12.2 per cent., from which, it appears, that the sugar has suffered no diminution, while its redistribution in the beets is very marked.

Sample No. 3 was harvested October 29, and a part of the sample was placed in a shallow silo immediately, in order to avoid any loss of water due to direct exposure to wind and sun; the rest of the sample was taken to the laboratory and the sugar determined. The silo was opened December 19, and the beets found to be frozen hard. The sample analyzed, October 29, showed 14.03 per cent. of sugar, with a co-efficient of purity of 82, while the frozen sample of December 19, showed 14.25 per cent. of sugar, and a co-efficient of purity of 84.

Simple freezing does not cause any change in the sugar. This is an important consideration, or would become so, if our farmers were raising beets for a factory. If thawing could be prevented, the crop is not necessarily lost, if once frozen.

THE DRYING OUT OF BEETS.

I have already made incidental reference to this subject. It is of interest to both the producer and the manufacturer. I stated in a former paragraph that it is an easy matter to make a really poor crop appear to be a good one. It has, for years, been a cause of complaint that parties could always obtain better results from their samples by sending them to the Agricultural Department at Washington, than by sending them to their home Station. The Station undoubtedly gave them too high results in the great majority of cases, and the Department, at Washington, has been giving them still higher, and yet, both of them have been giving them correct results for the samples as analyzed; the samples, however, have not been representative of the crop as it stood in the field.

The Department, at Washington, has repeatedly called attention to this fact. Dr. Walter Maxwell, in his report to Dr. Wiley, records several series of experiments made with the object of determining the amount of this loss, which he gives, as varying from 16 to 26 per cent. for beets tied up in a sack, and kept from the wind and sun for a period of seven days, and from 23 to 35 per cent. for beets under normal exposure to air and sun for the same length of time. Dr. Maxwell makes the average loss, in the case of beets protected from the action of wind and sun, 20 per cent. in seven days.

It may be well to put this statement in a more concrete form, as we receive samples which have been pulled, or harvested, longer than this, and kept without any protection whatever. Assume that our sample, as received, weighs 40 ounces, and the juice shows a reading of 15 per cent., we report the sugar in the beet as 14.25 per cent., showing the presence of 5.7 ounces of sugar. The amount of sugar given is correct, but the percentage of sugar in the beets is entirely too high, for the percentage is calculated on 40 ounces of beets, whereas, it should have been calculated on 50 ounces, and the percentage of sugar in the beets, as harvested, was only 11.4 per cent.

Dr. Wiley, in his report on the experiments with sugar beets in 1892, says:

"Again, the loss of moisture during transportation, or failure of the farmers to send their beets in as soon as harvested, may tend to reduce the amount of water present in the beet, and to raise correspondingly the quantity of sugar therein." In speaking of beets received from California, he says: "In this connection, however, it must be remarked that the beets were long in transit and must have lost a considerable quantity of water. They were somewhat wilted and shriveled in appearance when received. Such beets, of course, would indicate a higher percentage of sugar than they would really contain in a fresh state, and the same remark may be applied to the beets shipped any distance by mail, or to beets which have been exposed any considerable time to the air after harvesting, before the determination of the sugar." In speaking of the Colorado samples, he repeats the same, saying: "In regard to the content of sugar shown by these samples, the remark made with reference to California must be made here, viz., that the amount of sugar indicated on analysis is higher than that actually present at the time of harvesting, on account of the loss of water, during transportation."

These quotations are sufficient to show that the Department of Chemistry, at Washington, is fully aware of the error in the analysis of beets sent from this and other Western states, and no blame can, in any way, attach itself to them, because the figures given for the sugar in our beets is too high, by several per cent.—2.8 per cent. in the assumed case, which is far inside the facts.

This subject has a much wider bearing than the mere fact that determinations made, upon presumably identical samples, here and in Washington, do not agree. The Department of Chemistry has repeatedly warned the readers of its reports, that the figures are too high, and have given data by the aid of which an approximate correction can be made. I was not aware of Dr. Maxwell's experiments when I made mine, but I am gratified to find that the general results agree with his, though they differ in degree, owing, probably, to differences in the condition of the beets at the time of harvesting, the temperature, moisture of the atmosphere, etc.

My first experiments were made by taking two series of samples, wrapping the beets separately in paper, and placing them upon the cellar floor, which is the earth of the cellar, without covering. The light was very moderate. The samples were weighed, from time to time, during 17 days. A third sample was subsequently taken, but the conditions were different; the beets were maturer and had lain several weeks in the root cellar before taken for this experiment, which was made in the laboratory. After the first two days the beets were wrapped up carefully, and covered with four thicknesses of gunny sacking, to protect them more fully from the light. The maximum temperature in the laboratory, during the experiment, was 69° F., and the average about 60° F.

LOSS OF WEIGHT DUE TO DRYING.

Experiment No. 1.

Date of Weighing.	Weight of Sample. Grams.	Total Loss.	Per Cent. Total Loss	Per Cent. Loss from Day to Day.	Remarks.
October 6	2012	....	....	....	
October 7	1902	102	4.8	4.8	
October 8	1834	176	8.0	3.8	
October 9	1775	237	11.3	3.3	
October 11	1668	344	17 1	6.1	Average per day, 3.0
October 13	1584	428	21.2	5.0	Average per day, 2.5
October 16	1455	557	27.7	8.1	Average per day, 2.7
October 18	1392	620	30.8	4.3	Average per day, 2.1
October 21	1302	710	35.2	6.5	Average per day, 2.1
October 23	1240	772	38.3	4.7	Average per day, 2.3
Experiment No. 2.					
October 6	1536	....	....	....	
October 7	1446	90	5.9	5.9	
October 8	1388	148	9.6	4.0	
October 9	1343	193	12.6	3 2	
October 11	1268	268	17.6	5.6	Average per day, 2.8
October 13	1197	339	22.1	5.6	Average per day, 2.8
October 16	1099	437	28.5	8.2	Average per day, 2.7
October 18	1052	484	31.5	4 3	Average per day, 2.1
October 21	987	549	35.7	6.2	Average per day, 2.1
October 23	945	591	38.5	4.3	Average per day, 2.1
Experiment No. 3.					
January 3	5517	....	....	....	
January 4	5226	291	5.2	5.2	
January 5	4933	574	10 4	5.4	
January 6	4672	845	15 3	5.3	
January 7	4532	985	17.9	3.0	
January 8	4379	1138	20.6	3.4	
January 9	4258	1259	22.8	2.8	
January 10	4162	1355	24.5	2.3	
January 11	4055	1462	26.5	2.6	
January 12	3953	1564	28.3	2.5	
January 13	3853	1664	30.2	2.5	
January 14	3744	1773	32.1	2.8	
January 15	3649	1868	33.9	2.5	
January 16	3562	1955	35.2	2.4	
January 17	3487	2030	36.8	2.4	
January 18	3423	2094	37.9	1.8	

The experiments agree in showing a loss of rather more than 38 per cent. in 17 days, and also quite a uniformity in the rate of loss, with the greatest irregularity during the first days of the experiments. The maximum of loss, for any single 24 hours, is 5.4 per cent. of the weight of the beets at the beginning of the 24 hours. It fell from this to about 2 per cent. for each 24 hours, where it remained. Dr. Maxwell made the loss equal to 20 per cent. of the original weight in seven days. I make it rather more, due, probably, to differences of conditions, but there is a substantial agreement between our experiments.

The farmer will appreciate these figures more fully, perhaps, when they are converted into other terms. They mean this to him, *i. e.*, if he has a crop of beets of 20 tons to the acre, and delays marketing them for 24 hours, he has lost one ton, or one twentieth of his crop, and if he delays a week he will lose one fifth of his crop, by weight. The percentage of sugar will be higher, but the tonnage less, by the amount of evaporation, whatever that may be.

It is evident that such large losses totally destroy the value of samples sent to the Station for analysis, unless great care is exercised by the sender, that the beets reach us in as fresh a state as possible, and if they are not quite fresh, the analysis has no value to either the sender or to anyone else. In illustration of this, I give the sugar content of the samples used in the experiments just detailed. A sufficient number of beets were taken from each lot, at the beginning of the experiments, to give us representative samples, and the sugar was determined in them while the samples were perfectly fresh. The sample used in experiment No. 1 contained 9.8 per cent., that used in experiment No. 2 contained 9.3 per cent., and that used in experiment No. 3 contained 14.4 per cent. of sugar. At the end of the experiments, the 9.8 per cent. of No. 1 had become 15.5 per cent., the 9.3 per cent. of No. 2 had become 12. 6 per cent., and the 14.4 per cent. of No. 3 had become 21.6 per cent.

The difference in percentage, shown in samples analyzed immediately after being pulled, and after exposure in the field for 24 hours, was almost exactly 1 per cent. This difference would make the average percentage in the beets from our plots 13.3 per cent. and 13.7 per cent., instead of 12.3 per cent. and 12.7 per cent., respectively.

THE LOSS OF SUGAR ON LONG DRYING.

This question is not of so great and immediate interest to the raiser, unless the factory should refuse to buy and hold the beets, but require the raiser to either hold them until the factory could work them up, or, in some way, make the raiser share the loss during storage.

The loss of sugar in the third experiment was quite significant, amounting to 1 ton in 14 tons of sugar, and this was with mature beets, kept 15 days; but the largest loss was observed in the second experiment, continued for 17 days, in which the loss of sugar amounted to 1 ton in every 6 tons. The loss of sugar in the beets used for the first experiment was quite small, amounting to only 1 ton in 40 tons. This question is, in all cases, of sufficient importance to deserve the attention of the factory people. It is not likely that such high losses, as occurred in experiment No. 2, would often be met with, because these beets were not mature, but those used in experiment No. 3, were such beets as would be readily marketable. This loss of sugar was not due to heating or fermenting, as the term would usually be understood by the farmer; there were no visible marks by which one would judge that any fermentation process had been going on.

I will state in detail the second and third experiments, lest some one should be confused by the two statements that there is a gain in the percentage of sugar caused by the drying out, and that there is also a loss of sugar. The original weight of the sample was 1536 grams, and the percentage of sugar 9.3 per cent., which gives us 143.0 grams of sugar; the weight of the dried-out beets was 945 grams, and the percentage of sugar was 12.6 per cent., which gives us 119.0 grams of sugar. We had, however, 143 grams of sugar to start with, and only 119.0 grams at the end, or a loss of 24 grams, a trifle over one sixth of the sugar present.

In the third experiment, the original weight of the sample was 5517 grams, and the percentage of sugar was 14.44. per cent., showing the presence of 796.59 grams of sugar; at the end of the experiment there remained 3423 grams of beets, having 21.57 per cent. of sugar, *i. e.*, there was only 739.3 grams of sugar, or 57.2 grams less than we had at the beginning; one fourteenth of that present in the fresh beets had disappeared.

These examples will suffice to illustrate the importance of this question, and, also, that there is a loss of sugar, while there is an increase in the percentage of the sugar in the beet.

THE YIELD OBTAINED.

The varieties of beets planted were five in number: Kleinwanzlebener, Vilmorin, Lion Brand, Lane's Imperial, and Imperial. The stand in parts of the plot was thick, and in, probably as much as two thirds of it, the stand was good, but in the other third it was exceedingly poor. The poor stand, in this part of the plot, was not wholly due to failure of the seed to come up, but partly to drowning out of the young plants, and partly to the action of the alkali. The plants were thinned to nine inches apart. It was necessary to let them stand much longer before thinning than I desired, owing to the attack of insects, and to the dry weather. The beets, in the meanwhile, had grown so large that it was found impossible to pull the plants without serious injury to the ones we wished to leave, so we thinned them by cutting them out to the desired distance apart. The beets were harvested on October 14, and gave the following yields:

YIELD PER ACRE.

Variety.	*Tons Beets per Acre.*	*Tons Tops per Acre.*
Kleinwanzlebener	7.9	6.2
Vilmorin	8.6	7.9
Lion Brand	8.1	7.0
Lane's Imperial	15.9	7.1
Imperial	11.8	10.6

I learn from Prof. Cooke, in charge of the Department of Agriculture, that the yield of the College plots varied from eight to twelve tons per acre. It is clear that the yield from my plot does not vary enough from that of the other plots to justify the inference that the alkali had any influence upon the yield. The gross results, however, are not altogether conclusive, for the stand on the Farm plots was seriously affected by a spell of bad weather at planting time. My plot was sown at about the same time, and the stand was, on an average, poor enough, but other factors entered so largely into the question, that it is doubtful whether I would have had any better stand if the weather had been more favorable. The beets from the Farm plots were, as a rule, much finer beets, in shape and general appearance, than mine. I think that the coincidence, in the yields of the different plots, is accidental. The fact that they were grown under the same conditions, as to the weather, does not make them fully comparable.

RATIO OF BEETS TO TOPS.

Ware, in "The Sugar Beet," p. 93, says: "As a general thing, it is admitted that the weight of the leaves, in a given crop, is about equal to one half that of the roots, and one fourth to one third for beets containing 8 to 9 per cent. of sugar." Wiley, quoting from McMurtrie's Report, says: "Corenwinder and Contamine find that there is a relation between the size of the leaves and the richness of the roots; that roots which bear leaves of broad surface, are generally more rich in sugar than those having small leaves upon a contracted top, and these facts are confirmed by an analysis of subjects taken from the same field." At the same time, Deherain concludes, from his researches, that the weight of leaves of small beets is relatively greater than is produced by larger ones.

The tables, quoted both by Ware and McMurtrie, are given primarily to show that beets with heavy tops are richer in sugar than beets with lighter tops, and give us the ratio of the tops to the beets. It is for this purpose that I introduce them here:

Variety.	Per Cent. Sugar in Juice.	Weight of Roots. in Grams.	Weight of Tops.	Ratio Tops to Beets.	Per Cent. of the Beet.
Pink Top, 0	9.90	1393.0	281.0	1:4.95	20.0
Pink Top, Enterre	10.18	984.0	375.0	1:2.63	38.0
Improved, 1,093	14.42	863.0	531.0	1:1.62	61.0
Improved, 927	14.78	787.0	531.0	1:1.48	67.5

Other tables given, show that the weight of the leaves varies from 25 to 63 per cent. of the weight of the beets, and stress is laid upon the fact, that the sugar content increases as the ratio of the weight of the leaves to that of the roots increases.

The only other statement that I have been able to find, touching the relative weights of the tops and the roots, is given in Cornell University Station Bulletin 143, where it is shown to be, in one experiment, about 1: 5, or, more exactly, 20.29 per cent., and in another, 1: 3, or 35 per cent. These statements are not at all applicable to the beets grown in Colorado. The figures given on a previous page, under the caption of "The Yield Obtained," show that but one out of the five varieties yield 2 tons of beets to 1 ton of tops; in other words, that only one variety approached the rule, that the weight of the tops equals about one half the weight of the roots.

The figures given on the preceding page is for beets and tops trimmed as they would be for siloing, and not for factory use; if they had been, the Lane's Imperial would have given a much smaller weight of the beets, owing to their green necks, caused by their growing well out of the ground.

It is a patent fact, that the ratio of the weight of the leaves to that of the roots is less, at the time of maturity, than before this period, and that a study of this relation, prior to a reasonable development of the roots, would have no general interest. I began the study of this, and all the subsequent subjects, at the same time that I began to determine the sugar content of the crop, *i. e.*, September 2. The beets had already attained a fair size, the average weight of 93 beets, pulled on this date, being a trifle over 15 ounces, and the largest beets were always avoided. The sugar in the samples taken, on the respective dates, is given in the table under the caption, "The Sugar in the Crop."

RATIO OF LEAVES TO ROOTS.

Date.	Variety.	Number of Beets.	Weight of Tops. Grams.	Weight of Beets. Grams.	Ratio of Weight of Top to Weight of Beets.
September 2..........	Kleinwanzlebener	18	13111.7	9950.5	1:0.76
	Vilmorin	18	9273.6	6398.0	1:0.69
	Lion Brand...........	18	12832.7	7461.6	1:0.58
	Lane's Imperial	9	3218.5	5964.7	1:1.85
	Imperial	18	9152.1	5443.0	1:0.59
	Kleinwanzlebener No. 2...	6	4485.1	3898.2	1:0.87
	Vilmorin No. 2............	6	2789.6	2381.4	1:0.85
September 8.........	Kleinwanzlebener	12	8708.9	5261.6	1:0.60
	Vilmorin	15	8448.8	6962.7	1:0.82
	Lion Brand	14	9121.6	7805.2	1:0.85
	Lane's Imperial	11	5624.2	7756.4	1:1.27
	Imperial..................	15	8060.0	6668.6	1:0.82
	Kleinwanzlebener No. 2..	6	3487.1	3900.9	1:1.11
	Vilmorin No. 2............	2	1905.0	1474.2	1:0.77
September 15..........	Kleinwanzlebener	14	11475.8	8584.0	1:0.74
	Vilmorin	14	9253.2	8675.8	1:0.93
	Lion Brand................	12	7733.7	5057.5	1:0.66
	Imperial..................	14	11396.4	8447.9	1:0.74
	Kleinwanzlebener No. 2...	2	2336.0	2381.3	1:1.05
	Vilmorin No. 2............	2	1134.0	1564.9	1:1.38
September 22..........	Kleinwanzlebener	24	22021.8	15932.3	1:0.72
	Vilmorin	25	17864.0	17417.8	1:0.97
	Lion Brand	26	16635.4	12859.3	1:0.77
	Lane's Imperial...........	16	7688.4	13743.8	1:1.78
	Imperial..................	26	19106.3	13131.4	1:0.69
	Kleinwanzlebener No. 2..	2	861.8	1224.7	1:1.33
	Vilmorin No. 2...	2	1406.1	1247.4	1:0.86
September 29..........	Kleinwanzlebener	12	6005.9	7484.2	1:1.25
	Vilmorin..................	12	6395.7	6417.2	1:1.00
	Lion Brand..............	12	5896.7	5465.8	1:0.93
	Imperial	12	6373.0	6551.4	1:1.03
	Kleinwanzlebener No. 2..	2	1179.3	1247.4	1:1.00
	Vilmorin No. 2............	2	2404.0	3197.8	1:1.33
October 13............	Kleinwanzlebener.........	30	22180.4	22248.7	1:1.00
	Vilmorin...........	30	16147.7	19681.1	1:1.23
	Lion Brand................	30	17894.1	20991.6	1:1.17
	Lane's Imperial	30	11121.3	29316.7	1:2.55
	Imperial	30	17718.7	18665.2	1:1.06
	Kleinwanzlebener No. 2..	8	6576.8	7166.7	1:1.09
	Vilmorin No. 2............	8	4266.7	5802.7	1:1.35

The samples taken October 13 represent the mature crop for my plot, and, also, for the Farm plots, given in the table as Kleinwanzlebener No. 2, and Vilmorin No. 2. Omitting the Lane's Imperial, because of its exceptional ratio, and the fact that it grows out of the ground to a very considerable extent, whereas the others do not, we have the following figures, representing our sugar beets for the season of 1897: 136 beets grew 84784.4 grams of tops, equal to 624.2 grams, 22 ounces, of leaves per beet. The roots weighed 94556.0 grams, an average of 695.2 grams, equal to 24.5 ounces. The ratio of the weight of the tops to the weight of the beets is as 1:1.12.

The ratio of the weight of the tops to that of the beets, for the same varieties, deduced from the weights taken in the field, was 1:1.14. The ratios for the five varieties deduced from the yield as given under that head, are as follows:

Kleinwanzlebener	1:1.274;	weight of tops = 78.5 per cent. of weight of beets
Vilmorin	1:1.087;	weight of tops = 92.0 per cent. of weight of beets
Lion Brand	1:1.157;	weight of tops = 86.4 per cent. of weight of beets
Lane's Imperial	1:2.239;	weight of tops = 44.6 per cent. of weight of beets
Imperial	1:1.113;	weight of tops = 89.8 per cent. of weight of beets

The tops and beets were both weighed while entirely fresh. The beets were taken and handled in such manner that we lost none of the leaves. In the other samples the leaves were taken at the base of the leaf, but none of the crown was taken. This was weighed with the beet. The change in the ratio of the leaves to the beets, by weight, is due to both the increase in the weight of the beet and to the decrease in the weight of the tops; the average weight of the leaves for one beet, on September 22, was 742; on October 13, 623.4 grams.

Persons familiar with the growth of the sugar beet elsewhere, remark, upon seeing ours, that they grow very vigorous tops. The weights corroborate the judgment. If the relative weights of the tops and beets were an applicable measure of the quality of our beets, they should be very good, indeed, and I believe them to be such; for I think that careful investigation will establish the fact, that it is a very good beet, which, in a perfectly fresh condition, will show a sugar content of 12.5 per cent. We have had individual beets, analyzed immediately upon being removed from the ground, to run as high as 15.5 per cent. sugar, but they do not all run that high, and an individual beet of high excellence does not make the crop excellent.

The ratio between the weight of the leaves and that of the roots of the sugar beet, as grown here, is so entirely different from that given for other localities, that we evidently cannot safely accept their data, as applying to our conditions. The same is true in regard to the size of the beets. I doubt whether a crop of sugar beets can be grown on ground, really suitable for their cultivation, with an average weight, per beet, of less than two pounds. But it does not follow that they will be low in percentage of sugar, or in purity. I have received, from time to time, several samples of large beets carrying a fair percentage of sugar, and of a satisfactory purity, one beet weighing about 5 pounds, which I analyzed simply because it was so large, carried 14.0 per cent. sugar, with a co-efficient of 88, and I received three samples from another party, who excused himself for sending such large beets, but said that they were as near an average as he could get. The largest beet had been cut off at both top and bottom, so that there remained only the middle portion of the beet—this weighed 4.6 pounds. It was in excellent condition, the sugar present was 14.9 per cent., purity 81.2. The smallest beet weighed 3 pounds, and showed 12.1 per cent. sugar, purity 81.8.

These may give an idea of the exceptions to the general rules, as laid down for the sugar beet, with which we frequently meet. I do not know how the weight of the tops of these large beets compares with that of the roots, but evidently it must be less than in smaller beets. I have noticed in all of these cases that the crown is broad and full.

The observations were extended over a sufficient time, and enough of them made to give us conclusive data as to the relative weights of the tops and the roots, and also as to the rate of the increase of both, during the last six weeks of the season. On September 2, we find the average weight of the tops, for the four varieties of beets, *i. e.*, Kleinwanzlebener, Vilmorin, Lion Brand, and Imperial, to be 614.8 grams, or 21.5 ounces. We find the average for the tops of the same varieties, on October 13, 624.8 grams, or 22.0 ounces; in other words, the gain, if any, in the weight of the tops was very small, only one half ounce per beet; on the other hand, the average weight of the beet increased from 421.8 grams, or 14.9 ounces, to 695.2 grams, or 24.5 ounces—an increase of 9.6 ounces per beet, or 0.64 of its weight, on September the 2nd.

There is no material difference in the ratios for beets from the strongly alkalized ground, and from that practically free from it. The slight difference which exists shows the tops to be relatively heavier on the alkalized ground.

The maximum sugar content in the beets was reached as soon in the one case as in the other, and there was but a slight difference between the maxima. The weights of the beets and the percentage of sugar present at the various dates give us the rate of the deposition of the sugar. Both the increase in the crop and in the percentage of sugar, must be taken into consideration. In the case of our beets, it will be seen that, about one third of the sugar, in pounds per acre, was deposited between October the 6th and the 13th.* The same fact is observable in regard to the Farm plots, except that in the case of the Kleinwanzlebener variety, the increase in percentage, corresponding to the maturing of the plant, took place one week

* The average weight of the beets on October 6 was 20.2 ounces, and the percentage of sugar was 10.15 per cent.

earlier. I was unable to discover any assignable reason for this. I thought, perhaps, the absence of alkali might be the cause, but a study of the ash of these beets made me abandon this idea, and I have no explanation beyond the record that it is a fact.

THE DRY MATTER IN THE BEETS.

The dry matter was determined in three sets of samples, taken at intervals of two weeks, beginning on the 2nd of September, and other determinations were made with samples taken as late as December 10. The number of beets has been taken as large as practicable, in order to obtain results from which the variation in the individual beets has been, for the most part, eliminated. This is quite necessary, as this variation amounts to as much as 8 per cent. in beets pulled on the same date and treated similarly. It is, of course, understood that the weight of the air-dry matter, in any organic substance, cannot be made with the same satisfactory sharpness that the moisture in an iron ore can be made. The statement that individual beets, of the same variety, and harvested on the same date, may vary as much as 8 per cent., is based upon carefully made determinations, and probably gives the range of the dry matter in sugar beets, *i. e.*, from 17–25 per cent. The dry matter in the fodder beets is much lower, and the statement just made is not applicable to them.

The table on page 31 exhibits the development of the dry matter in the crops grown on alkalized, and, also, on other ground. I have appended some determinations, made at later dates, and, also, of other varieties of beets, all grown on the College Farm.

The column of percentages shows, very clearly, the difference between the sugar beets and the larger growing stock beets. The latter containing about 14 per cent. dry matter, and the former 18 per cent.

In regard to the Lane's Imperial, it may be proper to state, that I know nothing about the history of the seed. While it may be a true Lane's Imperial, it is certainly not a good strain, and was evidently mixed. I do not mean that it was mixed by seed of other varieties being mingled with it, but had been grown from hybridized beets. This strain attained a maximum percentage of 10.14 per cent. of sugar early in the season, and did not increase materially in the percentage of sugar after September the 22nd.

The amount of dry matter in sugar beets grown on alkali soil is a little lower than in the other samples, the Kleinwanzlebener and Vilmorin marked No. 2. This seems to have been the case throughout the season. The difference, however, is not always in favor of the higher ground, and is not so decided as one could wish it to be in order to base a conclusion upon it. On October 13, for instance, the total dry matter in my samples ranged from 16.69–

18.01 per cent., while the two varieties grown on ground free from alkali, showed 17.5–18.8 per cent., the latter was the Kleinwanzlebener, from the Farm plot. But I am in doubt whether this higher figure is not an accident, as I obtained for beets from the same plot, December 10, only 17.48 per cent.; this, however, is a little higher than the same variety from my plot showed.

AIR-DRY SUBSTANCE IN SUGAR BEETS.

Date.	Variety.	Number of Beets Taken.	Weight of Green Beets. Grams.	Weight of Dried Beets. Grams.	Per Cent. of Air-dried Substance,
September 2..........	Kleinwanzlebener........	12	5803.5	730.0	12.58
	Vilmorin..................	15	6092.6	675.5	11.08
	Lion Brand	14	7226.4	892.5	12.35
	Lane's Imperial	12	8777.0	775.5	8.84
	Imperial	15	4995.0	794.5	15.90
	Kleinwanzlebener No. 2..	5	3356.2	447.5	13.33
	Vilmorin No. 2...........	5	1942.4	283.0	14.62
September 22..........	Kleinwanzlebener.........	12	9377.9	1646.0	17.55
	Vilmorin............... ..	13	9956.3	1587.0	15.94
	Lion Brand............ .	14	7745.1	1373.0	17.73
	Lane's Imperial...........	16	10863.5	1458.0	13 42
	Imperial....................	14	7869.7	1400.0	17.79
October 13.............	Kleinwanzlebener.........	18	15603.5	2605.5	16.69
	Vilmorin..................	18	13965.9	2385.0	17.08
	Lion Brand..............	18	15095.0	2718 5	18 01
	Lane's Imperial...........	18	18834.6	2686.0	14 24
	Imperial....................	18	12519.0	2228.5	17,80
	Kleinwanzlebener No. 2...	6	5715.2	1074.5	18.80
	Vilmorin No. 2............	6	4419.7	773.5	17 50
October 21............	Lane's Imperial...........	....	2640.0	373.0	14.13
	Large Pink Beets †........	....	8067.0	982.0	12.25
October 29.............	Lane's Imperial...........	....	5500.0	739.8	13.45
	Long Red Mangoldwurzel	....	4500.0	641.6	14.28
	Yellow Globe............	....	3850 0	536 3	14.63
December 10...........	Kleinwanzlebener No. 2...	6	7170.0	1241.5	17.48
	Vilmorin No 2*...........	6	8364.0	1709.0	20.43

† The variety unknown. The seed was purchased as Lane's Imperial.
* This sample was taken from the root cellar, where it had lain about five weeks.

I have showed that about 17 per cent. of the crop is formed during the last two weeks of the growing season, also that about 33 per cent. of the total weight of the sugar was deposited during the last week or ten days, but we fail to observe any such increase in the total dry matter of the crop. From September 22 to October 13, there is an average increase in the percentage of sugar present of, say, 3 per cent., and the crop increase was still greater; but the total dry matter is practically the same, only one variety showing an increase of 1 per cent., while another shows a decrease of almost as much, 0.86 per cent. The evident explanation is, that there is a transformation of some of the solids during this period. The following table gives the amount of this transformation between September 22 and October 13, for the four varieties of sugar beets grown on my plot.

THE AMOUNT OF DRY MATTER OTHER THAN SUGAR TRANSFORMED.

Date.	Variety.	Average Weight of Beets. Grams.	Per Cent. of Total Air-Dried Solid.	Per Cent. of Sugar.	Grams of Air-Dried Solids.	Grams of Sugar.	Grams of Solids Other than Sugar.	Per Cent. of Solids Other than Sugar.
September 22........	Kleinwanzlebener	781.50	17.55	8.37	137.15	65.41	71.74	9.18
	Vilmorin..........	765.80	15.94	7.71	134.10	59.04	75.10	9.08
	Lion Brand........	553.20	17.73	8.41	98.00	46.53	51.50	9.11
	Imperial...........	562.10	17.79	10.22	100.00	57.50	42.50	7.56
October 13...........	Kleinwanzlebener	866.80	16.69	11.76	144.80	103.30	41.50	4.79
	Vilmorin..........	775.90	17.08	10.94	142.50	84.90	57.60	7.42
	Lion Brand........	838.80	18.01	12.76	151.00	107.40	43.60	5.19
	Imperial...........	695.50	17.80	13.65	123.60	94.90	28.50	4.09

The same relations hold good for the percentage of total solids, not sugar, in the Kleinwanzlebener and Vilmorin varieties from the Farm plots on the 13th of October, as is shown in the above table for the other samples. They have been omitted because the data for September 22 were lost. The above series includes representatives of my whole plot, though, as I have pointed out elsewhere, a portion of the beets might, and perhaps ought to be, excluded, because of the excessive wetness and very bad tilth of the ground in which they grew. Still they do not obscure the general rule that there is a very materially less quantity of solids, not sugar, on October 13 than there was on September 22. It would be interesting to establish what this loss may be due to, and what the nature of the total solids, which disappear, may be.

The leaves have been supposed to play an important part in the formation of the sugar in the beet; indirectly they may, but I believe that the disappearance of the solids, not sugar, is the equivalent, in weight, of the compounds already stored in the beet, and whose rapid change into sugar takes place at the maturation of the beet. There is only one other explanation which suggests itself to me; that is, that the ash constituents are either eliminated from the beet, or migrate to the leaves. This, however, is not the case. Fortunately, the answer is of such a character, that it matters not what the movement of the ash constituents in the plant may be, or whether elimination be taking place or not. The answer is simply this: The percentage of ash in the dry matter of the mature beet is not less than in the green beet, and the amount of ash in the beets on October 13, was greater than on September 22, which the following examples will show: On September 22 an average beet of the Kleinwanzlebener variety, contained 71.74 grams dry matter, not sugar, of this 9.92 grams was ash; on October 13 an average beet, weighing more than on the previous date, contained only 41.50 grams of dry matter, other than sugar, and of this 10.97 grams was ash. In the case of the other varieties, the amount of ash present on October 13 was either greater or practically equal to the amount present on September the 22nd; so the suggestion of elimination of ash has no weight. The weight of the leaves, per beet, is actually less on the ripe beet than on the green one. For instance, I found their weight about 120 grams per beet less, on October 13, than they were on September 22. This corresponds to an actual loss of dry matter, as the percentage of dry matter in the leaves is the same for the two dates, and the same is true for the percentage of ash; so there was an absorption of dry matter and ash constituents by the root during this period. The loss of weight in the leaves, green weight, is very nearly equal to the gain in weight in the beets. This may, in this case, be an accident, but, as it is the average of 105 beets, it is suggestive.

As I have not, up to the present time, examined the leaves for sugar, it is an open question whether this corresponds to the elaboration of sugar by the leaves. But, in consideration of the actual disappearance of dry matter from the beet, accompanied by an increase of the ash and sugar, I believe it points to the elaboration of formative compounds which pass into the beet, and are there transformed into sugar. The observations of Dr. Maxwell, on the deportment of soaked beets, would be easily explicable if this were the manner in which the sugar is formed, but otherwise one must subscribe to the doubt expressed by Dr. Wiley when he says: "The whole science of vegetable physiology and chemistry teaches that sugar is elaborated in the leaves of the beet plant by the condensation of formylaldehyde, which is produced by the action of the chlorophyl cell upon carbon dioxid and water. The beet itself has always been regarded simply as a storehouse, in which the elaborated sugar is conserved for the future use of the plant."

Dr. Maxwell's experiments are given in detail, and show that an actual formation of sugar took place in the beet during the seven days submergence. This seems, to me, to suggest the cause for the diminution of total solids, other than sugar, concurrent with the somewhat sudden increase in the amount of sugar present. It seems much more probable that so large an amount of sugar, as is developed within the brief period of ripening, should be produced from material already stored up in the beet, than by the activity of a dying leaf.

THE DRY MATTER IN THE RESPECTIVE THIRDS.

We have seen that there is only a slight difference in the sugar present in the respective thirds of the beet, taken by weight, and that this difference is so small and irregular that a large number of determinations would be required to establish its value. The same is true of the total dry matter in the beets. There is a small excess in the upper third. This varies in individual beets, but seems to be constant for the different varieties. The following table records the results:

Number of Beet.	Number of Third.	Kleinwanzlebener.		Vilmorin.		Average Per Cent. of Dry Matter.
		Oct 21. Per Cent. Dry Matter.	Dec. 10. Per Cent. Dry Matter.	Oct. 21. Per Cent. Dry Matter.	Dec. 10. Per Cent. Dry Matter.	
1	1	19.93	17.72	25.23	23.22	21.52
1	2	17.52	17.72	24.31	22.58	20.53
1	3	17.85	16.20	25.68	20.64	20.09
2	1	18.32	17.94	25.60	22.70	21.14
2	2	16.60	20.52	24.23	22.86	21.05
2	3	16.79	16.50	24.23	23.21	20.18
3	1	22.17	19.37	22.07	20.45	21.01
3	2	21.91	18.40	21.38	20.30	20.50
3	3	21.15	17.19	21.72	20.60	20.16
4	1	21.50	17.32	20.68	19.56	19.76
4	2	19.20	16.98	20.68	19.78	19.16
4	3	19.54	17.20	20.68	19.78	19.30
5	1	19.68	18.26	21.42	20.22	19.90
5	2	18.63	17.82	20.78	19.77	19.25
5	3	19.68	17.17	22.08	19.85	19.69
6	1	20.58	19.48	22.43	20.00	20.62
6	2	19.42	19.12	19.85	19.02	19.35
6	3	18.55	17.87	20.54	20.24	19.30

The average dry matter contained in these two varieties, on December 10, has already been given, as, 17.48 and 20.43 per cent., respectively, and the table corroborates the existence of a difference between the two varieties in this respect.

The quantity of dry matter is quite uniformily greater in the first third than in either of the others, while there is but little difference between the quantities present in the other two thirds. The dry matter, however, is so uniformly distributed throughout the beet that it requires the taking of the general average to make the law of its distribution evident. In an instance like this, the question, What does air-dry mean, ought to be anticipated. Determinations of moisture, in other samples, made by drying to constant weight, at the temperature of boiling water, showed an average water content of about 2 per cent. This determination is tedious, and somewhat unsatisfactory, but after trying the air bath at various temperatures I adopted the water oven, and heating to constant weight, as the most satisfactory.

Other varieties of beets, particularly stock beets, were experimented with and showed results identical with those recorded in the table, except, of course, that the percentage of dry matter is much lower.

THE MARC.

This is what is left of the beet after the sugar and other substances, soluble in water, have been removed. The extent to which the soluble portion of the beets is removed determines the percentage of marc. This percentage is assumed to be about 5 per cent. My samples were grated, or rasped, and washed with more care than can be given them on a manufacturing scale, and this, probably, is the reason that my figures are slightly below 5 per cent. This was not the case when the beets were simply sliced. The experiments were made to determine the effect of irrigation upon the amount of marc present; also, to study the ash constituents left in this by-product of sugar making.

The average of six determinations, using the Vilmorin variety, was 4.21 per cent.; the average of five determinations, made with the Kleinwanzlebener, was 4.38 per cent. Both of these series were raised with irrigation. Only one lot of beets, grown without irrigation, was tested to determine the marc, and this gave 5.25 per cent. I do not think that this result, though a large sample was taken, is conclusive that beets grown without irrigation really contain more marc than irrigated beets.

THE FODDER ANALYSES OF BEETS.

It is not my purpose to discuss the feeding value of either the roots or leaves of the beets. The value of the roots, for feeding purposes, is fully understood, as also the conditions under which their feeding produces the most favorable results. The primary object of the analyses on page 37 was to discover the effect of the different soils upon the feeding value, and, at the same time, to study the differences due to varieties, if such should be discovered. The samples are parts of the larger samples taken on October 13, and which were used for the other data given throughout this bulletin. All data given for beets, taken October 13, are for the same general sample, and are comparable. The numbers, 1, 2, 3, have the same significance that they have in the table showing the amount of sugar, from week to week. 1, is good soil; 2, is good soil, quite rich in alkali; 3, is soil in bad tilth and rich in alkali, but no more so than 2. The analyses, given in the table, were made in duplicate, but averages are given to save space; the limits of variation allowed were 0.02 per cent. for nitrogen, 0.2 for the other determinations, except for crude fibre, for which 0.4 was admitted.

Analyses Nos. 1, 2, and 3, are of samples grown on excellent ground, and free from alkali. The analyses are intended as standards of comparison by which to measure the effect of our alkali. Analyses Nos. 19 and 20, are of leaves from the same beets, and are taken as standards of comparison for the leaves.

An examination of the table giving the percentage of sugar present in the beets, from the different sections of the plot, will show more clearly than the few percentages given, that the samples from sections Nos. 1 and 2, were quite as rich in sugar as those taken from the Farm plots, which we used as standards. But the samples from section No. 3 almost always showed a lower percentage of sugar. As stated elsewhere, section No. 2, of the plot, shows, upon analysis, more alkali per acre than the other sections, but its sugar content is uniformly high; therefore, I have left it as an open question whether the depression of the sugar percentage in the samples from section No. 3 was due to the alkali, or to general conditions with which the presence of the alkali has but little or nothing to do. This uncertainty is not present in these results. The beets grown on the alkalized soil contain more ash and more crude portein, and less nitrogen free extract. They are better beets for feeding, but not so good for sugar making.

The difference in the leaves is confined to a small excess in the percentage of ash in the samples from the alkali soil.

Analysis No. 10 is of a sample received from New Mexico. The soil on which it was grown is a fine prairie loam, and the sugar content, when received by us, was 17.25 per cent. Owing to the excellent character of the soil, and its richness in sugar, I used it as a futher standard, and it agrees, within quite narrow limits, with the samples from the Farm plots.

FODDER ANALYSES.

Sugar Beets.

Number.	Date.	Variety.	Section of Plot.	Moisture.	Ash.	Ether Extract.	Crude Portein.	Crude Fibre.	Nitrogen Free Extract.	Total Nitrogen.	Per Cent. of Sugar.
1	October 13.....	Kleinwanzlebener.....	Farm	1.325	5.510	0.317	6.429	7.212	79.207	1.029	12.32
2	October 13.....	Vilmorin..	Farm	1.662	5.469	0.378	8.578	8.515	75.398	1.372	13.02
3	October 29.....	Kleinwanzlebener.....	Farm	6.620	3.707	0.421	4.944	4.696	79.612	0.791	.....
4	October 13.....	Kleinwanzlebener.....	1	1.709	7.435	0.439	10.975	11.502	67.940	1.756	12.15
5	October 13.....	Kleinwanzlebener.....	2	1.319	6.491	0.674	9.391	7.427	74.698	1.501	14.70
6	October 13.....	Kleinwanzlebener	3	1.565	8.836	0.507	11.756	13.527	63.809	1.881	8.44
7	October 13.....	Vilmorin...	1	1.734	7.723	0.745	10.180	13.111	66.507	1.629	12.49
8	October 13.....	Vilmorin...............	2	1.897	6 561	0.721	9.689	8.054	73.078	1.550	10.13
9	October 13.....	Vilmorin..............	3	2.879	7.109	0.300	8.586	6.164	74.962	1.374	10.21
10	....	Kleinwanzlebener *...	....	2.969	5.344	0.408	7.028	5.655	78.596	1.124	17.25
					Marc.						
11	November 8...	Kleinwanzlebener.....	Farm	4.490	4.542	0.272	5.541	23.122	62.033	0.886	.....
12	January 8......	Kleinwanzlebener.....	Farm	7.490	4.365	0.393	5.673	22.603	59 476	0.907	.....
13	January 8......	Vilmorin......	Farm	3.282	4.189	0.230	5.719	23.028	63.552	0.915	.....
					Fodder Beets.						
14	October 13.....	Lane's Imperial.......	1	2.035	7.239	0.360	6.789	5.999	77.578	1.086	11.25
15	October 13.....	Lane's Imperial.......	2	1.405	7.756	0.398	8.835	7.528	74 078	1.413	9.91
16	October 13.....	Lane's Imperial.......	3	2.130	9.361	0.480	10.487	11.552	65.990	1.678	9.21
17	October 21.....	Long Red Mangold....	Farm	1.313	7.280	0.422	6.172	6.033	78.780	0.987	.....
18	October 21.....	Large Pink............	Farm	3.417	8.983	0.453	8.322	6.016	72.809	1.335	.....
					Leaves—Sugar Beets.						
19	October 13.....	Kleinwanzlebener	Farm	3.435	20.671	1.790	16.642	12.103	45.449	2.663	....
20	October 13.....	Vilmorin...........	Farm	2.477	26.429	3.066	18.781	12.425	36.822	3.005	.....
21	October 13.....	Kleinwanzlebener.....	1	3.621	24.849	2.567	16.142	10.884	41.937	2.582	.....
22	October 13.....	Kleinwanzlebener.....	2	2.371	27.850	2.666	17.221	10.665	39.227	2.755	.....
23	October 13.....	Kleinwanzlebener.....	3	2.299	27.000	2.521	21.560	11.648	34.972	3.450	.....
24	October 13.....	Vilmorin..............	1	3.298	25.049	2.505	16.509	12.261	40.378	2.641	.....
25	October 13.....	Vilmorin.............	2	2.385	29.588	3.550	18.654	11.141	34.682	2.985	.....
26	October 13.....	Vilmorin............	3	2.442	27.620	2.553	19.593	10.460	37.442	3.137	.....
					Leaves—Fodder Beets.						
27	October 13.....	Lane's Imperial......	1	2.544	27.639	2.708	13.715	12.852	40.542	2.194	.....
28	October 13.....	Lane's Imperial.......	2	2.530	31.052	3.652	15.722	11.737	35.307	2.516	.....
29	October 13.....	Lane's Imperial.......	3	2.825	27.932	2.199	18.893	11.706	36.445	3.023	.....
30	October 13.....	Chard's	....	2.382	22.533	1 495	12.546	11.206	49.835	2.007	.....

* Grown in New Mexico.

The difference between the beets from the two soils, will, perhaps, be more easily understood from the statement that the average ash and crude protein percentage in the beets grown on soil free from alkali, is 5.03 and 7.36, respectively, while they are 6.75 and 10.10 for these constituents in the other samples; the proteids are nearly 3 per cent. higher in the beets grown in the presence of the alkali.

The composition of the marc exhibits the fact that five sixths of the crude protein is removed by the diffusion, and about four fifths of the ash. The feeding value of the dry marc is, pound for pound, but a little inferior to the dry sugar beet, others make it slightly better. It may be safe to estimate it as about equal, but it must be kept in mind that it takes 400 pounds of dry beets, or one ton of green beets, to yield 100 pounds of dry pulp or marc.

The dry matter from the leaves is exceedingly rich in crude protein, and were it not for the large percentage of ash present would, doubtlessly, make a good fodder. The green leaves contain about 10 per cent. of dry matter, and 2.7 per cent. ash. I have had no experience in feeding green beet leaves, but it would seem to be a question whether the ingestion of so large an amount of ash constituents, largely potash and soda salts, would be beneficial.

The analyses of the fodder beets are interesting, but in estimating their value it must be remembered, that the fresh beet contains from 86–88 per cent. of water, against 79–82 per cent. in the sugar beet.

The chards were analyzed, purely as a matter of interest. I cultivated them in the hope that I would find them more effective in removing soda salts from the soil than the beets. I was disappointed; they did not endure the soil conditions nearly as well as the beets, and the dry matter in the tops contained less ash than the beet leaves. I expected them to produce an immense crop of leaves, but they did not. If success is to be attained by growing a heavy crop of foliage, rich in ash carrying much soda, some other plant than the chard must be chosen.

The percentage of crude fibre in the beets is very irregular, but is uniformly higher in the beets from the alkalized ground than in the others. In the leaves the contrary is noticeable, the percentage of crude fibre being quite constant. The nitrogen free extract is also quite uniform in quantity. The effect of the alkali is greater upon the composition of the beets than upon that of the leaves.

The increase in the proteids is probably due to the presence of nitrates in the ground water. The amount of nitrogen in the soils of my plot is small, varying from 0.04 to 0.065 per cent. The ground water, on the other hand, contains appreciable quantities of nitric acid. The amount of total solids in the ground water varies with the different wells, and at different times. The nitric acid, calculated as potassic nitrate, usually corresponds to about 0.20 per cent. of the total solids, often more, and sometimes much more.

The letters, A, B, C, D, in the following table, represent four wells at points 150 feet apart, on a line running through the centre of my plot; they are sunk to the gravel bed. E is a well to the east of my plot in a piece of ground which has been heavily fertilized with sheep manure, but is about 100 feet west of an underdrain; in other respects the following table explains itself:

POTASSIC NITRATE IN THE GROUND WATER.

	Date.	Total Solids per Million.	Percentage of KNO_3 in Total Solids.
Well A	July 12, 1897	4440.0	0.74
Well A	September 20, 1897	2789.1	0.32
Well B	September 20 1897	3985.7	0.16
Well C	September 20, 1897	2561.4	0.37
Well D	September 20, 1897	3407.1	0.37
Well F *	September 21, 1897	2187.0	0 83
Well E	September 20, 1897	807.1	0.092

* This sample was taken below the gravel in a newly opened well.

I have given the potassic nitrate in one set of samples taken about 23 days before the crop was harvested, which shows that the beets had access to an abundant supply of nitrates, and one greatly in excess of that present in the soil proper.

THE PERCENTAGE OF ASH IN THE BEETS.

The fodder analyses, given on a preceding page, indicate that the general effect of alkali is to increase the percentage of ash in the beets grown on ground affected by it. An attempt to establish this as a general fact, and to follow the accumulation of the ash in the beet plant, is recorded in the following paragraph.

The samples were carefully prepared for this purpose, and any exceptional percentages, appearing in the table, cannot be attributed to the presence of sand. The figures represent pure ash. The number of beets taken as a sample was usually four, in a few cases I took more. The leaves in every case correspond to the beets of that variety taken on the same date and from the same section of the plot.

PERCENTAGE OF ASH.

Sugar Beets.

Date Harvested.	Variety.	Section.	Per Cent. Insoluble Ash.	Per Cent. Soluble Ash.	Per Cent. Ash.	Per Cent. Ash in Green Substance.	Per Cent. Dry Substance in Sample.
September 2...	Kleinwanzlebener............	Farm	1.5166	5.3318	6.8484	0.9129	13.33
September 2...	Vilmorin.....................	Farm	1.4190	5.9604	7.3794	1.0346	14.02
September 2...	Kleinwanzlebener............	1	1.5360	4 8770	6.4130	0.7913	12.34
September 2...	Kleinwanzlebener............	2	1.9090	9.1710	10.0800	1.3191	13.10
September 2...	Kleinwanzlebener............	3	1.7610	9.0640	10.8250	1.2806	11.83
September 2...	Vilmorin.....................	1	2.0589	8.5761	10.6350	1.2007	11.29
September 2...	Vilmorin.....................	2	2.0714	7.4660	9 5390	1.2961	13.59
September 2...	Vilmorin.....................	3	1.8998	3.5569	5.4567	0.7187	13.17
September 2...	Lion Brand..................	1	2.3468	9.8608	12.2076	1.3380	10.96
September 2...	Lion Brand..................	2	2.1531	7.4155	9.5686	1.2583	13.15
September 2...	Lion Brand..................	3	2.0873	8.1086	10.1959	1.3479	13.22
September 2...	Imperial.....................	1	....	....	9.0543	....	....
September 2...	Imperial.....................	2	....	....	7.0858	0.8843	12.48
September 2...	Imperial.....................	3	....	....	7.5097	1.2063	15.93
September 22..	Kleinwanzlebener....	1	1.2020	4.0616	5.2604	0.9952	18.92
September 22..	Kleinwanzlebener............	2	1.4228	5.0375	6.4603	1.2604	19.51
September 22..	Kleinwanzlebener.......	3	1.5416	8.4357	9.9773	1.3390	13.42
September 22..	Vilmorin.....................	1	1.4072	6.6911	8 0983	1 2086	14.93
September 22..	Vilmorin.....................	2	1.3492	5.5881	6.9373	1.2902	18.45
September 22..	Vilmorin.....................	3	....	....	9.8277	1.3958	14.20
September 22..	Lion Brand..................	1	1.2450	5.5804	6.8254	1.2038	17.37
September 22..	Lion Brand.............	2	1.3322	4.1254	5.4576	1.1689	21.44
September 22..	Lion Brand..................	3	1.8732	8.1285	10.0017	1.6680	16.68
September 22..	Imperial.....................	1	1.3129	6.2825	7.5954	1.2785	16.83
September 22..	Imperial.....................	2	1.3198	4.9655	6.2853	1.3111	20.86
September 22..	Imperial.....................	3	1.7768	6.9175	8.6943	1.3850	15.93
October 13.....	Kleinwanzlebener............	Farm	1.5768	3.9330	5.5098	1.0525	18.80
October 13.....	Vilmorin.....................	Farm	1.3115	4.1579	5.4694	0.9572	17.50
October 13.....	Kleinwanzlebener............	1	1.5620	5.8727	7.4347	1.2792	17.26
October 13.....	Kleinwanzlebener............	2	1.3885	5.1026	6.4911	1.1742	18.09
October 13.....	Kleinwanzlebener......... ...	3	1.5594	7.2770	8.8364	1.3350	15 11
October 13.....	Vilmorin.....................	1	1.4230	6.2996	7.7226	1.2539	16.24
October 13.....	Vilmorin	2	1.4040	5.1560	5.5606	1.1439	18.96

PERCENTAGE OF ASH—(Continued.)

Sugar Beets.

Date Harvested.	Variety.	Section.	Per Cent. Insoluble Ash.	Per Cent. Soluble Ash.	Per Cent. Ash.	Per Cent. Ash in Green Substance.	Per Cent. Dry Substance in Sample.
October 13.....	Vilmorin.....................	3	1.3628	5.7462	7.1090	1.2204	17.17
October 13.....	Lion Brand....................	1	1.7794	4.8050	6.6044	1.2548	19.12
October 13.....	Lion Brand....................	2	1.4504	4.2645	5.7149	1.1132	19.49
October 13.....	Lion Brand....................	3	1.9505	7.7976	9.7481	1.3928	14.87
October 13.....	Imperial	1	1.4225	5.6254	7.0479	1.2672	17.98
October 13.....	Imperial......................	2	1.2384	3.7372	4.9756	1.0866	21.84
October 13.....	Imperial......................	3	1.9918	8.6668	10.6586	1.4495	13 60
September 2...	Marc, Kleinwanzlebener......	....	3.0214	1.3440	4.3654	....	....
September 2...	Marc, Kleinwanzlebener......	....	1.6100	2.6400	4.2500	....	....
September 2...	Marc, Kleinwanzlebener......	....	....	....	5.0700	....	....
November 11...	Marc. Kleinwanzlebener......	....	....	....	4.4600	0.2283	....
December 31...	Crowns, Vilmorin............	....	1.4188	3.1696	4.5884	1.1201	22.23
December 31...	Crowns, Vilmorin............	....	1.1938	3.1358	4.3296	....	....
....	French Seed..................	N. M.	....	....	5.5280	1.1498	20.80
....	Kleinwanzlebener............	N. M.	....	....	4.4950	1.0910	24.27
....	Kleinwanzlebener............	N. M.	....	....	5.0020	1.0700	21.40
....	Kleinwanzlebener............	N. M.	....	....	6.2070	1.2960	20.88
....	Kleinwanzlebener............	Farm	....	....	5.2740	1.0070	19.09
....	Kleinwanzlebener............	....	....	....	5.3780	1.1430	21.25

Fodder Beets.

Date Harvested.	Variety.	Section.	Per Cent. Insoluble Ash.	Per Cent. Soluble Ash.	Per Cent. Ash.	Per Cent. Ash in Green Substance.	Per Cent. Dry Substance in Sample.
September 2...	Lane's Imperial...............	1	1.7773	10.2727	12.0500	0.9627	7.99
September 2...	Lane's Imperial...............	2	1.4668	8.4832	9.9500	0.9044	9.09
September 2...	Lane's Imperial...............	3	1.8504	13.1343	14.9847	1.3456	8.98
September 22..	Lane's Imperial...............	1	1.3232	8.2042	9.5274	1.2509	13.13
September 22..	Lane's Imperial...............	2	1.2995	7.0603	8 3598	1.1586	13.86
September 22..	Lane's Imperial...............	3	1.5112	6.7253	8.2365	1.1939	13.28
October 13.....	Lane's Imperial....	1	1.0732	6.1653	7.2385	1.1371	15.71
October 13.....	Lane's Imperial...............	2	1.2907	6.4652	7.7559	1.1370	14.66
October 13.....	Lane's Imperial...............	3	1.8025	7.5582	9.3607	1.1214	11.98
October 29.....	Lane's Imperial...............	Farm	0.9305	6.5277	7.4582	1.0031	13.45
October 29.....	Yellow Globe.................	Farm	1.0685	7.0353	8.1038	1.1855	14.63
October 29.....	Long Red Mangold...........	Farm	1.1811	6.8990	7.2801	1.0395	14.25
November 11..	Large Pink Beets............	Farm	1.1551	7.8267	8.9826	1.2692	14.13

PERCENTAGE OF ASH—(Continued).

Leaves—Sugar Beets.

Date Harvested.	Variety.	Section.	Per Cent. Insoluble Ash.	Per Cent. Soluble Ash.	Per Cent. of Ash.	Per Cent. of Ash in Green Substance.	Per Cent. of Dry Matter in the Sample.
September 2...	Kleinwanzlebener............	Farm	6.0100	18.9042	24.9142	3.3206	13.33
September 2...	Vilmorin......................	Farm	5.6108	22.8132	28.4240	2.4121	12.01
September 2...	Kleinwanzlebener............	1	6.1427	21.6657	27.9084	2.3206	8.35
September 2...	Kleinwanzlebener............	2	5.7396	24.4700	30.2096	2.4680	8.17
September 2...	Kleinwanzlebener	3	4.8003	22.5977	27.3980	2.2581	8.24
September 2...	Vilmorin......................	1	4.8149	22.2602	27.0751	2.2174	8.19
September 2 ..	Vilmorin......................	2	5.6923	22.5583	28.2506	2.4493	8.67
September 2...	Vilmorin......................	3	5.7813	24.8516	30.6329	2 7630	9.02
September 2...	Lion Brand	1	4.8236	23.0358	27.8594	2.0805	7.47
September 2...	Lion Brand	2	5.3696	21.8552	27.2248	2.3557	8.65
September 2...	Lion Brand	3	5.7520	23.8686	29.6206	2.6373	8.94
September 2...	Imperial	1	5.6692	21.8643	28.5335	2.0800	7.29
September 2...	Imperial	2	5.9602	21.4842	27.4444	2.5495	9.29
September 2...	Imperial	3	5.5796	23.1323	28.8919	2.5713	8.90
September 22..	Kleinwanzlebener............	1	3.4194	19.2906	22.7100	2.0498	11.00
September 22..	Kleinwanzlebener............	2	3.3376	23.4965	26.8341	2.8559	10.64
September 22..	Kleinwanzlebener	3	3.7002	21.1696	24.8698	2.5049	10.07
September 22..	Vilmorin......................	1	4.7782	21.4531	26.2313	2.5732	9.81
September 22..	Vilmorin......................	2	4.0478	21.8570	25.9048	2.6099	10.07
September 22..	Vilmorin......................	3	4.0378	21.5575	25.5953	2.6448	10.33
September 22..	Lion Brand	1	3.2416	19.7522	22.9938	2.5293	11.00
September 22..	Lion Brand	2	3.9410	18.2716	22.2126	2.7654	12.45
September 22..	Lion Brand	3	4.0769	22.3222	26.3991	2.3830	9.03
September 22..	Imperial	1	3.3407	21.5265	24.8672	2.5737	10.35
September 22..	Imperial	2	3.8977	21.8771	25.7748	2.9460	11.43
September 22..	Imperial	3	5.4272	20.9275	26.3547	2.9754	11.29
October 13.....	Kleinwanzlebener............	Farm	3.0416	17.6298	20.6714	2.2283	10.18
October 13.....	Vilmorin......................	Farm	5.0199	21.4095	26.4294	2.8675	10.85
October 13.....	Kleinwanzlebener	1	3.3282	21.5212	24.8494	2.4395	9.82
October 13.....	Kleinwanzlebener	2	3.8774	23.9726	27.8500	3.0944	11.11
October 13.....	Kleinwanzlebener	3	3.5996	23.4004	27.0000	2 7081	10.03
October 13.....	Vilmorin......................	1	3.9930	21.0562	25.0492	2.5083	9.97

PERCENTAGE OF ASH—(Concluded).

Leaves—Sugar Beets.

Date Harvested.	Variety.	Section.	Per Cent. Insoluble Ash.	Per Cent. Soluble Ash.	Per Cent. of Ash.	Per Cent. of Ash in Green Substance.	Per Cent. of Dry Matter in the Sample.
October 13.....	Vilmorin......................	2	5.4476	24.1404	29.5880	3.3096	11.19
October 13.....	Vilmorin......................	3	4.2844	23.3354	27.6198	2.7192	10.10
October 13.....	Lion Brand....................	1	2.9932	20.3170	23.3102	2.6690	11.45
October 13.....	Lion Brand....................	2	4.1459	20.9634	25.1093	2.9829	11.84
October 13.....	Lion Brand....................	3	3.3740	21.5660	24.9400	2.3069	9.25
October 13.....	Imperial......................	1	3.0633	22.6348	25.6981	2.7985	10.89
October 13.....	Imperial......................	2	3.8809	21.0601	24.9410	2.9729	11.92
October 13.....	Imperial......................	3	3.6136	22.5378	26.1514	2.1574	8.25

Leaves—Fodder Beets.

Date Harvested.	Variety.	Section.	Per Cent. Insoluble Ash.	Per Cent. Soluble Ash.	Per Cent. of Ash.	Per Cent. of Ash in Green Substance.	Per Cent. of Dry Matter in the Sample.
September 2...	Lane's Imperial...............	1	8.0789	24.9496	33.0285	2.9824	9.03
September 2...	Lane's Imperial...............	2	4.5602	25.7718	30.3320	2.4144	7.96
September 2...	Lane's Imperial...............	3	7.1726	28.8794	36.0328	2.8393	7.88
September 22..	Lane's Imperial...............	1	4.2517	23.7127	27.9644	2.6901	9.62
September 22..	Lane's Imperial...............	2	5.8499	24.8072	30.7591	3.0573	9.94
September 22..	Lane's Imperial...............	3	4.8015	23.3716	28.1731	2.4961	8.86
October 13.....	Lane's Imperial...............	1	4.9276	22.7118	27.6394	2.6094	9.04
October 13.....	Lane's Imperial...............	2	5.5246	25.5276	31.0522	3.2668	10.52
October 13.....	Lane's Imperial...............	3	4.8318	23.0998	27.9316	2.6513	9.42
September 29..	Chards........................	1	3.1350	17.7539	20.8889	2.1866	10.47
September 29..	Chards........................	2	4.0638	18.4694	22.5332	2.5937	11.51
Sedtember 29..	Chards........................	3	3.2086	20.6892	23.8978	2.1787	9.12
October 13.....	Chards........................	....	3.2600	19.2730	22.5330	2.3231	10.31

The table shows that by the 2nd of September, more than one half, and less than two thirds, of the total ash taken up by the roots, has already been accumulated—stated a little more explicitly, about 58 per cent.—while the leaves have stored up about 70 per cent. of the ash contained in them at maturity. The deposition of the greater part of the ash takes place earlier in the leaves than in the roots, but continues in both until the time of ripening, or maturing of the beet. I took no samples of leaves for analysis subsequent to

October 13, but I have elsewhere stated what I mean by the maturing of the beet. The percentage of ash in the fresh roots is seen to slightly decrease with the advancement of the crop; this is due to the rapid increase in the weight of the crop itself, and not to an elimination of the ash constituents. The mature beet, as grown here, contains a trifle over 1.10 per cent. of ash, and the leaves contain a little more than twice as much.

The table also shows clearly the influence of the alkali in the soil upon the percentage of ash, *i. e.*, that it causes an increase of about 2 per cent., reckoning the ash on the dry matter. The results are quite in harmony with those previously given, except that the percentage of ash in the beets grown on alkali soil is still greater than shown by the fodder analyses. The actual percentages for beets grown on good ground and on alkali ground are 5.32 and 7.58, respectively. The varieties of soils within the plot itself, indicated by the figures 1, 2 and 3, show no such evident effect, and there is no regularity in the variations of the percentage of ash in the samples from these sections. The beets from section 3, especially in the latter part of the season, show a higher percentage of ash than the samples from the other two sections. The samples from this section are lower in percentage of dry matter, also in the percentage of sugar, but higher in percentage of proteids, than the others. This is the wettest portion of the plot, and shows, during either cold or dry weather, an abundant efflorescence of alkali, but the analyses of the soils do not show that it contains more, or even as much, as section 1. The corroding effect of the alkali was scarcely noticed at all in this (the 3rd) section, while it was observed in the 2nd. This may be due to the character of the salts in solution, and not to their quantity; still, the total alkalies in section 2 is greater, apparently, than in section 3. The effect of the alkalies upon the tilth of this ground is not clear to me. The soil in this section is so saturated with calcic sulphate that small aggregations of gypsum crystals are plentiful in some portions of it. The tilth is very bad, but whether this is due to the water, and the fineness of the soil, or in any larger measure to the alkali, which is practically sodic sulphate, may be an open question, but I am quite convinced that the alkali has comparatively little effect, directly or indirectly, in determining the character of the beets in this case. The effect of the crop upon the soil was little, or nothing.

It has been shown that the leaves of the sugar beet plant, as it grows with us, are equal to from 70 to 90 per cent. of the weight of the roots. The percentage of ash in the green substance shows that ton for ton, the leaves remove from two to two and one fourth times as much ash material as the roots. I had hoped to find in this ratio, and the tolerance of the beet plant for alkali, a means of keeping down, or removing, considerable quantities of alkali from the soil, especially as I hoped to find that the plant would, in the presence of so large a supply of soda salts, take up a large percentage of them. I expected to find this the case in both the roots and leaves—to a greater extent, of course, in the leaves than in the roots. It was with this idea that I planted chards, but I was disappointed in the results of this experiment, for they made no such crop of leaves as they should have made, and they were not as high in percentage of ash as the leaves of the beets. The experiment with the chards was so evidently a failure, in regard to its primary object, that I practically abandoned it.

The table also contains the results obtained from fodder beets. The crop of roots is usually very much larger, while the percentage of ash in the fresh crop is rather less. In regard to the leaves, their ratio, by weight, to the roots being much lower, amount to about the same on a basis of 2 tons of fodder beets to 1 ton of sugar beets. The percentage of ash is quite the same in the two classes, and the mineral constituents removed by such crops would be about equal. The roots of a crop of fodder beets removes, because of their high tonnage, from two to three times the amount of ash constituents that is removed by a crop of sugar beets.

THE DISTRIBUTION OF THE ASH IN THE BEET.

The sugar and dry matter in the respective thirds of the beet, numbered from the top downward, have been given. Two series of experiments were made with the Kleinwanzlebener and Vilmorin varieties, to see whether we could establish any difference between the ash content of the thirds, and also its value. The series consisted of six beets each ; the Kleinwanzlebener samples were freshly dug, but the Vilmorin sample was taken from the cellar. The average percentage of sugar in the Kleinwanzlebener variety was 12.70 per cent.; in the Vilmorin, 14.90. The percentage of dry matter in these series is given in detail under the caption, " Distribution of the Dry Matter in Beets," where it is shown that there is a little more in the first third than in either of the other thirds, but that the difference is very small, varying from three tenths to one per cent.

Variety.	Series.	Thirds.	1		2		3		4		5		6	
			Per Cent. of Ash.	Per Cent. of Ash in Fresh Beet.	Per Cent. of Ash.	Per Cent. of Ash in Fresh Beet.	Per Cent. of Ash.	Per Cent. of Ash in Fresh Beet.	Per Cent. of Ash.	Per Cent. of Ash in Fresh Beet.	Per Cent. of Ash.	Per Cent. of Ash in Fresh Beet.	Per Cent. of Ash.	Per Cent. of Ash in Fresh Beet.
Kleinwanzlebener..	No. 1	1	5.53	1.10	5.83	1.07	5.17	1.15	4.25	0.91	6.48	1.28	4.63	1.05
		2	5.68	1.00	6.36	1.06	5.33	1.17	5.36	1.03	6.27	1.17	5 69	1.10
		3	5.90	1.05	6.63	1.11	5 70	1.21	5.46	1.07	6.05	1.19	6.78	1.26
	No. 2	1	5.91	1.05	5.78	1.04	4.95	0.96	7.67	1.33	5.59	1.02	4.50	0.88
		2	5.90	1.04	5.67	1.16	5.11	0.94	6.84	1.16	5.37	0.96	4.17	0.80
		3	6.44	1.04	4.93	0.81	5.84	1.00	6.50	1.12	5.69	0.98	4.88	0.87
Vilmorin..	No. 1	1	4.95	1.25	4.10	1.05	4.36	0.95	5.46	1.13	6.12	1.31	5.29	1.19
		2	4.32	1.05	4.54	1.10	4.19	0.90	5.12	1.06	6.11	1.27	5.96	1.18
		3	4.57	1.17	4.71	1.14	4.61	1.00	5.71	1.18	5.97	1.32	6.63	1.36
	No. 2	1	5.28	1.23	5.17	1.17	6.21	1.27	7.04	1.38	6.86	1.39	7.10	1 42
		2	4.85	1.10	5.31	1.21	6.48	1.22	6.77	1.34	6.35	1.26	7.10	1.35
		3	5.35	1.10	5.47	1.27	6.69	1.38	6.86	1.36	6.71	1.33	6.95	1.41
Lane's Imperial ...	......	1	7.64	1.09	5.77	1.06	7.56	1.13	......	......	......	......	......	......
		2	7.25	1.01	4.92	0.85	5.53	0.82	......	......	......	......	......	......
		3	7.35	1.04	4.83	0.82	5.77	0.86	......	......	......	......	......	......
Large Pink	......	1	9.53	1.20	9.44	1.25	......	......	......	......	......	......	......	......
		2	8.91	1.07	11.03	1.27	......	......	......	......	......	......	......	......
		3	8.56	1.03	12.46	1.42	......	......	......	......	......	......	......	......

An inspection of the results obtained upon individual beets, leaves the impression that there is a larger percentage of ash in the third, or lower one third, than in the others, which is really the case, but it is much less decided than appears from a simple inspection of the table. The averages, taken by series, is as follows:

Variety.	Thirds.	Series I.		Series II.	
		Per Cent. of Ash in Dry Matter.	Per Cent. of Ash in Fresh Beets.	Per Cent. of Ash in Dry Matter.	Per Cent. of Ash in Fresh Beets.
Kleinwanzlebener........................	1	5.31	1.09	5.71	1.05
	2	5.78	1.09	5.51	1.01
	3	6.09	1.13	5.70	0.97
Vilmorin................................	1	5.05	1.15	6.27	1.31
	2	5.04	1.09	6.14	1.25
	3	5.37	1.19	6.24	1.31

Taking the averages of all the respective thirds in their order, we have, for the first third, 5.59 per cent. ash in the dry material, 5.61 per cent. for the second, and 5.85 per cent. for the third, or bottom third. This appears to prove that the percentage of ash increases in the lower portion of the beets. We have already seen that the sugar is a little higher in the lower two thirds than in the upper third, *i. e.*, first third contained 13.08 per cent. sugar, the second 13.22 per cent., and the third 13.19 per cent. sugar. According to this, the percentage of both the ash and sugar increase in the lower part of the beet. If, however, we take the percentage of ash in the fresh beet, which seems to me the proper basis, the matter stands differently in respect to the ash, *i. e.*, it is greater in the first third, and diminishes in the lower portions of the beet, for we have them in the thirds, beginning at the top, 1.15, 1.09, 1.05 per cent. In either case the difference is much less than I had hoped and expected to find. A concrete statement will possibly make the smallness of this difference plainer to some readers. It means, that, if we had a crop of sugar beets, of 15 tons to the acre, and divided every beet into three equal parts, by weight, there would be, in the five tons of upper thirds, ten pounds more of ash than there would be in the five tons of lower thirds.

The percentage of ash given for the dry matter is misleading in this, that it gives no statement of the fact that the percentage of dry matter is greater in the first third of the beet. If we take this into account, we find, on calculating the ash, for the assumed crop of 15 tons to the acre, that there is practically no difference. We get 116.22 pounds in the first third, and 115.77 pounds for the third, or lower third, of our crop. Both methods of calculation lead to the same conclusion, *i. e.*. that the ash in the beet root is quite evenly distributed throughout the beet, with a slight excess in the upper portion of the root, but the percentage of ash is greater in the dry matter of the lower third.

THE COMPOSITION OF THE ASH.

It was my expectation, when this work was planned, to find in the composition of the ashes, particularly of the leaves, a means of removing large enough quantities of soda salts to ameliorate the alkaline condition of the soils, as we find it in Colorado.

The ashes were prepared with care, but it seems to be a difficult task to prepare them so that no organic matter shall be left. The sample was, in every case, first charred, the soluble ash thoroughly washed out, and the carbon then burned out of the residue. The ash of the whole sample was mixed with ammonic carbonate, and heated to 200° C., for two hours.

The portion of ash, insoluble in water, is very variable, especially in the beets. In the leaves it is higher in early September than subsequently, and always lower by 2 or more per cent. of the total ash, than in the roots.

In the following table is given the composition of the ashes of samples taken at three different periods of development, which may be best judged of by the dates on which the samples were taken. With the composition of the ash we complete the data concerning the samples. The same samples were used for the estimation of the sugar, the dry matter, the fodder analysis, and for the work on the ash. For instance, the sample of Kleinwanzlebener, taken on October 13, was taken large enough to furnish material for the different determinations. The data obtained gives a complete history of the plant's development. I may state that 1,200 pounds of beets, and nearly as many tops, were used during the course of this investigation, the object being to obtain results which would be representative.

The plan was to study each of the varieties planted, but I have been compelled to confine the study to the Kleinwanzlebener. I have taken two as comparative standards, the Kleinwanzlebener and Vilmorin. I gave up my original plan the more willingly, as the examination of the one series shows so great a uniformity in composition, that there is no evident object to be gained which is nearly commensurate to the work involved. I give the direct results of the analyses, believing that they convey a sufficiently clear idea of the composition of the ash to the general reader, while the chemist, or other person, who wishes to reduce the terms to another basis, can easily do so.

The following tables have been grouped together so as to present the condition, and the effect of the variety of soil, without further explanation. In the first table I have given the analyses of the ashes which I assumed to be representative of good soils, to which I have added an analysis of the ash of the marc, from Kleinwanzlebener beets, grown on the Farm plot, and corresponding to the analysis given in the first column:

	Kleinwanzlebener.	Kleinwanzlebener.	Vilmorin.	Marc.
Sugar Content in Beets	12.32 per cent.	17.25 per cent	13.02 per cent.	12.90 per cent.
Where Grown	Farm Plot.	New Mexico.	Farm Plot.	Farm Plot.
Carbon	None.	None.	Trace.	None.
Sand	0.699	1.212	0.931	15.671
Silica	1.196	1.506	1.264	4.787
Sulphuric Acid	3.481	2.777	2.878	1.622
Phosphoric Acid	8.607	3.336	6.088	3.283
Carbonic Acid	20.214	18.213	19.177	23.807
Chlorin	5.686	12.500	10.887	0.155
Potassic Oxid	32.334	39.639	40.065	14.802
Sodic Oxid	17.888	9.940	11.161	3.711
Calcic Oxid	3.257	3.458	3.409	15.790
Magnesic Oxid	6.065	7.024	5.264	9.768
Ferric Oxid	0.286	0.468	0.414	1.300
Aluminic Oxid	0.268	0.232	0.774	0.848
Manganic Oxid (brown)	0 298	0.361	0.186	0.364
Loss on Ignition	1 272	2.073	....	[4.126]
Sum	101.544	102.739	102.498	100.034
Oxygen equivalent to Chlorin	1.281	2.817	2.441	0.034
Total	100.263	99.922	100.057	100.000

ASH OF THE SUGAR BEET IN ALKALI SOIL.

Harvested September 2.

	Section 1.		Section 2.		Section 3.	
	Beets.	Leaves.	Beets.	Leaves.	Beets.	Leaves.
Carbon	None.	Trace.	Trace.	Trace.	None.	Trace.
Sand	1.830	4.484	1.892	1.859	1.417	1.549
Silica	1.680	3.154	1.744	2.319	1.957	2.883
Sulphuric Acid	3.212	3.369	3.191	3.612	3.098	2.261
Phosphoric Acid	6.433	2.167	8.758	2.212	7.201	2.823
Carbonic Acid	14.495	12.632	14.817	14.484	16.381	15.991
Chlorin	13.779	20.729	12.315	18.219	11.326	18.000
Potassic Oxid	36.477	21.260	39.832	23.170	32.820	19.657
Sodic Oxid	15.755	23.901	12.130	24.381	19.220	28.577
Calcic Oxid	1.740	2.667	1.190	2.137	1.216	1.661
Magnesic Oxid	4.485	6.577	4.100	7.132	4.474	5.916
Ferric Oxid	0.590	0.652	0.581	0.464	0.682	1 119
Aluminic Oxid	0.276	0.512	0.370	0.330	0.339	0.498
Manganic Oxid (brown)	0.142	0.086	0.133	0.121	0.168	0.128
Loss upon Ignition	2.328	3.095	1.614	5.693	1.994	2.768
Sum	103.222	105.185	102 667	104.123	102.293	103.831
Oxygen equivalent to Chlorin	3.105	4.673	2.775	4.105	2.552	4.056
Total	100.117	100.512	99.892	100.018	99.741	99.775

Harvested September 22.

	Section 1.		Section 2.		Section 3.	
	Beets.	Leaves.	Beets.	Leaves.	Beets.	Leaves.
Carbon	None.	Trace.	Trace.	Trace.	None.	None.
Sand	0.665	0.538	0.868	0.139	0.610	0.700
Silica	0.858	1.024	0.855	0.651	0.931	1.933
Sulphuric Acid	3.949	3.821	3.612	3.281	2.550	2.976
Phosphoric Acid	7.906	2.286	8 786	1.902	7.688	3.133
Carbonic Acid	16.467	12.528	14.758	10.760	16.471	16.117
Chlorin	11.493	24.923	12.826	27.781	14.408	21.349
Potassic Oxid	36 780	20.738	41.620	28.225	34.895	21.572
Sodic Oxid	13.434	27.608	9.744	22.863	18.637	27.859
Calcic Oxid	2.826	2.699	2.180	2.295	1.254	1.841
Magnesic Oxid	5.783	5.731	5.512	5.110	4.028	5.770
Ferric Oxid	0.309	0.179	0.310	0.058	0.290	0.502
Aluminic Oxid	0.158	0 170	0.156	0.206	0.103	0.395
Manganic Oxid (brown)	0.190	0.139	0 214	0.155	0.114	0.161
Loss upon Ignition	1.690	3.511	1.842	3.261	1.624	....
Sum	102.408	105.895	103.283	106.687	103.603	104.308
Oxygen equivalent to Chlorin	2.590	5.616	2.890	6.265	3.246	4.811
Total	99.818	100.279	100.393	100.422	100.357	99.497

ASH OF THE SUGAR BEET IN ALKALI SOIL—(Concluded).

Harvested October 13.

	Section 1.		Section 2.		Section 3.	
	Beets.	Leaves.	Beets.	Leaves.	Beets.	Leaves.
Carbon........	Trace.	None.	Trace.	None.	None.	None.
Sand..................................	0.822	0.408	1.188	0.314	0.497	0.394
Silica..................................	1.144	0.842	1.102	0.758	0.941	0.960
Sulphuric Acid....................	3.585	3.803	3.476	3.859	3.400	3.580
Phosphoric Acid.................	8.049	2.051	8.668	1.793	7.504	2.317
Carbonic Acid.....................	14.051	10.628	15.690	10.940	16.734	14.848
Chlorin................................	14.961	28.511	12.599	27.766	13.561	23.289
Potassic Oxid......................	38.966	23.780	42.976	25.718	37.491	23.838
Sodic Oxid..........................	12.828	25.375	8.811	22.324	16.123	25.515
Calcic Oxid.........................	2.101	2.437	1.951	2.527	1.331	1.537
Magnesic Oxid....................	5.339	6.000	5.573	6.169	4.791	5.624
Ferric Oxid.........................	0.815	0.125	0.146	0.128	0.276	0.062
Aluminic Oxid....................	0.213	0.113	0.538	0.123	0.400	0.173
Manganic Oxid (brown)..........	0.183	0.068	0.195	0.137	0.197	0.106
Loss upon Ignition..............	....	2.943	....	4.054	....	3.421
Sum......	103.057	107.084	102.912	106.610	103.246	105.664
Oxygen equivalent to Chlorin.....	3.166	6.425	2.839	6.257	3.057	5.226
Total..........................	99.891	100.659	100.073	100.353	100.189	100.438

ASH OF FODDER BEETS.

	Lane's Imper'l.	Yellow Globe.	Long Red Mangold.	Large Pink.
Where Grown.....................	Farm	Farm	Farm	Farm
Carbon..............................	None.	Trace.	None.	None.
Sand..................................	0.237	0.597	0.216	0.725
Silica..................................	1.044	0.857	0.594	1.052
Sulphuric Acid....................	3.900	2.189	2.832	2.597
Phosphoric Acid..................	4.605	6.547	5.232	6.209
Carbonic Acid.....................	23.344	16.949	21.447	21.871
Chlorin..............................	7.813	16.827	9.628	9.252
Potassic Oxid......................	33.474	38.620	38.787	27.656
Sodic Oxid	21.465	14.559	16.151	24.397
Calcic Oxid.........................	2.015	1.909	2.661	1.992
Magnesic Oxid....................	3.270	3.189	3.274	3.262
Ferric Oxid.........................	0.191	0.497	0.175	0.254
Aluminic Oxid........	0.040	0.777	0.073	0.108
Manganic Oxid....................	0.210	0.216	0.575	0.194
Loss on Ignition..................	0.714	0.548	0.923	2.716
Sum..................................	102.322	104.251	102.568	102.285
Oxygen equivalent to Chlorin....	1.761	3.778	2.169	2.085
Total..............................	100.561	100.473	100.399	100.200

COMPOSITION OF ASH COMPARED WITH SUGAR CONTENT.

	Vilmorin.	Kleinwanz-lebener.	Kleinwanz-lebener.	Kleinwanz-lebener.	Kleinwanz-lebener.	Kleinwanz-lebener.
Where grown	Col. Farm	Col. Farm	Col. Farm, alkali soil	Col. Farm, alkali soil	Col. Farm, alkali soil	New Mex.
Sugar content	13.02 per ct.	12.32 per ct.	7.86 per ct	10.73 per ct.	14.70 per ct.	17.25 per ct.
Date harvested	October 13	October 13	Sept. 2	Sept. 22	October 13	?
Silica	1.58	1.54	2.10	1.02	1.33	1.91
Sulphuric Acid	3.59	4.47	3.91	4.37	4.18	3.53
Phosphoric Acid	7.62	11.02	10.73	10.65	10.45	4.25
Chlorin	13.61	7.30	15.08	15.53	15.16	15.90
Potassic Oxid	50.12	41.41	48.74	50.42	51.70	50.59
Sodic Oxid	13.96	22.91	15.05	11.81	10.60	12.65
Calcic Oxid	4.26	4.19	1.46	2.64	2.35	4.42
Magnesic Oxid	6.59	7.76	5.02	6.68	6.70	8.93
Ferric Oxid	0.52	0.37	0.73	0.37	0.18	0.59
Aluminic Oxid	0.99	0.34	0.46	0.19	0.65	0.29
Manganic Oxid	0.23	0.39	0.16	0.26	0.13	0.45
Sum	103.07	101.70	103.44	103.54	103.40	103.54
Oxygen equiv. to Chlorin	3.05	1.65	3.40	3.50	3.42	3.59
Total	100.02	100.05	100.04	100.04	99.98	99.95

Composition of ashes of beets having different percentages of sugar, calculated from data quoted from Champion and Pellet by Dr. McMurtrie:

	Beets Having 10 per Cent. Sugar.	*Beets Having 15 per Cent. Sugar.*
Silica	5.555	5.546
Sulphuric Acid	3.594	3.486
Phosphoric Acid	9.640	9.357
Chlorin	9.310	9.172
Potassic Oxid	47.870	48.807
Sodic Oxid	8.330	8.257
Calcic Oxid	6.860	6.970
Magnesic Oxid	6.210	6.055
Undetermined	2.610	2.385
	99.979	100.035

The leaves, presumably belonging to the two samples whose ash analyses are given above, yielded ashes of the following composition :

	Ash of Leaves from Beets Having 10 per Cent. Sugar.	Ash of Leaves from Beets Having 15 per Cent. Sugar.
Silica	1.100	1.110
Sulphuric Acid	5.340	5.400
Phosphoric Acid	7.940	8.000
Chlorin	11.510	11.560
Potassic Oxid	32.880	33.330
Sodic Oxid	11.510	11.560
Calcic Oxid	12.470	12.500
Magnesic Oxid	10.010	10.100
Undetermined	7.230	6.400
	99.990	99.960

The analyses, quoted from Champion and Pellet, evidently include, under the term undetermined, the excess of oxygen corresponding to the chlorin present. The large quantity of silica in the beet ash suggests the fluxing of sand and fine particles of soil during the incineration of the sample.

This source of silicic acid in the ash, has been frequently suggested in my own work, and I am fully convinced, that it is so good as impossible to prepare an ash from a sample containing sand and dust without fluxing some of it, and so bringing silicic acid into a soluble form. And I doubt the correctness of the practice of reckoning even the soluble silicic acid in the ash analysis proper.

Neither the analyses of the ashes from my own series, nor the two quoted, show a sufficiently decided variation in the composition of the ashes of beets, having different percentages of sugar, to admit of any conclusion in regard to any relation existing between the percentage of sugar and the composition of the ash. Further, a comparison of the percentages of sugar and ash present in mature beets, fails to show any relation between the percentage of sugar and the percentage of ash, as a few examples will serve to show:

RELATION BETWEEN PERCENTAGES OF SUGAR AND ASH.

	Per Cent. of Sugar.	Per Cent. of Ash in Dry Matter.	Per Cent. of Ash in Fresh Beet.
Beets harvested October 13	12.15	7.43	1.27
Beets harvested October 13	14.70	6.49	1.17
Beets harvested October 13	10.13	5.56	1.14
Beets harvested October 13	12.49	7.72	1.25
Beets harvested October 13	12.84	6.60	1.25
Beets harvested October 13	13.61	5.71	1.11
Beets harvested October 13	11.84	9.75	1.39
Beets harvested October 13	15.20	7.05	1.27
Beets harvested October 13	12.15	4.97	1.09
Beets harvested October 13	13.65	10.65	1.45

The only thing shown by these samples is that the ash of the sugar beet, as it grows with us, contains more alkalies than is shown by the two analyses of French beets, by about 7 per cent. The ash from our beets, without any relation to the sugar content, carries about 63 per cent. of potash and soda together. The carbonic acid, sand, and organic matter, is not considered as belonging to the ash. We also find a certain uniformity in the amount of lime and magnesia present. Counting these in terms of lime, we find the range mostly within the limits of 11 and 14 per cent. In the two samples of French beets it is 15.5 per cent. The phosphoric acid in the eight analyses, which we have tabulated, agree closely in six instances, while the other two are much lower. In the case of the sample of Vilmorin, harvested October 13, and carrying 13.02 per cent. of sugar, the low percentage of phosphoric acid cannot, in my opinion, be explained by ascribing it to the lack of this constituent in the soil, it must be ascribed to some other cause. In regard to the sample from New Mexico, I can express no opinion, as I have no intimate knowledge of the conditions under which it was grown. I am frank to say that I doubt whether this New Mexican sample ought to be taken as an example of a beet, rich in sugar. That it showed the presence of 17.25 per cent. of sugar when I received it, is true, but that it did not show that much when it was fresh, is quite as certain. I believe the high percentage to have been due to drying out, rather than to a naturally high degree of richness.

The percentage of ash, in the French samples, is rather lower than we find in our samples, but other data for French beets make it about the same. The percentage of ash in the leaves, assuming the dry matter equal to 10 per cent., is the same as we find for Colorado beets, but the composition of the ashes of the leaves is not at all alike. They are similiar only in containing the same chemical elements. The composition of the ash of the leaves from the French beets is quite comparable to that of the ash of the beets themselves, the differences consisting of an excess in the percentages of soda, lime, magnesia, and chlorin, over that of the beet ash, while the percentage of potash in the ash of the leaves is less than that in the ash of the beets by 15 per cent.

The table on page 54 shows to how great an extent the ash constituents of the leaves differ from those of the beets in their relative quantities, and also, how the ashes, both of the roots and the leaves, of Colorado grown beets differ from those grown in France. I have quoted the analyses of the French beets, and do not know how nearly representative they may be, but as to the Colorado beets, any one of the samples given on previous pages could be used for the same purpose quite as well as the one chosen. This one was taken simply because its percentage of sugar, being so near that of the sample quoted, eliminates any question of doubt which might arise because of differences in the quality of the beets.

I place the analysis of a sample of the ash of Kleinwanzlebener beets, carrying 14.7 per cent. sugar, together with that of the ash of its leaves, side by side with that of a French beet, supposed to carry 15 per cent. sugar, and its leaves :

	Kleinwanzlebener. Grown in Colorado.		Grown in France.	
	Beets. Per Cent.	Leaves. Per Cent.	Beets. Per Cent.	Leaves. Per Cent.
Silica	1.330	0.890	5.546	1.110
Sulphuric Acid	4.180	4.470	3.486	5.400
Phosphoric Acid	10.450	2.120	9.357	8.000
Chlorin	15.160	32.670	9.172	11.560
Potassic Oxid	51.700	30.270	48.807	33.330
Sodic Oxid	10.600	26.270	8.257	11.560
Calcic Oxid	2.350	2.980	6.970	12.500
Magnesic Oxid	6.700	7.260	6.055	10.100
Ferric Oxid	0.180	0.150	2.385*	6.400*
Aluminic Oxid	0.650	0.150	....	....
Manganic Oxid	0.130	0.160	....	....
Sum	103.400	107.390	....	....
Oxygen equivalent to Chlorin	3.420	7.380	....	....
Total	99.980	100.010	100.035	99.960

* Undetermined.

In considering the effect of the soil, particularly of the alkali, upon the percentage of sugar, I adopted, as a standard of comparison, beets grown upon two other plots of ground, free from alkali, and in good tilth. In this case the meteorologic conditions were the same in every respect, and it was simply a question of soil. The same was true in regard to the feeding value, of both the roots and the leaves; with the constituents of the ash, which are obtained wholly from the soil, the question is not so simple, for there is an uncertainty in regard to the measure in which one constituent may replace another in the economy of the plant, and also in regard to the conditions which influence the replacement of one compound by another.

Some points are so evident, regarding the composition of the ashes from my plot, *i. e.*, that the sulphuric acid is very constant at about 3 per cent., and that the magnesia and lime are also nearly constant, that a multiplication of analyses had no object. In the series of samples, taken September 2, we have for the magnesia, in the samples taken from the three sections, 4.48 per cent., 4.10 per cent., and 4.47 per cent., and for the lime we have 1.74 per cent., 1.19 per cent., and 1.22 per cent. The phosphoric acid is almost as constant, its limits being, as a rule, within 1 per cent., as the series taken October 13, in which we have 8.05 per cent., 8.67 per cent., and 7.50 per cent., may illustrate. It was then evident, that, so far as my own series was concerned, the variations in the composition of the ashes were to be looked for in the chlorin and the alkalies. We obtain a clear view, in regard to the amount of alkalies present, by comparing the alkalies in the different samples after we have eliminated the sand, the carbon dioxid, and the organic matter; when we find, for a series of six ashes, the following figures: 64.08 per cent., 64.32 per cent., 63.79 per cent., 62.23 per cent., 62.30 per cent., and 63.24 per cent. There is here a general rule, holding, at least for my samples, *i. e*, that the total alkalies amount to about 63 per cent of the ash. The percentages of chlorin in the series of six ashes from which the figures for the alkalies have been taken, present one exception; the percentages are as follows: 13.61 per cent., 7.30 per cent., 15.08 per cent., 15.53 per cent., 15.16 per cent., and 15.90 per cent. Owing to the one exception, I will give six others, in two series of three each, one series taken September 22, and the other October 13. Neither has been corrected for carbon dioxid, etc. The September series gave: 11.49 per cent., 12.82 per cent., and 14.41 per cent., the October series gave 14.96 per cent., 12.60 per cent., and 13.56 per cent.

We conclude that the ash of the beet, that is the root, has a pretty uniform composition, represented by the following percentages, the carbon dioxid, organic matter, and sand, included: For sulphuric acid, about 3.5 per cent.; for phosphoric acid, from 7 to 9 per cent., mostly about 8.5 per cent.; for the alkalies, from 48 to 52 per cent.; for lime, from 2 to 3 per cent.; for magnesia, about 6 per cent., and for chlorin, from 11.50 to 14.50 per cent., while the carbon dioxid does not vary by more than 1 per cent. from 15 per cent. of the fine ash.

It is easily recognized that either all of our soils had the same effect upon the ashes of the different samples, or the composition of the ash of the beet root is really constant, and is but little effected by the variety of soil. I believe the latter to be the case, *i. e.*, that the variation in the general composition of the ash of the beet root is constant within narrow limits, and is not materially affected, beyond those limits, by the character of the soil.

I, unfortunately, have almost no analyses of beet ashes at my disposal, and the few I have cannot be reduced to any common basis, and lose much of the value that they might otherwise have. The best I have is an average analysis taken from Wolff's "Aschen Analysen." According to this, the alkalies amount to 66 per cent. of the ash, carbon dioxid, etc., rejected, the lime and magnesia together to 11.5 per cent., phosphoric acid 11 per cent., sulphuric acid 4 per cent., but the chlorin is only 5 per cent.

The two analyses, quoted from Champion and Pellet, by McMurtrie, give 60 per cent. for the alkalies, 10 per cent. for the chlorin, 7.5 per cent. for lime, and 6.5 per cent. for magnesia. The Massachusetts Report, of 1894, gives for the alkalies, uncorrected, 53.3 per cent., for the phosphoric acid 9.7 per cent.

The experiment was undertaken to determine the effect of the excessive quantity of alkali salts upon the beet, and in the hope that we might find the condition of the land ameliorated by the removal of soda salts. The effect upon the percentage of ash in the beet was to raise it from 2 to 3 per cent., and this increase was proportional in the components of the ash, so that the proportion of alkalies remained the same. The ratio of the soda to the potash was not affected, as I had hoped to fine it; in fact, it was lower for the soda to the potash, in the ashes from samples grown on alkali ground, than in that from some samples from the Farm plots which I had taken as my standard. In samples from sections 1 and 2 of my plot the percentage of soda varied from 10 to 15 per cent. The average analysis taken from Wolff's tables is 10.25. The samples taken from section 3, varied from 16 to 19 per cent., with a corresponding depression of the percentage of potash. This increase in the soda ratio is general in the samples from this section, and I, at first, considered it as due to the influence of the alkali, but one of the samples from the Farm plot, where there is no alkali, in the sense in which this term is used, showed 18 per cent. of soda, and the beets were of excellent quality. I think that the causes which brought about the appropriation of the soda in the two cases were different; still so long as the causes are not definitely determined, the presence of 18 per cent. of soda in the latter case fairly raises a doubt whether the excessive soda salts, in the soil, was the real cause of the large percentage of soda in the former case, as I believe they were. The total alkalies taken up from the alkalized ground, was almost exactly the same as that taken up from the good ground.

The chlorin in the ashes, with one exception, is nearly the same, but the average is higher for my plot, owing to the influence of section 3. The conclusion is this, that on soil which is in good, or even fairly good, mechanical condition, the composition of the ash of the beet is not affected by the presence of alkali, but the percentage of ash is raised. On land, however, which is wet and in bad condition, the alkali increases the amount of soda and chlorin in the ash. This increase in the soda amounts to from 4 to 7 per cent., and in the percentage of chlorin to about the same. The conditions which are required to produce these results are so unfavorable, that the production of any other crop is quite out of the question.

The lime and magnesia, as already stated, are constant in their respective percentages, but they are much lower than the percentages for the German and French samples or averages. This cannot be due to any deficiency of these compounds in the soil, for both the soil and the ground water are rich in them. I have neither an explanation nor a theory to offer. The twenty odd analyses agree in showing that, especially, the lime is low. The ground water carries from 125 to 200 grains of calcic sulphate ($CaSO_4$) to the gallon, and the soil is full of this salt. It is evident, from the very low lime percentage in the ash, that the beet does not appropriate it freely—indeed, scarcely at all. The same is suggested by the uniform percentage of sulphuric acid, not only in regard to the calcic sulphate, but also in regard to the sodic sulphate.

In regard to the leaves, I can find no more data than regarding the beets. All that I can find is from the sources already mentioned, Champion and Pellet, quoted as above, and an average analysis taken from Wolff's tables. These agree as well as one could expect, for the German analysis is an average, while the two French ones are of individual samples.

The French analyses make the sulphuric acid 5 per cent., phosphoric acid 8 per cent., chlorin 11.5 per cent., potash 33 per cent., soda 11.5 per cent., lime 12.5 per cent., and magnesia 10 per cent. The German data give the sulphuric acid as 5 per cent., the phosphoric acid as 7 per cent., potash 28.5 per cent., soda 14.5 per cent., lime 14.5 per cent., and magnesia 14.5 per cent. These percentages are only close approximations, but they are sufficient to convey a pretty definite idea of the composition of the ash of the leaves, as given by these authorities.

I have, in the tables, placed the analyses of nine samples of ashes from leaves, side by side, with those of the beets on which they grew, in order that the composition of the leaf-ash and beet-ash might be easily compared, but I have no analysis of a leaf-ash which may be taken as as standard, so there remains nothing else than to take the general averages given by Wolff's average analysis. A comparison of any of my analyses with this shows a wide departure from it. The sulphuric acid is some lower, the phosphoric acid very much lower—5.6 per cent.—the chlorin is over twice as high, the potassic oxid is from 3 to 5 per cent. lower, the sodic oxid 8 to 10 per cent. higher, the lime about 12 per cent. lower, and the magnesia 8 or 9 per cent. lower. In other words, there is no agreement at all, and I take my analyses, of October 13, as representing the composition of the ash of beet leaves, according to which we have, for sulphuric acid, 3.5–3.9 per cent.; for phosphoric acid, 1.8–2.3 per cent.; potash, 23.7–25.7 per cent.; soda, 22.3–25.5 per cent.; lime, 1.5–2.5 per cent.; magnesia, 6.0 per cent.; chlorin, 23.3–28.5 per cent.; carbon dioxid, 10.6–15.0 per cent. The soda may be too high, and the potash too low, by a few per cent., but the percentages serve to indicate the general composition of the ash.

The weight of leaves to the single plant is over 100 per cent. greater than that given for the average good beet in France. The few statements which I have found indicate a higher percentage of dry matter, 11 to 16.5 per cent., than I find for our leaves. It must be remembered that leaves, so succulent as the beet leaf is, lose weight very rapidly, and that the percentage of dry matter in the leaf, at the time of weighing, will depend upon the length of time that they have been pulled, and also, upon other circumstances. The percentage of ash, in the dry matter, is given as 28 to 30 per cent., in ours it ranges from 25 to 31 per cent.

In a preceding paragraph it has been pointed out that, while there is a general composition assignable for the ash of the beets, there is none, in the same sense, for that of the leaves, and I can only compare the samples from different sections of my own plot. In discussing the beet ashes I made no mention of any differences due to the different stages of development at the time the sample was taken. The reason for this apparent omission is, that there is no regular variation large enough, and constant enough, to force one to the conclusion that it is due to this cause. In illustration of this, we will take the beets from section 2 for the three dates, September 2, September 22, and October 13, when we have, for sulphuric acid, 3.19 per cent., 3.61 per cent., and 3.48 per cent.; for phosphoric acid, 8.76 per cent., 8.79 per cent., and 8.68 per cent.; for carbon dioxid, 14.82 per cent., 14.76 per cent., and 15.69 per cent.; for chlorin, 12.31 per cent., 12.83 per cent., and 12.60 per cent.; for potash, 38.83 per cent., 41.62 per cent., and 42.98 per cent.; for soda, 12.13 per cent., 9.74 per cent., and 8.81 per cent., and if the potash and soda be taken together, there is practically no difference in the percentage of alkalies present on the three dates.

The whole analyses might be given, but would show no exception to the statement that the ash in the immature beet had the same percentage composition as that in the mature beet. There seems to be one exception to this rule in the leaf-ashes, and this is in the case of the chlorin, which increases so generally and uniformly that it is suggestive of a relation between the maturity of the plant and the quantity of chlorin present. The percentages are averages for the dates September 2, September 22, and October 13, in the order given—18.98 per cent., 24.68 per cent., and 26.52 per cent. This is the only one of the constituents which shows this variation. The alkalies, on the other hand, are quite constant, with an average of about 48.4 per cent., against 52.0 per cent. in the beets. The alkalies in the leaf-ashes are, in a rough way, divided about equally, with the soda usually, but not always, slightly predominant. We conclude that the ash of the beet leaf has a general composition which is the same throughout the season, except that there is an accumulation of chlorin, as the plant approaches maturity.

The principal differences between the ash of the roots, and of the leaves, are the following: The ash of the roots contains from three to four times as much phosphoric acid; from one half to two thirds as much chlorin; about one thirteenth more alkalies; a little less lime, and two thirds as much magnesia. The most important of these differences is the smaller quantity of phosphoric acid in the ash of the leaves, the larger quantity of chlorin, and, not the difference in the quantity of the total alkalies, but in the ratio of the soda to the potash in them, which has been stated to be 1:1, roughly, with exceptions in favor of a higher soda ratio.

Apropos to the question of this ratio in the beet ashes, I notice a great variation in the analyses taken from Wolff's tables. The ratio for soda to potash is 1:2, and in the analyses of Champion and Pellet, it is 1: 6. In my samples the ratio varies from 1:1.8 to 1:5. The largest amount of soda was found in samples from section 3, and the next highest was found in a sample representing the Farm plot, supposed to be entirely free from alkali, and which is in most excellent condition. I have no analysis of the soil from the Farm plot, but as it was a piece of old alfalfa sod, there was probably an abundance of available potash present.

The principal effects of the alkali upon the beet crop were, in cases where the alkali alone was in question, that the percentage of sugar was scarcely affected at all, but rather beneficially than otherwise. That the nitrogen content was increased, and the ash content, also, by about 2 per cent.

THE FOOD REQUIREMENTS OF THE CROP.

I, of course, hoped to find this plant so tolerant of soda salts that it would utilize soda in its economy in place of potash, and thereby to be able to remove them from the soil, or at least to forestall their accumulation to a deleterious extent. As touching this particular object, the study leads to an adverse conclusion, or, at best, leaves it in serious doubt, for, with two exceptions, we do not find the amount of soda removed to be dependent upon the relative quantities of this compound in the soil. In the two cases in which larger amounts of soda than normal, or what appears to be normal, were removed, one could and the other could not be attributed to an alkalized condition of the soil. But we are enabled, by the establishing of a general composition for the ashes of the beets, and of the ratios between the roots and the tops, and the dry matter in each, to give the requirements of this crop in Colorado in quite definite terms. If we assume a crop of fourteen tons to the acre, and this will be a good average crop for our section, we have a total of from 294 to 384 pounds of mineral matter removed by the roots. This is on a basis of 1.05 per cent. ash in the fresh beets, grown on good soil, and 1.3 per cent. for beets grown on alkali soil. The tops will remove about 586 pounds, assuming them to be equal to 80 per cent. of the weight of the roots, and to have an average of 2.62 per cent. of ash, which is their average on our soils. This gives us a total ranging from 880 to 970 pounds of mineral matter per acre—or deducting one seventh for carbon dioxid, we have from 754 to 832 pounds—of which nearly 60 per cent., or from 450 to 500 pounds, is potash and soda together. The ratio of the soda to the potash is so indefinite, as has been shown, that there is no basis for a very close estimate of the amount of soda removed, but, owing to the large amount of ash in the leaves, and the richness of this ash in soda, about one half of the total alkalies, or from 225 to 250 pounds, must be soda. The total phosphoric acid removed is between 40 and 50 pounds. This is more than the average German crop of equal weight removes. The chlorin removed has possibly more significance for our main question than any other constituent. We may consider the ash of the root, including the carbon dioxid, as containing 12 per cent., and that of the leaves as containing 25 per cent. On this basis the roots remove from 35 to 46 pounds, and the leaves 146.5 pounds of chlorin per acre, which corresponds to about 307 pounds of sodic chlorid, or salt, to the acre. The sodic chlorid seems to be the only constituent of the alkali removed by the beet plant, but as the sulphate of soda constitutes the principal part of the alkali, and this being without influence upon the composition of the ash, it is not clear, even granting that we could raise a crop of 14 tons to the acre, to what extent the removal of this amount of sodic chlorid would better the condition of the soil.

The soil in question contains chlorin to the amount of 0.025 per cent. of the air-dried soil, or, taken to the depth of two feet, about 2,800 pounds of sodic chlorid to the acre. The water soluble in the soil, varies in different portions of the plot from 0.09 per cent. to 1.4 per cent. of the air-dried soil. The salts, soluble in water, consist of sodic sulphate, 33 per cent.; calcic sulphate ($CaSO_4$) 36 per cent.; magnesic sulphate ($MgSO_4$) 21 per cent.; sodic chlorid 2.5 per cent.; and loss on ignition, rather less than 7 per cent. The quantity removed would soon reduce the supply of the sodic chlorid in the soil if it were not renewed from some source, but the ground water is charged with alkali, of which from 3 to 10 per cent. is sodic chlorid, a quantity quite sufficient to replace that removed by the crop.

A legitimate question here, is whether this amount of sodic chlorid, 2,800 pounds to the acre, taken to a depth of two feet, has any detrimental effect upon the growth or quality of the crop. I think that the answer must be that it does not.

While the experiment was made with sugar beets, I did not exclude stock beets, and an examination of the analyses of these races, given with those of the sugar beets, shows that they remove a much larger quantity of soda salts in the roots than the sugar beet does, but this is confined to the roots, as the ratio of the weight of the leaves to that of the roots is only about one half as high in the stock beets as in the sugar beets; so that the actual weight of the leaves in the two cases is about the same. Still it appears from the analyses that the stock beets would remove more soda salts from the soil than the sugar beets, crop for crop, but not ton for ton. The percentages of dry matter and sugar show what the relative feeding value of the crops would be. It appears, considering all things, that the Lane's Imperial was the best variety for my purpose, and probably would be for feeding purposes, but this discussion lies beyond the scope and purpose of this bulletin.

SUMMARY.

The object of this bulletin is to present the results of my study of the effect of alkali upon the composition of the sugar beet, and to contribute to our knowledge of the chemistry of this plant.

The beet seed will germinate freely in soil containing as much as 0.10 per cent. of sodic carbonate, but the young plants are attacked by as much as 0.05 per cent., and it is doubtful whether any of them can survive when there is as much as 0.10 per cent. of this salt present in the soil.

Sodic sulphate affects the germination to a much less degree, even when it is equal to 0.80 per cent. of the air-dried soil, but it is injurious when present in larger quantities. When both salts, sodic carbonate and sodic sulphate, are present in equal quantities, the action of the carbonate, or black alkali, is only slightly, or not at all, mitigated.

Magnesic sulphate retards, but does not prevent, germination when present in quantities equal to 1 per cent. of the air-dried soil.

Sodic salts hasten germination by from 36 to 48 hours.

The effect of the alkali, present in our soil, upon the sugar content of the beet is, of itself, not detrimental. The maturing, or ripening, of the crop corresponds to an increase of from 2 to 3.5 per cent. of sugar in the beet, and about one third of the total yield of sugar.

Beets may remain unharvested, under favorable conditions, without loss of sugar or weight of crop. In our case, there was a slight gain between October 6, 1897, and January 8, 1898.

The difference in the average percentage of sugar in the thirds of beets, taken by weight and numbering from the top, is less than 0.20 per cent. in favor of the second and third thirds, while the average co-efficient of purity is quite the same for the respective thirds.

The percentage of sugar in the crowns is about 1 per cent. less than in the rest of the beet, and the co-efficient of purity is but little lower than that of the beet.

Simple freezing does not affect the quality of the beet. The sugar is not changed thereby, but the distribution of the sugar in the beet may be materially affected in cases where only a portion of the beet has been frozen, especially if subsequent thawing has taken place.

The drying out of beets increases the percentage of sugar, but is accompanied by an actual loss of sugar.

The rate of drying out is about 5 per cent. for the first 24 hours, but by the end of five days it falls to about 2 per cent., and remains practically constant for the next 12 days.

The weight of the leaves of the Colorado grown sugar beet, equals about 87 per cent. of the weight of the roots. The weight of the leaves does not increase materially during the last six weeks of the growing season, but during this time the weight of the root increases by 64 per cent. of its weight at the beginning of the period, or 39 per cent. of the weight of the mature beet.

The presence of alkali increases the weight of the leaves very slightly, and has no marked influence on the date of maturing.

The amount of dry matter is the same in beets grown upon alkali ground as in those grown on ground free from alkali.

As the sugar is formed, there is a disappearance of dry matter, other than sugar, in the beet, suggesting the formation of the sugar in the root by the transformation of substances already deposited therein.

The dry matter in the upper, or first, third of the beet, taken by weight, is a little higher than in the other two thirds.

The effect of the alkali upon the composition of the beet, as shown by the ordinary fodder analyses, is an increase in the percentages of the ash, and the crude protein, and a decrease in the percentage of nitrogen free extract. The effects of the alkali are greater upon the composition of the beet than upon that of the leaves.

The percentage of ash in the fresh roots is about 1.10 per cent., and in the fresh leaves it is rather more than twice as much.

The effect of alkali upon the percentage of ash in the roots is to increase it by about 2 per cent., reckoned on the dry matter.

The amount of mineral matter removed by a crop of stock beets is from two to three times as great as that removed by a crop of sugar beets. The amount of mineral matter removed by the leaves is about the same.

The percentage of ash in the respective thirds of the beet, taken by weight, is, for the fresh beet, a little higher in the upper third than in either of the other two thirds, but the dry matter from the third, or bottom, third is richer in ash than either of the other two thirds.

I have failed to find any relation between the percentage of sugar and the percentage of ash, and also between the percentage of sugar and the composition of the ash.

The composition of the ash of the beets seems not to have been affected by the different character of the soils experimented with, either because there was so great an abundance of available, and to the plant, acceptable mineral matter present that it was not affected by the presence of a large quantity of other salts, or the composition of the ash of the sugar beet is very constant. I think that the latter is the case; the composition of the ash being represented by the following approximate percentages: Sulphuric acid, 3.5; phosphoric acid, 7–9; alkalies, 48–52; lime, 2–3; magnesia, 6; chlorin, 11.50–14.50; carbon dioxid, about 15.

The ash of the beet leaf has a general composition which, like that of the beet, is the same throughout the season, except that there is an increase in the chlorin as the plant approaches maturity.

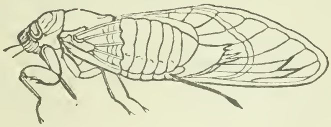
The ash of the leaves differs from the ash of the roots in the following points: The ash of the leaves contains from one third to one fourth as much phosphoric acid, from two to three times as much chlorin, a little more lime, about one half more magnesia, and about one thirteenth less alkalies. The most important difference is the ratio of the soda to the potash, which is one, or more than one, to one.

THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO 47.

Colorado's Worst Insect Pests And Their Remedies.



Approved by the Station Council,
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

JULY, 1898.

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Colorado's Worst Insect Pests And Their Remedies.

BY CLARENCE P. GILLETTE.

INTRODUCTION.

It has been the object of the writer, in the preparation of the present bulletin, to put together, in condensed form, the largest possible amount of information that will be of practical value to the people of the state in combating insect pests. I have, therefore, avoided all technical expressions that might be annoying and meaningless to the general reader, and have only given the information that seemed to me necessary to enable one, who is not specially trained in entomology, to recognize the insect or its injury in each case and to know how to prepare and use the best remedies. There are a number of cases where the popular reader would say "worm," where I have said "larva," or "caterpillar," which are the more correct words; and I have used the words "pupa" or "chrysalis" for the resting stage of insects, but I take it that nearly all my readers know the meaning of these terms.

I have not attempted to make the present paper exhaustive, as that would be impossible in a bulletin of modererate size. I have only taken up those insects about which I am most often asked questions and concerning which I think information is most needed by the people.

It is hoped that all who are troubled with insect pests of any sort will feel free to make inquiries of the Experiment Station as to best methods of destroying them or preventing their injuries. Whenever possible, specimens of the insects or their work should accompany the inquiry.

ACKNOWLEDGEMENTS.

The figures that are not original in this bulletin, or that have not been used in previous bulletins of this station, have been obtained through the courtesies of Dr. L. O. Howard, Dr. J. B. Smith and Dr. C. M. Weed.

Figures 1, 4, 13, 14, 21, 30, 37, 41, 43 and 48 are duplicate electrotypes from Smith's "Economic Entomology" and were purchased from J. B. Lippincott & Co.

Figures 17A, 23 and 24 are duplicate electrotypes from "Insects and Insecticides"—Weed, and were purchased from Dr. Weed.

Credit for the other figures is given in each case, beneath the illustration.

APPLE-TREE ENEMIES.

THE CODLING MOTH. (*Carpocapsa pomonella* Linn.)

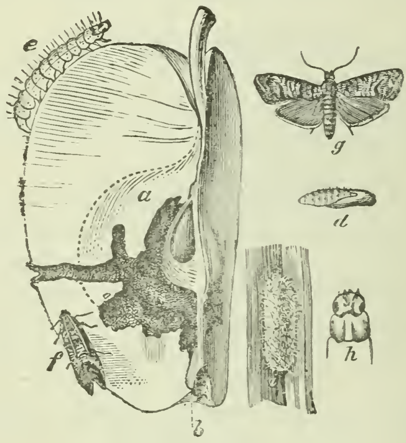


Fig. 1—The Codling Moth: a, apple showing burrow; b, place where the worm entered; d, chrysalis or pupa; e, larva or worm; f, moth with wings closed; g, moth with wings spread; h, head end of larva; i, cocoon in which the larva changes to a chrysalis. All about life size except h. (After Riley).

A flesh-colored worm, eating into the fruit and making what are commonly called wormy apples. Common wherever apples have been grown for a series of years.

Remedies—About one week after the blossoms have fallen, make a thorough application of Paris green or London purple in a coarse spray in the proportion of 1 pound to 160 gallons of water. At the end of one week repeat the treatment, using the poison a little weaker (one pound to 200 gallons of water), unless heavy rains have intervened to wash off the poison of the first application. The Kedzie arsenite of lime may be used in place of the above poisons if preferred.

In addition to one of the above mixtures use the following: Put burlap bandages on the trunks about June 15th and remove them every seven days to kill the larvæ and pupæ under them until the last of August. Then leave them until winter or *early* the next spring, when they should be again removed and the worms beneath them killed. The prompt destruction of fallen fruit will destroy some of the worms, but not a large proportion of them, probably about 15 per cent. Keep screens on windows and doors of cellars and fruit houses where apples are stored to prevent the moths that hatch in these places from flying to the orchard.

Scald in boiling water all boxes and barrels that have recently contained apples, pears or quinces.

THE APPLE FLEA-BEETLE. (*Haltica ignita* Ill.)

A small metallic-green beetle, about one-eighth of an inch in length, that eats holes in the leaves and jumps or takes wing quickly when disturbed.

Remedies.— Use London purple or Paris green in the proportion of one pound to 160 gallons of water; or use these poisons dry, diluted with flour. The Kedzie arsenite of lime, or arsenate of lead, would probably be equally efficient.

Dusting the foliage with lime, plaster, ashes, or tobacco dust, will usually drive the beetles from the trees, but these applications will not kill.

FRUIT-TREE LEAF-ROLLER (*Cacœcia argyrospila* Walk.)

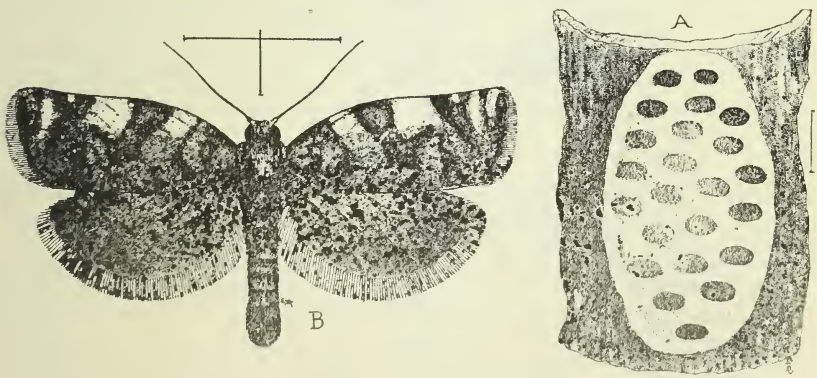


Fig. 2.—Fruit-tree Leaf-roller: A, egg-patch on bark from which the worms have escaped; B, moth. Both enlarged. The lines at the sides show the actual sizes.

Light green worms with black heads appearing upon the trees as soon as the leaves begin to open. The leaves are rolled or folded about the worms for the protection of the latter from their enemies. When abundant, both apples and foliage are sometimes entirely destroyed. The worms change to pupæ in the leaf rolls from which small yellow or rust colored moths appear in July. These moths deposit their eggs in oval patches on the trunk and branches of the trees where they remain dormant until the following spring.

Fig. 3.—Fruit-tree Leaf roller: A, twig from apple-tree showing the rolled and eaten leaves; b, apples that have been eaten by the worms.

Remedies.—Crush as many of the egg patches as can be found during the winter or early spring when other work is not pressing. As soon as the blossoms have fallen spray with Paris green, London purple or arsenite of lime as for the Codling Moth. At the end of a week repeat the application. If heavy rains intervene, or if, for any reason, the worms are found to be continuing their work in large numbers after the end of another week, make a third application. Make the first treatment in the strength of about 1 pound of the poison to 160 gallons of water and the later ones a little weaker, about 1 pound to 200 or 240 gallons of water.

If the eggs are very abundant, it will be well to make one treatment just before the blossoms open.

The treatments made after the blossoms have fallen will also do service in destroying the Codling Moth and any leaf-devouring insects that may be present.

A thorough coating of white-wash upon the trunks and main limbs will destroy a large proportion of the worms while eating out from the eggs. My experiments have shown that the little worms cannot survive eating through a layer of lime over their egg patches. If the coating of lime does not cover the patches, or if it becomes loose and scales off before the worms eat their way out of the eggs, this treatment will do no good. The application of lime should be made about the middle of April, or just in advance of the blossoming of the earliest plum trees. Use the best quality of lump lime in making the wash.

Mr. David Brothers, of the Colorado State Board of Horticulture, reports great success in capturing the moths in pans of dilute cider vinegar set about the orchard at night. The moths begin to fly about the last days of June and continue for two or three weeks. This insect also occurs abundantly on many other trees, particularly, in this state, upon plum, cherry, pear, osage orange and currant and rose bushes.

THE TENT CATERPILLAR. (*Clisiocampa fragilis* Stretch.)

This insect is readily recognized by its white silken webs or tents in the crotches of the limbs of the trees early in the season. The tents begin to be formed as soon or a little before the leaves of apple trees begin to open. The caterpillars make their homes in the tents, but go out over the tree to feed. The tents are quite dense and seldom attain more than one foot in length. The caterpillars are all gone by the first of July.

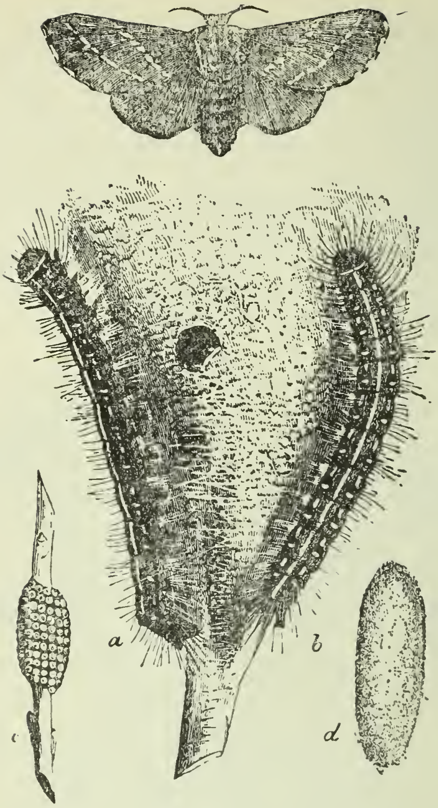


Fig. 4.—American Tent Caterpillar, (*Clisiocampa americana*): a and b, full grown worms on the outside of the tent; c, egg-mass with the gummy covering removed; d, cocoon containing the chrysalis; above all, the moth. (After Riley.)

Our western species (*Clisiocampa fragilis*) resembles the above so closely that the figure serves equally well for it.

Remedies.—Collect and burn the tents as soon as they are seen. This should be done early in the morning or in the evening when the worms are in the nests.

THE FALL WEB-WORM. (*Hyphantria cunea* Dru.)

A yellowish or brownish caterpillar with a black head that forms a large loose web or tent in a great variety of trees, beginning to appear about the first of July and continuing through the summer. The larvæ are rather sparsely covered with long hairs that are whitish or yellowish in color, with occasional black ones for variety. This insect is readily distinguished from the Tent Caterpillar in habits as the larvæ of the Fall Web-Worm form a very loose tent with which they inclose the leaves upon which they feed, and they do not appear until the Tent Caterpillars have nearly or quite disappeared.

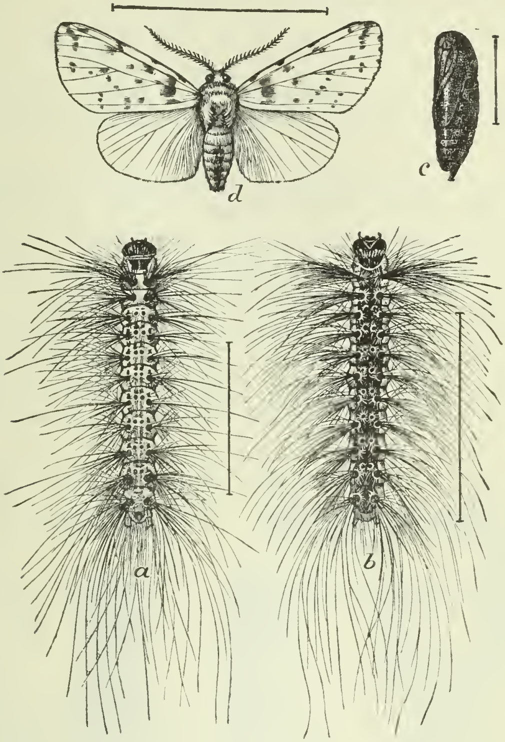


Fig. 5.—Fall Webworm: a and b, full grown larvae showing light and dark forms; c, the chrysalis; d, moth, showing dark spots. All some enlarged. The lines show the actual lengths. Usually the moths are entirely white. (Howard Yearbook, U. S. Dep. of Agr. 1895.)

Remedies.—If the webs are noticed when small they should be cut out and the larvæ destroyed. If the web has become large, enclosing many branches of the tree, it may be better to burn out the worms with a torch. Where there is no danger of poisoning fruit, Paris green may be sprayed or dusted upon the foliage immediately surrounding the web. These leaves will soon be enclosed for food and the worms eating them will die.

THE FLAT-HEADED APPLE-TREE BORER. (*Chrysobothris femorata* Fabr.)

A yellowish white larva boring beneath the bark in the sapwood of apple and many other trees and quite peculiar in appearance on account of its having the anterior segments of its body (not its head) greatly enlarged and flattened.

Remedies—This borer is usually found on the south or southwest side of the tree where the bark has been scalded by the sun and it seldom attacks healthy, vigorous trees. So that the protection of the trunk from sun-scald and other injuries to the bark will do much to prevent the attacks of this insect.

If the borers get into the trees their presence is detected by the dark color of the bark, and in such cases there is probably no better remedy than to make a vigorous use of the pocket knife for their removal. This may be done in the fall or winter when work is least pressing.

The use of strong soapy mixtures and of kerosene emulsion during the month of June and the fore part of July are also much recommended, but the writer believes the pocket-knife remedy will prove most satisfactory.

THE APPLE-TWIG BORER. (*Amphicerus bicaudatus* Say.)

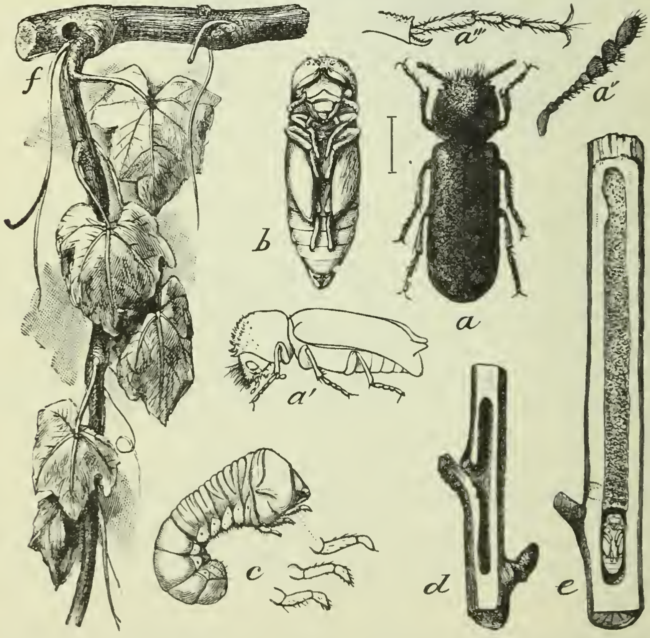


Fig. 6. Apple Twig Borer: a. beetle, dorsal view; a', beetle, side view; b, pupa from beneath; c, grub, side view; d, apple twig showing burrow; e, burrow in tamarisk with pupa at bottom; f, stem of grape showing burrow. All enlarged except the stems showing burrows. (Marlatt, Farmer's Bull. 70, Div. Entomology, U. S. Dep. of Agr.)

A cylindrical, mahogany-colored beetle, about one-third of an inch in length, boring holes in twigs of apple, pear, cherry, osage orange and other trees and grapevines, the burrow starting just above a bud and extending downwards.

Remedy—Cut out the infested stems and burn them.

THE BUFFALO TREE-HOPPER. (*Ceresa bubalus* Fabr.)

A light-green, three-cornered insect, about one-third of an inch in length. What appears to be the head, really the thorax, is large and broad and terminates abruptly, having on either side a short, sharp spine, or thorn, somewhat resembling the horn of the buffalo, and hence the common name of the insect, which is, withal, a good jumper. This insect feeds upon a great variety of plants and is quite abundant in Colorado. It does its chief injury while depositing eggs during the months of August and September in small limbs of various trees, including the apple. A double row of eggs is deposited in a longitudinal slit that the female makes in the bark. The growth of the limb spreads the slit into an oval scar as shown in the accompanying illustration.

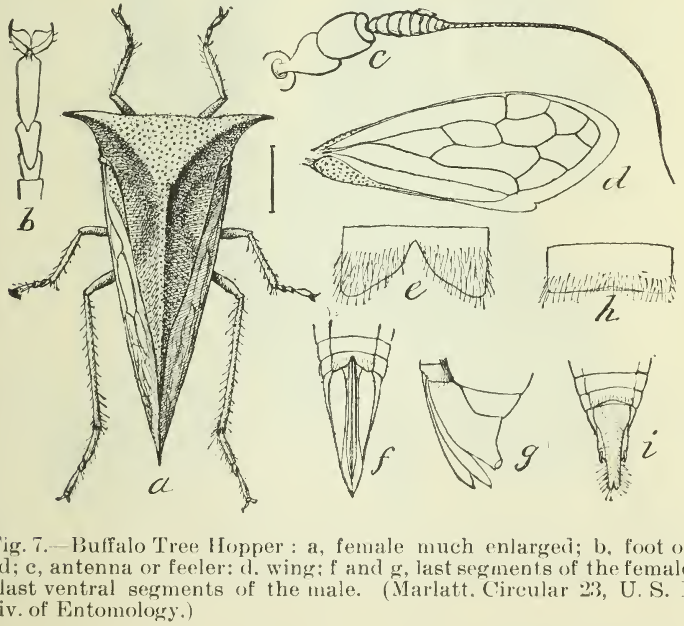


Fig. 7.—Buffalo Tree Hopper: a, female much enlarged; b, foot of same enlarged; c, antenna or feeler: d, wing; f and g, last segments of the female abdomen; i, last ventral segments of the male. (Marlatt. Circular 23, U. S. Dep. of Agr., Div. of Entomology.)

Remedy—These hoppers seem to have the habit of accumulating on certain small trees to deposit their eggs, so that some trees will be almost covered with scars, while others near by have few of them. About the only remedy seems to be to cut out the limbs in which the eggs have been deposited before the eggs hatch in the spring and burn them.

I have noticed these badly infested trees, as a rule, about the borders of the orchard or in orchards where a large amount of foul stuff was growing, and I believe clean culture will do much to keep this pest out of the orchards.

THE SCURVY BARK LOUSE. (*Chionaspis furfurus* Fitch.)

The presence of this insect is indicated by very small white scales upon the trunks or limbs of the trees, when abundant, entirely covering the bark and appearing like a covering of scurf or dandruff, and hence the common name. The female scales are broad and oval at one end and are about a tenth of an inch long; the male scales are not over one-twenty-fifth of an inch in length and are long and narrow.

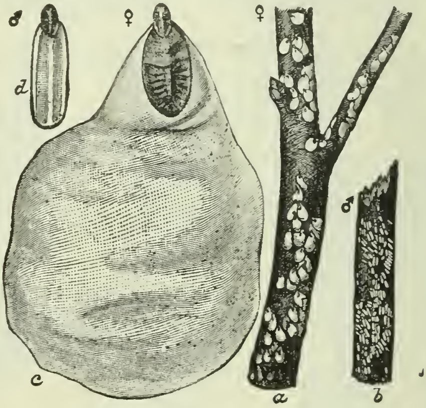


Fig 8. –Scurvy Bark Louse: a. twig showing scales of female louse; b, twig showing scales of male louse; c, scale of female greatly enlarged; d. scale of male greatly enlarged. (Howard, Yearbook. U. S. Dep. of Agr., 1894.)

Remedies—Whale-oil soap, 2 pounds to a gallon of water, kerosene emulsion that is one-fourth kerosene, or lime, sulphur and salt mixture, applied while the trees are dormant, would probably kill the scales. After the leaves are out, if the lice have not been killed, use kerosene emulsion of ordinary strength about the last of May and again about the 10th of June.

THE OYSTER-SHELL BARK-LOUSE. (*Mytilaspis pomorum Bousche.*)

This scale is common in the eastern and northeastern U. S. and in Canada. It is an enemy of the apple-tree of considerable importance and will doubtless be found in some of the orchards of this State at no distant date, though it has not yet been reported in Colorado. It is a very easy pest to overlook. The scales are about one-eighth of an inch in length, a little curved like an oyster shell, and the color is almost exactly that of the bark of an apple tree. They occur chiefly upon the bark and, when abundant, weaken the vigor of the tree or even cause it to die. The scales are very well shown in Fig. 9. During the fall, winter and early spring, these scales have eggs beneath them. About the last of May the eggs hatch and the minute yellowish lice travel about over the tree, find suitable locations, insert their beaks, feed and grow, forming over themselves the peculiar scale under which they deposit eggs and die by the last of August or early in September.

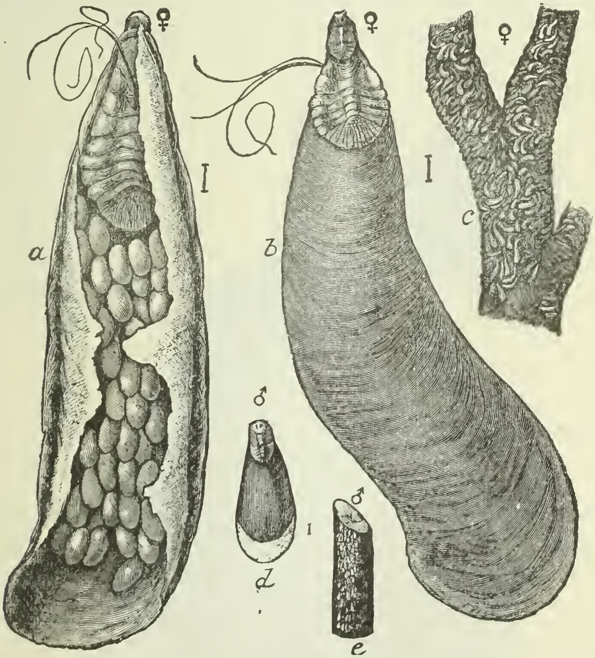


Fig. 9.—Oyster-shell Bark Louse: a, female scale from below, showing eggs, greatly enlarged; b, the same from above; c, female scales on twig natural size; e, male scales, natural size; d, male scale enlarged. (Howard, Yearbook, U. S. Dep. of Agr., 1894.)

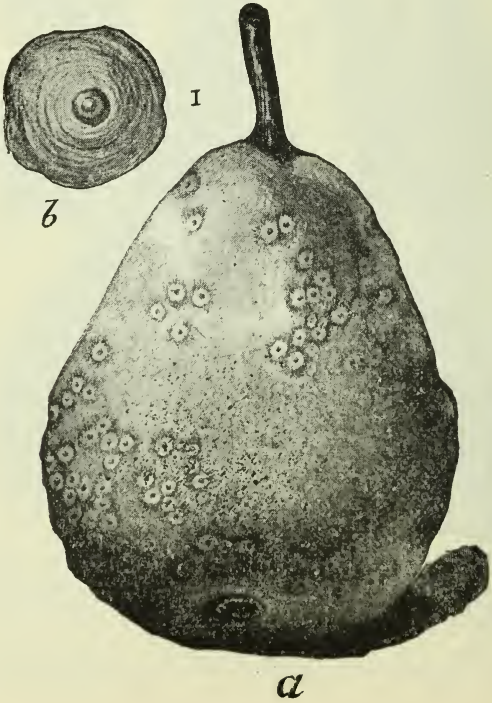
Remedies—The same as for the preceding species.

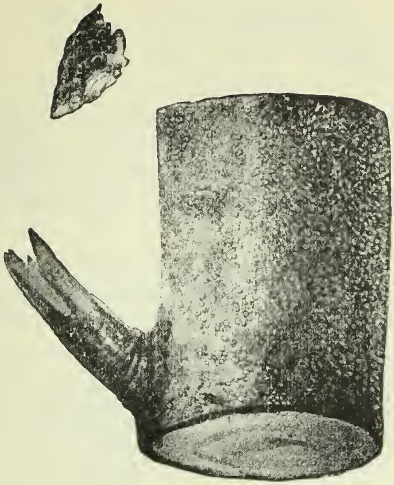
THE SAN JOSE SCALE. (*Aspidiotus pernicious* Comstock.)

This is the most dreaded of the insect pests of the apple orchard. As yet there has been no authentic record of its occurence in any of the orchards of this State, but it has been a most destructive orchard pest in California, Oregon, Washington, and in several of the eastern and southern states. It is transported from place to place almost entirely upon nursery stock and the utmost care should be exercised to prevent its gaining an entrance into any of the orchards of Colorado. It will feed upon almost any of the deciduous trees and shrubs and consequently is very hard to exterminate in any locality where it has once gained an entrance.

The scales are very inconspicuous so that trees are liable to be killed by the insects before the owner becomes aware of the presence of the scale.

The female scales are circular in shape and dark gray in color with a small red or rust-colored spot at the center and measure from one-sixteenth to one-twelfth of an inch across. The male scales are black in color and are smaller than those of the female. They occur upon trunk, limbs, leaves or fruit, and usually cause a reddish coloration of the tissue immediately about the scales, which is very characteristic of this species.





B

Fig. 10.—San Jose Scale: a, pear showing the scales, natural size; b, female scale enlarged; B, section of limb showing scales natural size. (Howard, Yearbook, U. S. Dep. of Agr., 1894.)

Remedies—While the trees are dormant use the same remedies as are recommended for the Scurvy Bark-Louse. In case it becomes necessary to treat the lice after the leaves are out, use kerosene emulsion or whale-oil soap of the ordinary strengths and make five or six applications at intervals of about five days. If an orchard, or even isolated trees, become badly infested and the lice do not succumb to winter treatment, it will usually be better to cut down the trees and burn them completely.

PUTNAM'S SCALE. (*Aspidiotus ancylus* Putnam.)

This scale resembles the preceding so closely that it is impossible to give characters that will enable one who does not possess a compound microscope to distinguish between them with much certainty. The small male scales of this species are not black, however, as in case of the San Jose scale. When either of these scales are suspected it will be well to send specimens to the experiment station for determination.

Remedies for this species are the same as for the Scurvy Bark-Louse mentioned above.

THE APPLE PLANT-LOUSE. (*Aphis mali* Fabr.)

During the winter and early spring there are small shining black specks in rough places in the bark and about the buds, or, as is often the case when abundant, distributed promiscuously over the surface of small limbs, usually most abundant where there is abundance of fine plant hairs making a felty covering to which the eggs are easily attached. See Fig. 12.

Just before the buds open, the eggs hatch, producing a green louse which grows to about one-twelfth of an inch in length and which takes up its abode upon the leaves where it grows rapidly and, by its injuries, causes the leaves to curl so as to form for itself a partial protection.

Remedies—The best time for treatment is while the trees are dormant, any time after the leaves fall and before the buds open. For treatment during this time use either kerosene emulsion, double strength (diluting only enough to make the mixture one-seventh kerosene), or whale-oil soap in the proportion of 1 pound to six gallons of water. The very best time to make the application is after the lice have all hatched and just before the buds open enough to give the lice protection. The danger in waiting for this time is that one is liable to wait a day or two too long and then the lice will get into the open buds and be so protected that some will escape to perpetuate the species and the increase is very rapid.

After the leaves are out, kerosene emulsion of the ordinary strength (one-fifteenth kerosene), or whale-oil soap in the proportion of 1 pound to 8 gallons of water, are the best remedies. Apply as a spray and be sure to make the application thorough.

THE WOOLLY APHIS. (*Schizoneura lanigera* Hausm.)

A very soft-bodied louse, more or less covered with a white, flocculent excretion, resembling wool, and causing a blood-brown stain when crushed in the hand. One form of this insect occurs on the roots of the trees and produces wart-like swellings; another appears on the trunk and limbs and is usually densely covered with the woolly excretion.

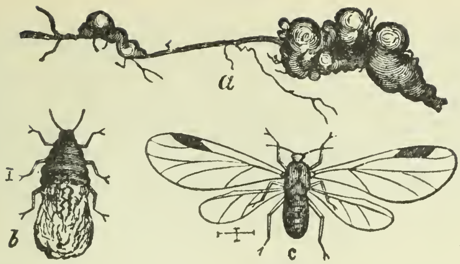


Fig. 13.—Woolly Aphis, root form : a, small root showing swellings caused by the lice; b, wingless louse showing woolly secretion; c, winged louse. The lice are very much enlarged, the actual sizes being shown by the lines at the sides of the illustrations.

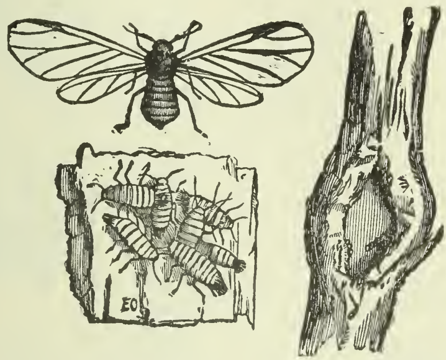


Fig. 14.—Woolly Aphis, aerial form, showing winged and wingless lice enlarged, and a scar on a limb that has been attacked by the lice.

Remedies—Probably the best remedy for the root form is tobacco dust worked into the ground to the amount of 3 to 6 pounds about the crown of the tree and then wet with water.

In the hands of one who has had experience, carbon bisulphide may be used effectually by injecting it into the ground about the crown of the tree. Kerosene emulsion, whale-oil soap and hot water, have all been used successfully, but probably all should give way to tobacco dust,which is cheap, effectual and lasting in its effects.

To keep the aerial form in check, begin in the latter part of May when the little white patches of lice begin to appear about wounds and tender places on the bark of the tree and, by means of a paint brush, apply pure kerosene to every patch of lice that can be found.

If the lice spread over the tops of the trees they may be treated with kerosene emulsion, ordinary strength, but it is necessary to throw it with a great deal of force so as to wet through the "wool" which protects the lice from any light spray.

Where the lice are found on the roots of nursery stock, it is advisable to dip the roots in ordinary kerosene emulsion, or in whale-oil soap in the proportion of 1 pound to 8 gallons of water or to fumigate with hydrocyanic acid gas.

Other insects mentioned in this paper that sometimes occur on the apple, are Red Spider, the Brown Mite and Grasshoppers.

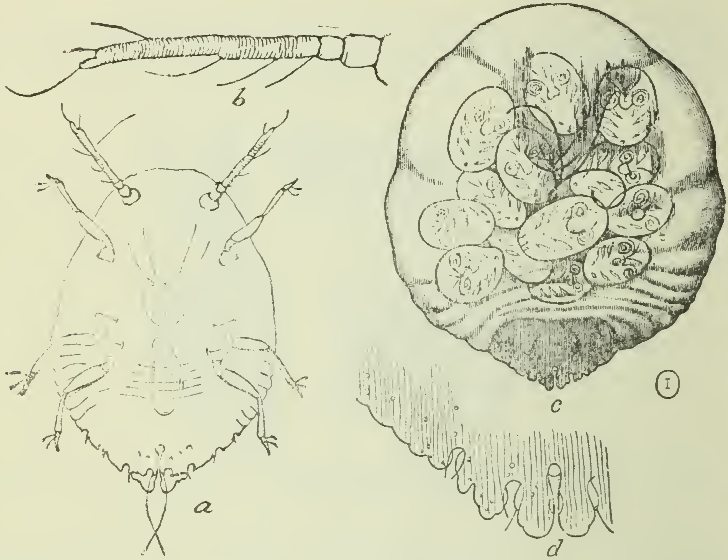


Fig. 11.—San Jose Scale: a, female removed from scale; a, antenna; c, gravid female showing unborn young; d, tail end of a female, all greatly enlarged. (See page 14.)

PEAR-TREE ENEMIES.

THE BROWN MITE. (*Bryobia Pratensis*, Garman.)

This insect is also called "Clover Mite," and in some localities it is called "Red Spider" on account of the rust-red color, but the last name is applied to another mite treated on another page. The eggs of this insect are nearly globular, of a bright red color, and often occur in enormous numbers on the bark of pear, apple and other orchard trees, most often on the pear in Colorado. They give the bark a rusty red appearance and will stain the hand if it is rubbed over them. The eggs are so small that, without a glass, it would be impossible to discover their real nature. During May they hatch and the little mites coming form them are, at first, a bright vermilion red in color. As they grow this color fades into a rusty brown. When mature, the mite resembles a very small spider and is just large enough to be plainly seen by one who has fairly good eye-sight.

As the result of the attacks of this mite the foliage of the tree becomes bleached and sickly in appearance. Aside from the pear it attacks badly the cherry, apple and plum and perhaps a few other trees.

Remedies—Those who use the lime, sulphur and salt wash in the vicinity of Grand Junction, Colo., assure me that it completely rids their trees of Brown Mite.

In my own experiments I have found whale-oil soap in the proportion of one pound to 4 gallons of water, or kerosene emulsion diluted so that the kerosene will be one-eighth of the mixture, applied before the eggs hatch, to destroy the latter completely, none whatever hatching where thousands were treated. The same applications in one-half the foregoing strengths will kill the mites after they hatch. The best time to make the treatment is before the eggs hatch.

THE PEAR-TREE SLUG. (*Eriocampa cerasi* Peck.)

This insect attracts attention as slimy, olive-green slugs upon the leaves, which they kill by eating off the soft part and leaving the veins. When abundant, they entirely destroy the foliage, leaving the leaves brown and dry as if killed by fire. There are two broods, one appearing in June and one in August.

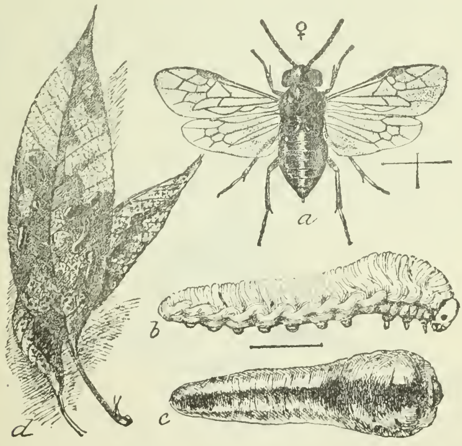


Fig. 15.—Pear Slug: a, adult female fly; b, larva or slug with the slimy covering removed; c, same as the preceding in natural condition; d, leaves showing slugs and their injuries. (Marlatt, Circular 26, Second Series, U. S. Dep. of Agr., Div. of Entomology.)

Remedies—There are several remedies that may be successfully used against this insect. White hellebore lightly dusted over the foliage in the evening, or applied in a watery spray in the proportion of an ounce to three gallons, is probably the best. Paris green or London purple dusted or sprayed upon the foliage will accomplish the same result. Air-slaked lime or strong wood ashes have often been recommended and are probably of some use. Even fine road dust has been recommended as all sufficient for the destruction of the slimy larvæ of this saw-fly, but I am inclined to think that the last of these remedies, at least, is of little use, and I have dusted lime freely upon the slugs without any apparent harm to them. Pyrethrum, or Persian Insect Powder, dusted over the slugs will kill all that it comes in contact with.

This slug also attacks the foliage of plum and cherry trees.

THE PEAR LEAF-BLISTER. (*Phytoptus pyri* Scheuten.)

This disease is indicated by small black spots appearing upon pear leaves, sometimes so numerous as to run together and involve a great portion of the leaf. Before turning black the spots are green like the rest of the leaf. An examination of the spots will show that they are slightly thickened portions and each one is the habitation of a large number of very minute parasites.

Remedies—The parasites spend the winter, chiefly, under bud-scales upon the trees, and may be killed during winter or early spring, when the trees are dormant, by a spray of kerosene emulsion in which the kerosene is one-fifth of the mixture.

Other insects mentioned in this paper that are sometimes found attacking the pear, are: Codling Moth, Red Spider, Brown Mite, Fruit-tree Leaf-roller, Tent Caterpillar, Flat-headed Borer, Fall Webworm, Buffalo Tree-Hopper, San Jose Scale and Putnam's Scale.

PLUM-TREE ENEMIES.

THE PLUM GOUGER. (*Coccotorus prunicida* Walsh.)

This insect is often mistaken for the Plum Curculio, mentioned below, which does not occur in Colorado as yet. The Gouger is a native of the Western United States, where it has fed from time immemorial upon native plums and it has not yet acquired a taste for th . more luscious European varieties. At least, it seldoms attacks anything but native varieties of the plum.

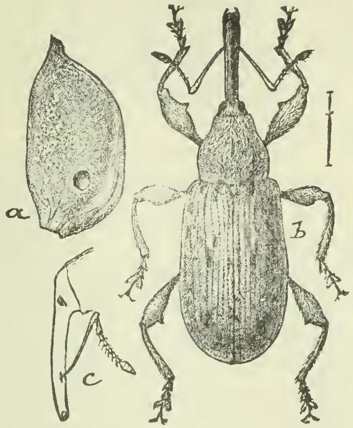


Fig. 16.—Plum Gouger: a, plum pit showing hole for exit of Gouger; b, Gouger. (Riley & Howard. Insect Life. Vol. II. U. S. Dep. of Agr., Div. of Entomology.)

The beetle is about one-fourth inch in length, has a rather long, curved snout, or rostrum; the wing covers are of a leaden gray color, finely spotted with black and brown, while the thorax and head are ocherous yellow. The beetles begin appearing before the blossoms open. At first they puncture the calyx and feed on the ovary of the flower, completely destroying it for the production of fruit. Later their punctures may be seen on the growing plums, some being made for food and others for the purpose of depositing eggs. In the laboratory six of the beetles, in 24 hours, punctured the calyces and ate the ovaries of 65 buds and blossoms. The punctures made for egg-laying are shallow and the egg, after being deposited, is flush with the surface

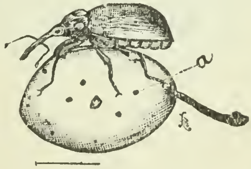


Fig. 17.—Plum Gouger and its punctures on a plum. (After Bruner.)

of the plum. For a short time it is yellowish white in color, but, where it is exposed to the light, it soon becomes shining jet black. The larvæ on hatching eat their way directly to the pit leaving a minute black line to mark their course. On reaching the pit they do not burrow about it as in the case of the Plum Curculio but burrow straight on into the meat of the pit on which they feed until fully grown. Then the grub eats a hole through the pit so it can escape after it has changed to a beetle. The beetles emerge usually a little before the plums ripen, and destroy the fruit. The fruit that is punctured by the beetles becomes hard and gnarly and is usually worthless.

Remedies— My experiments do not indicate that poisonous sprays can be used to any profit against this insect. The best remedy we know of at present is to jar the trees daily, either in the morning or in the evening and catch the beetles on sheets spread beneath the trees. Make a large sheet for the purpose, slit it from the middle of one side to the center and, in using, pass the strips thus made either side of the tree so that the latter will stand at the center of the sheet. Two men can use such a sheet very rapidly. Begin the work as soon as the trees blossom and continue as long as you can get half as many gougers as the number of trees jarred.

THE PLUM CURCULIO (*Conotrachelus nenuphar* Herbst.)

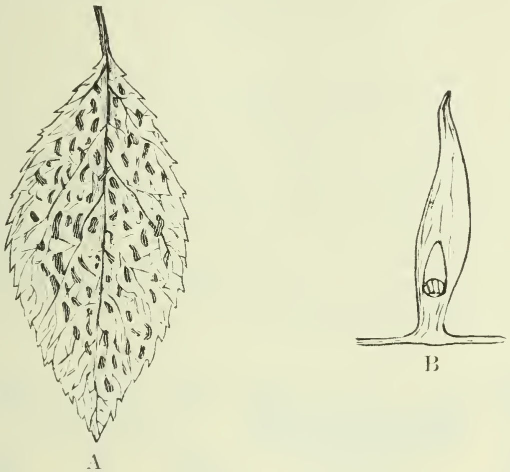
This is by far the most serious pest to plum culture in the East. It also attacks other pit fruits, including the cherry. A dark brown to blackish snout beetle, about one-fifth of an inch long and with four prominent humps on each wing cover. The mark that the beetle makes on the fruit when "stinging" it for the deposition of an egg is very characteristic and has given this insect the appellation, "Little Turk." A puncture is made with the jaws and an egg deposited in it and then the beetle turns about and cuts a crescent partly surrounding the egg. The grub eats through the flesh of the plum to the pit and then feeds about the pit but never eats into it. The fruit, as the result of this injury, falls.

Remedies—Jarring as for the Plum Gouger is the best remedy for this insect. Some benefit can be derived from the use of arsenical sprays but, if the same expense is put into the work of jarring and collecting the beetles, it is generally believed that more good will be derived.

Where chickens can be kept in large numbers under the trees early in the season this insect seldom does much injury.

THE PLUM-LEAF NAIL-GALL (*Phytoptus* sp.)

The leaves of the American varieties of the plum are sometimes injured by the production of a large number of slender tubular projections standing out from their upper surfaces as shown in the accompanying illustration. Inside each gall is a large number of very small spider-like insects or mites of the appearance of Fig. 19.



Figs. 18 and 19.—A. plum leaf showing the galls; B. one of the galls enlarged and cut to show the interior.

Remedies—Probably nothing can be done of much value while the leaves are on the trees. Fallen leaves should be destroyed as far as possible by fire and the trees should be sprayed during the winter or early spring with

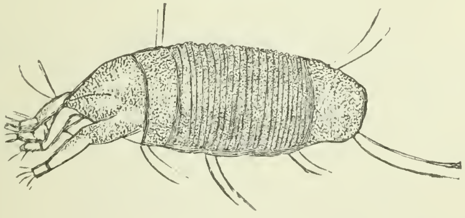


Fig. 20.—One of the mites that produce the nail-galls on plum leaves greatly enlarged.

kerosene emulsion of double strength (an emulsion in which the kerosene is about one-seventh of all), or whale-oil soap in the proportion of 1 pound to 4 gallons of water.

PLANT LICE.

For all plant lice attacking the plum, use the remedies recommended for the Apple Aphis. Apply the mixtures with considerable force so as to thoroughly wet the bodies of the lice.

The following insects, treated in this bulletin, also attack the plum: The Pear Slug, Tent Caterpillar, Fall Webworm, Red Spider, Brown Mite, Peach Borer, Grape Leaf-hopper, San Jose Scale and Putnam's Scale.

PEACH-TREE ENEMIES.

THE PEACH BORER (*Sannina exitiosa* Say.)

A yellowish white larva, or borer, working beneath the bark at the crown of the tree and down on the roots causing the exudation of a gummy substance. The eggs are laid about the crown of the tree by a small moth with narrow steel-blue wings that flies in the bright sunshine and much resembles a wasp in appearance.

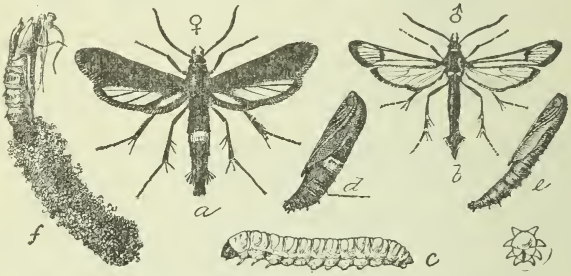


Fig. 21.—Peach tree Borer: a, adult female; b, adult male; c, full-grown larva; d, female pupa; e, male pupa; f, pupa skin and cocoon. All about natural size. (Marlatt, Circular 17, Second Series, U. S. Dep. of Agr. Div. of Entomology.

Remedies—Wherever the gummy exudation is seen, cut out the borer with a knife. This should be done early every spring, without fail, and if thoroughly attended to, will keep the insect in check. A little dirt should be brushed away from the the crown of the tree to discover any burrows that may not be apparent at the surface. Many preventives have been recommended to keep the female moth from depositing her eggs upon the trees. Wrapping the trunks of the trees to a height of 8 or 10 inches with tarred paper is probably as good as any of these.

Any of the following insects mentioned in this bulletin may also be found attacking the peach: Plum Curculio, San Jose Scale, Red Spider, Brown Mite and Plant Lice.

CHERRY-TREE ENEMIES.

The insects mentioned in this paper that may also be found attacking the cherry are : the Fruit-tree Leaf-roller, Tent Caterpillar, Fall Webworm, San Jose Scale, Brown Mite, Pear Slug and Plum Curculio.

THE ACHEMON SPHINX. (*Philampelus achemon* Drury.)

The young larva has a long horn on the last segment of the body while the fully grown worm only has a shining black spot. The eggs are deposited early in July on the leaves of grape and Virginia creeper. The larvæ soon hatch from them and feed on the leaves until about the last of August when they become fully grown and descend to the ground to pass the winter in the chrysalis.

Remedies—The worms are so large that they are readily seen and can be collected by hand and destroyed. They may also be destroyed by the use of Paris green or London purple sprayed or dusted on the leaves or, when unsafe to apply poison, by the use of Pyrethrum.

INSECT ENEMIES OF VIRGINIA CREEPER.

The foregoing enemies of the grapevine also attack the Virginia creeper and the remedies to use are the same in both cases.

INSECT ENEMIES OF SMALL FRUITS.

THE EIGHT-SPOTTED FORESTER (*Alypia octomaculata* Fab.)

The larvæ of this insect are common upon the grape vines in July and again in September. They are marked with numerous white, black and reddish cross-lines. On the middle segments of the body there are about eight black and seven white cross-lines to a segment and a broader reddish line on the middle of the segment. Low on the sides of the body and back of the three anterior pairs of legs there are rather irregular white blotches. When fully grown the larvæ are about one and one-half inches long.

The moth spans a little more than an inch from tip to tip of wings, and is black in color with two large cream colored spots on each fore wing and one large and one small white spot on either hind wing, the large spot being at the base of the wing. The moths fly in May and again in the early part of August.

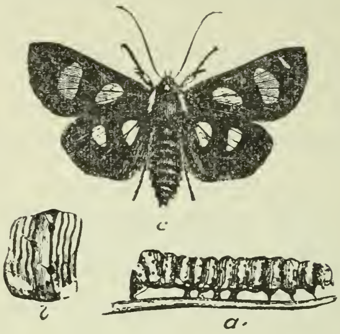


Fig. 22.—Eight spotted Forester: a. larva; b, one segment of body of larva enlarged; c, moth. Natural size except b.

Remedies—When safe to use poisons, spray thoroughly with Paris green or London purple. If there is fruit nearly grown so as to make the application of poison unsafe, use a bellows duster and make a thorough application of Buhach (Pyrethrum.)

This insect also attacks Virginia creeper badly.

THE GRAPE LEAF-HOPPER. (*Typhlocyba comes* Say.)

A very small jumping insect about one-eighth of an inch long and light yellow in color beautifully marked with red and black. When abundant, these hoppers will fly from the vines in large numbers when the latter are jarred. They cause the leaves to turn pale and sometimes they will even turn brown and curl up. In early spring, before the grape leaves open, these insects sometimes occur in enormous numbers on strawberries and I have also seen them in considerable numbers on currant and gooseberry bushes and upon Virginia creeper.

Remedies—Spray forcibly with kerosene emulsion early in the morning, before sunrise. At this time the hoppers are dumpish and can be easily knocked off the leaves with the spray and wet down with it.

When abundant on strawberries early in the spring it is very important to make a thorough treatment of the emulsion as above, or, if the vines have not started too much, spread a light covering of straw over the patch and burn it.

THE IMPORTED CURRANT BORER. (*Sesia tipuliformis*, Linn.)

Piths of currant stems burrowed out by a yellowish white larva about half an inch long. Before maturing the larva eats a hole to the outside. Bored stems sometimes wilting and dying and sometimes breaking down as the result of the injury.

Remedy—Cut out the infested stems and burn them before the first of June each year.

THE NATIVE CURRANT SAW-FLY. (*Pristiphora grossulariae* Walsh.)

A green larva, about half of an inch long when fully grown, feeding upon the leaves of currant and gooseberry bushes. Appearing late in June and again about the last of August. The adult insect is a black four-winged fly about the size of a house-fly. The eggs are deposited, one in a place, under the epidermis of the leaves.

Remedies.—The best remedy for this pest is white hellebore dusted lightly over the foliage in the evening. If this is carefully done, nearly every larva can be found dead under the bushes the next morning. Paris green or London purple may be used either dry or in water as for other leaf-eating insects. The latter poisons should not be used before the currants are picked.

THE WESTERN CURRANT AND GOOSEBERRY SPAN-WORMS. (*Thamnonoma*, sp.)

Light yellow larvæ, about one inch long when mature, and looping their bodies when walking. Sometimes completely stripping the foliage from the bushes.

Remedies.—Dust or spray Paris green or London purple as for other leaf-eating insects, or dust freely with Buhach (Pyrethrum). A thorough spraying with kerosene emulsion would probably be equally effectual.

Other insects mentioned in this paper that attack currants and gooseberries are: Red Spider, Tent Caterpillar, Fruit-tree Leaf-roller, Grape Leaf-hopper and Grasshoppers.

STRAWBERRY LEAF-ROLLER. (*Phoxopteris fragariae*, W & R.)

Small yellowish-brown to greenish larvæ, attaining nearly one-half inch in length when fully grown, and having the habit of folding the leaves of the strawberry vines for their protection. When abundant they almost completely defoliate the vines. There are two broods, one appearing late in June and another in August.

The mature insect is a small rust-colored moth with more or less white and black markings on the wings and spanning about half an inch from tip to tip of wigs.

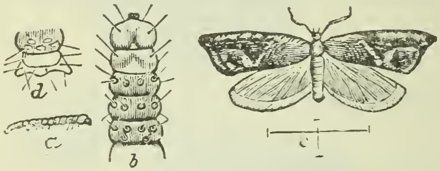


Fig. 23.—Strawberry Leaf roller: a, larva natural size; b, head end of larva enlarged; c, moth about twice natural size; d, tail end of larva enlarged. (After Riley).

Fig. 24.—Strawberry leaves showing their appearance when folded by the roller. (After Weed).

Remedies.—This is a rather difficult insect to manage as it is not safe to use the arsenites on the plants for the first brood. When the larvæ first appear, dusting the foliage lightly with white hellebore will destroy many of them. When the second brood appear, and the berries have been picked, apply Paris green in flour dusting it thoroughly over the leaves in the evening when there is some dew on. An application very early in the morning will do equally well. Mix the poison and flour in the proportion of about 1 to 20 by weight and dust from a cheesecloth sack.

This insect has been reported quite abundant about Rocky Ford, this state, and it is the only place that I know it to occur in Colorado.

The other insects mentioned in this paper that attack the strawberry are: Red Spider, Apple Flea-Beetle and the Grape Leaf-hopper.

INSECT ENEMIES OF ROSE BUSHES.

THE RED SPIDER. (*Tetranychus*, sp.)

This insect is seldom abundant enough to do appreciable harm to orchard trees, but often becomes a serious pest on rose and currant bushes, sweet peas and other low plants. Although called "Red Spider," it is seldom red in color, but nearly always pale green with about three dark blotches on either side of the body. It is spider-like in appearance and is so small as to be seen with difficulty without the aid of a magnifying glass. It inhabits, chiefly, the under side of the leaves.

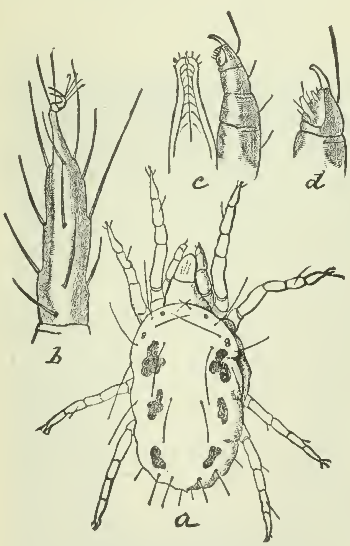


Fig. 25,—Red Spider: a, view from above, adult; b, one of the feet showing claw; c, the beak and one of the feelers or palpi; d, the end of the palpus more enlarged. All greatly enlarged. (Riley, Insect Life, Vol. II, U. S. Dep. of Agr. Div. of Entomology.)

where it works beneath a very delicate web which it spins. In this respect it differs from the Brown Mite which does not spin a web. The eggs are deposited under the web and are globular and transparent.

Remedies.—This insect thrives best in a dry atmosphere and the free use of water is probably as good a remedy as has been found. Apply often in the form of a spray taking pains to treat the under side of the foliage.

In addition to the above, the Fruit-tree Leaf-roller and a Plant Louse also attack the rose. I have also been informed that the Rose Slug, an insect resembling the Pear Slug, has become a pest in Denver. The remedies for it are the same as for the Pear Slug.

SHADE-TREE ENEMIES.

THE BOX-ELDER LEAF-ROLLER. (*Cacœcia semiferana*, Walk.)

This insect is a close relative of the Fruit-tree Leaf-roller and it is quite commonly thought not to be different. It seems to confine its attacks exclusively to the box-elder, however, in this state, as I have never yet found the larvæ feeding upon anything else. Its habits and appearance are much like the fruit tree species.

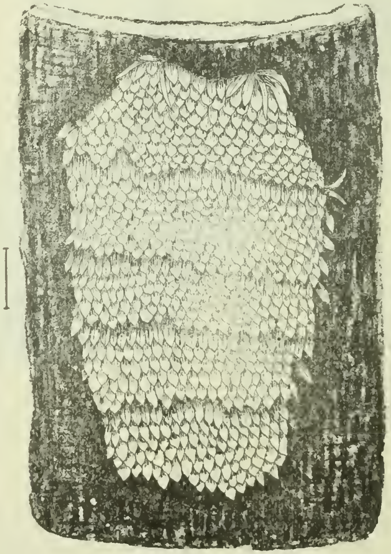


Fig. 26.—Egg patch of Box-elder Leaf-roller, greatly enlarged to show the arrangement of the scales.

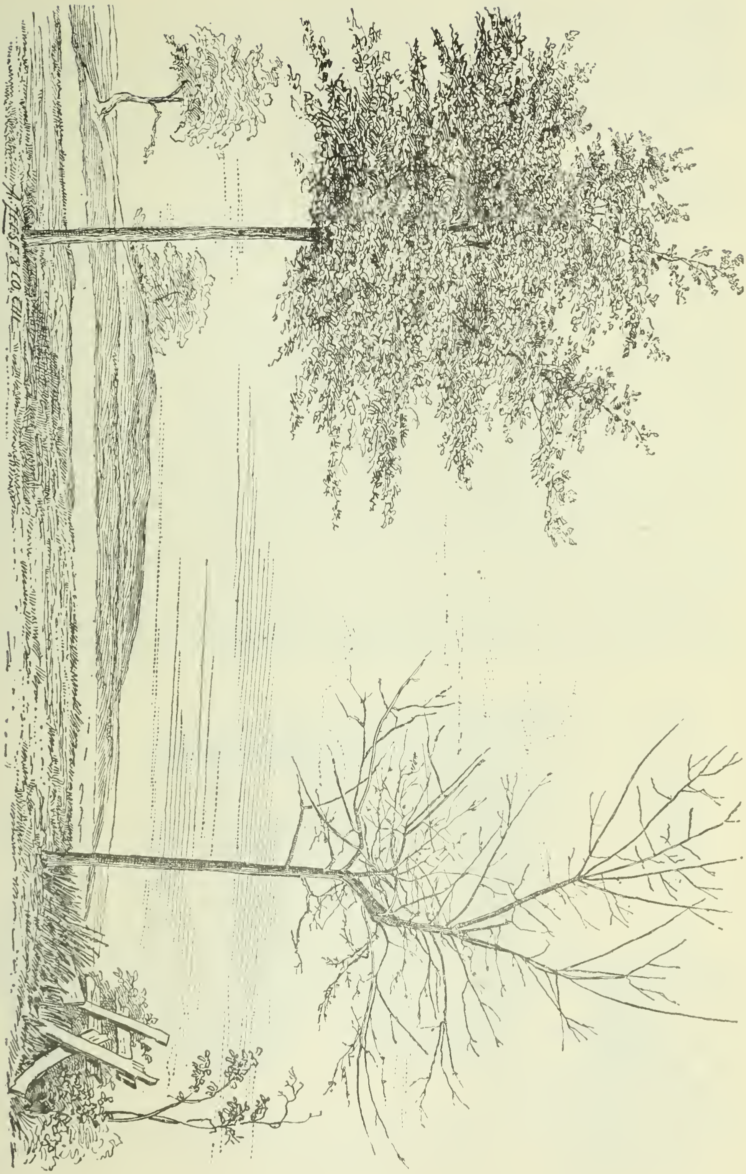


Fig. 27.—Two trees that were standing side by side, the one at the right untreated and the foliage all eaten off; the one at the left treated with Paris green and the foliage saved. From photograph by the author.

The moths are almost pure straw yellow, some with dusky markings above, and the abdomen of the female is largely black beneath. The eggs are laid in the crevices of rough bark and are covered with the scales from the underside of the abdomen of the female which are placed like shingles upon a roof as shown in Fig. 26. The larvæ are light green or yellowish green in color and lack the black coloration of the head which is so distinct in case of the fruit tree species.

Remedies—The same as for the Fruit-tree Leaf-roller.

THE BOX-ELDER PLANT-BUG. (*Leptocoris trivittatus* Say.)

A rather flat bug, about half an inch in length, appearing black with narrow red margins to the thick portion of the wings and to the thorax, and with the body beneath the wings red. The adult bug lives over winter in protected places and often becomes very annoying in the fall and on warm days in the winter by crawling into dwellings. Often seen in large numbers on the south side of stone or brick walls in the sunshine and sometimes called "brick bug" in consequence. When warm weather in the spring comes on, the bugs go to box-elder trees and deposit their reddish eggs in crevices of the bark. The young feed chiefly on box-elder.

Remedies—Boiling hot water dashed upon the bugs when clustered upon buildings will destroy them. Ordinary

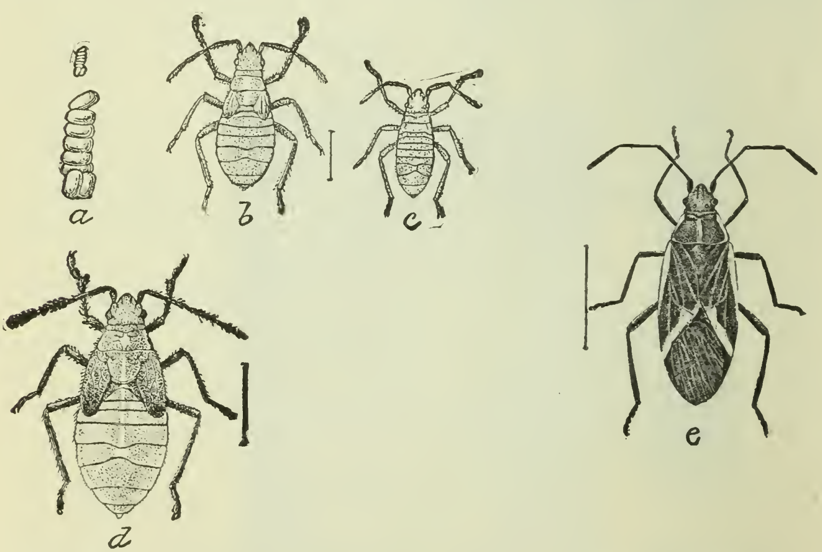


Fig. 28.—Box-elder Plant-Bug: a. eggs; b, c, d, different stages of the immature insect; e, mature insect. All considerably enlarged. [Howard, Circular 28, Second Series, U. S. Dep. of Agr., Div. of Entomology.]

applications for the destruction of these adult hibernating bugs are useless. I have used kerosene emulsion, whale-oil soap, tobacco decoction, Zenoleum and Pyrethrum, all very strong, and with almost no effect except to make the bugs uncomfortable for a time. I do not know of any experiments having been tried upon the young but presume that kerosene emulsion or whale-oil soap of ordinary strengths will kill them if thoroughly applied.

The only other insect that troubles the box-elder badly in Colorado is the plant-louse (*Chaitophorus negundinis* Thos). Use the same remedies as for the Apple Aphis.

THE COTTONY MAPLE SCALE. (*Pulvinaria innumerabilis*, Rath.)

A yellowish or brownish oval scale on the twigs of soft maple. During the fall, winter and early spring the scales are quite flat, but, during May, the scales become convex and, finally, a mass of white cottony threads appear at one end, raising that end of the scale from the limb to an angle of about forty degrees or even more. In this cottony mass an enormous number of minute yellowish eggs are deposited, often as many as 2,000 to the single scale. It is at this time that the scales attract most attention on account of the cottony secretion.

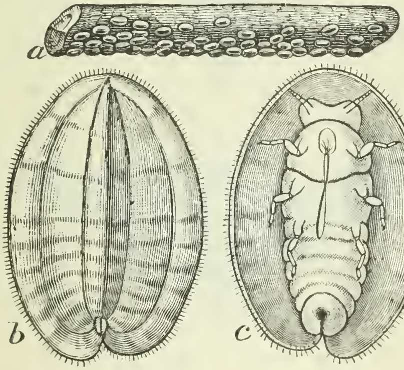


Fig. 29.—Cottony Maple Scale: a, eggs before hatching; b, egg after hatching; c, young larva; all much enlarged. (Riley, U. S. Dep. of Agr. Rep., 1884.)

Remedies—A thorough spraying with kerosene emulsion or whale-oil soap of ordinary strength will kill the young lice. If the application is delayed too long after hatching, the scales will so protect the lice that it will be necessary to increase the strength of the mixture. If this is found necessary it will probably be better to treat as for the Scurvy Bark-Louse.

The soft maple is also attacked by the Fruit-tree Leaf-roller, Flat-headed Borer, Fall Webworm and Plant Lice.

THE ASH GALL-LOUSE. (*Pemphigus fraxinifolii* Thos.)

Greenish plant lice curling the leaves of white ash. The lice usually accumulate on the leaves at the end of a limb. The leaves curl and become so swollen and loaded with lice that the limb will often be bent down with the weight.

Remedy—As soon as the leaves at the end of the limb begin to curl, cut the limb off far enough back to include all the infested leaves and burn it.

THE COTTONWOOD BORER. (*Prionoxistus robiniæ* Peck.)

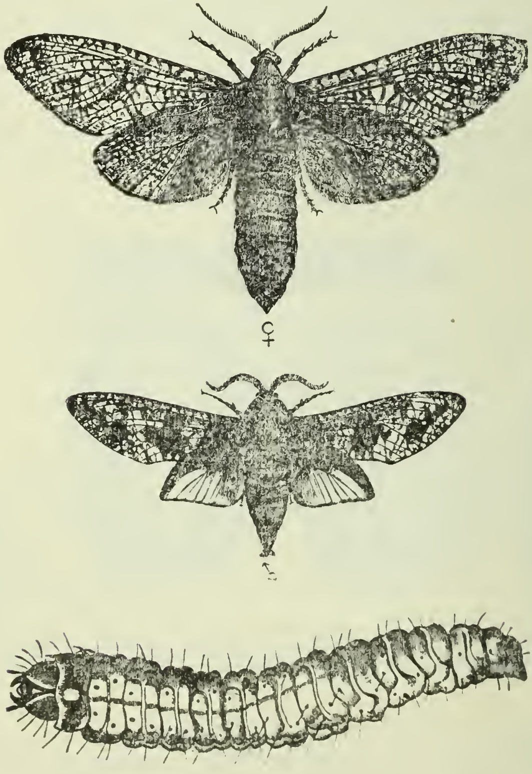


Fig. 30. Cottonwood Borer (*Prionoxistus robiniae*): Showing male and female moth and the larva. The female moth is the larger.

This insect is also known as the Oak Carpenter-Worm, but in Colorado it is known almost exclusively as a cottonwood borer. The larva, when fully grown, is nearly three inches in length, with a shining black head, and it cuts large holes in the trunks of the trees. Its work is most often noticed where a limb has been cut off or the trunk injured in some other way. The castings of the borers are pushed out on the surface and the tree bleeds as a result of the wounds made to the surface. The sap runs down on the trunk and sours, making a breeding place for maggots of certain flies. The moths have been taken at night at Fort Collins between June 14th and July 21. The females are larger than the males and both are well represented in the accompanying figure at about life size. The general color is gray, but the male has a large yellow spot covering the central portion of the hind wing on either side.

Remedies—It is hard to suggest a good remedy for this insect. Tacking a little wire gauze over the burrow before the middle of June would prevent the escape of the moth. Probably a wooden plug driven into the hole would serve the same purpose. With a stout wire one could kill many of the larvæ or pupæ in their burrows. Avoid scarring the trees as much as possible as the borers usually enter at such places.

The cottonwood is also attacked by Plant Lice, Fall Webworm and Putnam Scale, which have already been mentioned with their remedies. It is also attacked by a white scale (*Chionaspis ortholobis*), much resembling the scale figured on a following page on pine and spruce leaves. Remedies the same as for the other scales.

THE ELM LEAF-CLUSTER GALL. (*Schizoneura americana*, Riley.)

The author's observations upon elms on the College grounds the present spring show that this louse appears on the trees before the leaf-buds begin to open, and that it attacks the base of a bud, soon becomes covered with a white flocculent secretion (see Fig. 32, e,) and that the bud, as it opens, curves downward so that the leaves hide the louse. The attack stimulates the opening of the bud and the growth of the leaves so that they are usually in advance of the other buds of the tree. By the middle of June, the infested leaves have formed a loose cluster, often as large as a man's fist or larger, within which is a disgusting mass of lice and little globules of watery excretion that they have thrown off. Later the lice leave the galls, which become brown and dry, and go onto the leaves or tender bark about wounds on the tree. The leaves, as a result of the attack, become swollen and curled and usually take on a reddish coloration over the swollen portion.

Remedies—When the leaf clusters first appear, begin the work of cutting them off and destroying them. They occur mostly, on the small twigs near the trunk and on the lower branches of the tree. By going over the trees two or three times at intervals of about a week it will be possible to get nearly all before the lice spread over the foliage generally. It is stated by Riley that the eggs remain over winter on the trunk of the tree. If this is true, it is probable that a thorough spraying of whale-oil soap, 1 pound to 4 gallons of water, or kerosene emulsion, in which the kerosene is about one-fourth of the mixture, would kill nearly all the eggs.

The elm is also attacked by the Fruit-tree Leaf-roller, to some extent.

THE PINE-LEAF SCALE (*Chionaspis pinifoliae* Fitch.)

White elongated scales on leaves of pine and spruce trees are shown in the accompanying illustration. Beneath the scales, in the spring, will be found a mass of purple eggs. Sometimes very abundant, causing the leaves to fall, as many of them have from the twig of silver spruce shown in the figure. (See Fig. 34.)

Remedies—The same as for the Scurvy Bark-Louse of the apple. The best time to make the application is just after the young lice have hatched, which will be about the first of June. By the aid of a hand lens one can easily keep watch of the eggs and learn just when they hatch each year. The exact time will vary with the lateness or earliness of the season.

INSECT ENEMIES OF THE SPRUCE.

The scale mentioned above is quite as common on silver spruce in Colorado as on pine. The remedy, of course, is the same.

There are also two important plant lice attacking the spruce trees, one of which (*Chermes abietis* Linn.) produces brown cone-shaped galls at the tips of the twigs. The adult females live over winter on the trees and deposit clusters of brownish eggs, all of which are attached to the twig or to each other by means of slender silken threads. The writer has found over 400 eggs in a single cluster. The eggs hatch about the first of June at Fort Collins and the young lice, according to the observations of Mr. R. A. Cooley of the Mass. Agricultural College, go at once to the bases of the young leaflets where they insert their beaks and suck the sap which causes the peculiar growth mentioned above. I have seen the galls on silver spruce, only, in Colorado, and have seen them most abundant near timber line on the mountains.

Remedies—Probably the best remedy is to collect and destroy the galls during the latter half of June and early in July, before the lice escape from them. Where very abundant, it would pay to make an application of kerosene emulsion or whale-oil soap in about double the ordinary strengths during the latter half of May.

What appears to be another species of *Chermes*, lays its eggs in great numbers on the leaves of Douglass spruce during the month of May. The female, while laying the eggs, secretes a quantity of white waxy threads which so surround the egg-clusters that the latter are hardly visible. The eggs hatch at Fort Collins about the 25th of May and the little dark-colored lice locate on the leaves. A twig showing these egg-clusters covered by the waxy secretion of the lice is shown in the accompanying illustration. (See Fig. 35.)

Remedies—I have been completely successful in destroying both eggs and lice by applications of either kerosene emulsion or whale-oil soap in double the ordinary strengths. In the ordinary strengths, the majority of both lice and eggs were killed.

MILKWEED BEETLE. (*Tetraopes femoratus* Lecont.)

Injuring Young Nursery and Forestry Trees.

A plantation of young forestry trees set out on the College grounds by the Department of Agriculture, Division of Forestry, has been badly injured by the above beetle. My attention was first called to the injuries by Professor Crandall who brought me a specimen of the beetle doing the work. The beetle did the damage by cutting transverse gashes in the tender stems and in the petioles of the leaves. A great many gashes were usually cut in each stem, causing them to die or break over. In many of the gashes eggs were deposited. Fig. 36 shows two of the beetles and stems of locust on which they are working. The drooping leaves were all dead and brown.

Remedies—These beetles seem to have come onto the little trees from a large patch of milkweeds that were close by. If the milkweeds had not been allowed to grow in the vicinity of the forestry plot it is probable that the trees would not have been injured.

INSECTS INJURIOUS TO FARM AND GARDEN CROPS.

THE SQUASH BUG. (*Anasa tristis* De Geer.)

A rather large bug, varying from one-half to three-fourths of an inch in length and varying in color from a grayish brown to a dull black color above and dingy yellow beneath. On account of their strong musky odor they are often called "stink bugs." The bugs begin to accumulate about various vines of the squash family, particularly the vines of the Hubbard and other winter squashes about the time the first true leaves appear. There are two broods, the adults of the second brood living over winter under rubbish.

Remedies—As this insect does its feeding by inserting a sharp beak and sucking the sap of plants, it is evident that it would be useless to apply a poison that has to be eaten to kill. For a considerable number of days before egg-laying

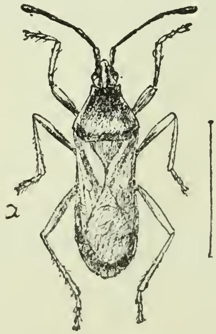


Fig. 37.—Squash bug enlarged. (After Snow.)

the mature bugs gather about the vines to feed and mate. Often they collect on a single leaf causing it to wilt. By visiting the vines each morning the bugs can be rapidly crushed or collected and destroyed. This is really one of the best methods we have of keeping this insect in subjection. A little later the eggs, which are deposited on the under side of the leaves in loose clusters, can be quite rapidly destroyed by hand collecting. When the young hatch they have the habit of collecting in large numbers on single leaves. They are very shy and will run rapidly away when approached in the warm part of the day, but one can collect them rapidly in the morning about sun-rise. Take a basin or other suitable dish, with a little water in the bottom and a spoonful of kerosene on top, and go to these infested leaves and quickly brush the bugs into the basin. Every one that comes in contact with the oil will die in a very few seconds.

I have been able to kill large numbers of bugs with kerosene emulsion by spraying it forcibly upon them and thoroughly wetting them down, but in most hands the preceding remedies will prove most successful.

THE STRIPED CUCUMBER BEETLE. (*Diabrotica vittata* Fabr.)

A small yellow beetle, about one-sixth of an inch long with a black head and three black longitudinal stripes on the wings when the latter are closed. The beetles appear soon after the cucumber, melon and squash vines are up and eat holes in the leaves until the plants wither and die.

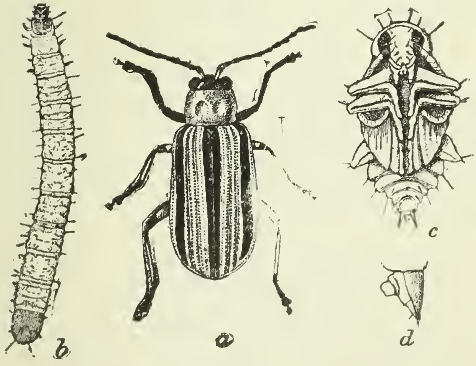


Fig. 38.—Striped Cucumber Beetle: a, mature beetle; b, mature larva; c, pupa; d, side view of last segment of larva. All considerably enlarged. (Chittenden, Circular 31, Second Series, U. S. Dep. of Agr., Div. of Entomology.)

Eggs are also laid about the stems of the plants and the grubs hatching from these burrow down into the roots of the plants which also causes their death.

So far, this insect seems only to occur in this state, along the Arkansas River from Canon City to Rocky Ford.

Remedies—There are many methods of dealing with this pest. One is to plant much more seed than is wanted to grow that enough of the plants may be left after the beetles have had what they want. Planting extra seed is all right, but more should be done. Dusting the leaves freely with lime, plaster or ashes in the evening or early morning, while the dew is on, will usually result in driving the beetles to some other patch, but will not destroy them. A method much practiced consists in covering the plants with mosquito netting until they are large enough to withstand the attack of the beetles. This may be done by tacking the netting over one end of open boxes that are then set about the plants, or by bending a withe over the plants, laying the netting upon it and holding it down by clods of earth.

I have found I can kill these insects very successfully by dusting Pyrethrum or Insect Powder upon them from a cheesecloth sack. To be successful the treatment must be made before sun-rise in the morning. Then, by lightly brushing the leaves, the beetles, damp and sluggish with the dew of the night, will fall to the ground and, if dusted in this condition with the Pyrethrum, will be readily killed.

THE MELON LOUSE. (*Aphis cucumeris* Forbes.)

A greenish louse occurring in great numbers on the underside of the leaves of watermelon, muskmelon, cucumber and squash vines, causing them to curl and turn yellow.

Remedies—It is so difficult to get insecticides upon this louse that there are no satisfactory remedial measures known for it. It is probable that its attacks can be avoided to some extent by a judicious rotation of crops and by plowing under the vines of infested patches as soon as the crop has been gathered.

FLEA-BEETLES.

There are several species of minute flea-beetles usually black in color and not as large as the head of an ordinary pin, which attack various garden plants, principally cabbages, radishes, beets tomatoes and potatoes. The damage is done by eating small holes in the leaves. When approached, the beetles jump and hence the name "flea beetles."

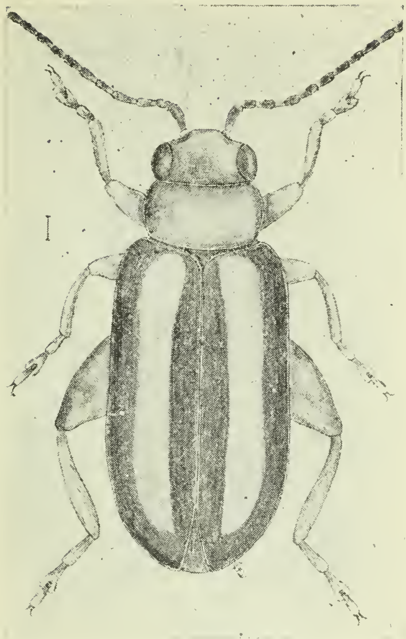


Fig. 39.—Striped Flea-Beetle (*Systena taeniata*) greatly enlarged.

Remedies—The same as for the Striped Cucumber Beetle.

THE BEAN BEETLE. (*Epilachna corrupta* Muls.)

This is by far the most destructive bean pest in Colorado. The mature insect is a beetle about one-third of an inch in length and yellowish to rusty brown in color with sixteen small black spots on its wing covers. The beetles deposit their yellow eggs in patches on the underside of the bean leaves. The grubs are light yellow in color and are covered with stout branched spines. The insect, in all stages, feeds upon the leaves and green pods of the cultivated beans and particularly wax beans. Lima beans are seldom badly eaten by them. See Fig. 40.

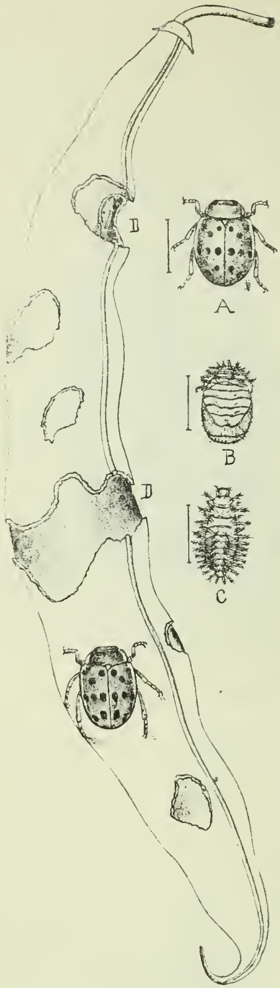


Fig. 40.—A, beetle; B, pupa; C, larva; D, a pod that has been eaten into. All a little enlarged.

Remedies—On account of beans being very susceptible to injury from the application of arsenites, it is rather difficult to treat this insect with satisfactory results. If the arsenites are used, lime should be freely added. I have had best success by using kerosene emulsion of double strength (in which the kerosene is one-eigth of the mixture), spraying it on the underside of the leaves for the destruction of the eggs and newly hatched grubs.

THE PEA WEEVIL. (*Bruchus pisi* Linn.)

This is the insect that causes what are known as "buggy peas," and by most people it is only known in the beetle state, in the spring of the year, when it is found in the peas or the peas are found to have large holes in them made by the weevils. These beetles lay small yellow eggs on the pods of the green peas and the little grubs hatching from them eat through the pod and enter the peas and are often devoured in great numbers by those who eat green peas. If the grubs have entered the peas the fact can be discovered by the presence of very small punctures as if made by the point of a needle.

Remedies—As soon as the green peas have been gathered, pull the vines and destroy them by fire or otherwise.

For the destruction of the beetles in seed peas inclose the seed in a tight receptacle and use carbon bisulphide, about one tablespoonful to a cubic foot of space. Continue the treatment for 24 hours.

THE COLORADO POTATO BEETLE. (*Doryphora 10-lineata* Say.)

This beetle, so common upon potato vines, is too familiar to the farmer to need any description. In this state it is also common upon its native food-plant, the "buffalo bur" (*Solanum rostratum.*)

Fig. 41.—Colorado Potato Beetle: a, a, egg patches; b, b. young larvæ; c, pupa; d, mature beetle; e. the fore wing much enlarged to show markings.

Remedies—Paris green or London purple dusted or sprayed upon the potato vines are so efficient remedies that no others need be mentioned.

THE ONION THRIPS. (*Thrips striatus* Osb.)

A very small insect, slightly yellowish in color and one twenty-fourth of an inch in length, very active and mature, occurring upon onion tops in enormous numbers, causing them to whiten and wilt down prematurely. The insects

Fig. 42.—Onion Thrips, adult, greatly enlarged.

are so minute that it is often the case that the cause of the dying down of the tops is not discovered by the owner of the crop.

Remedies—At the beginning of the attack thoroughly spray the onions with kerosene emulsion or whale-oil soap of the ordinary strengths.

CABBAGE APHIS. (*Aphis brassicae* Linn.)

A green plant louse on the underside of the leaves of cabbage, cauliflower, turnip and similar plants. The bodies of the lice are covered with a fine whitish powder, often occurring in enormous numbers late in the summer and in the fall.

Remedies—Kerosene emulsion and whale-oil soap are the standard remedies against these as well as other plant lice. It is difficult to make the application effectual, however, on account of the curling of the leaves of the plants that the lice infest and the mealy covering to the lice which causes all liquids to run from their bodies as water runs from a duck's back. To be effectual the application must be made with sufficient force to knock the lice from the leaves, in which case most of the lice will be killed. The lice live over winter upon cabbages or their stumps that are left in the field in the fall. These should all be plowed deeply under or otherwise destroyed in the fall. An additional precaution of considerable value is to rotate the crop so as not to grow a crop nearer than necessary to ground where the lice were present the preceding year.

THE IMPORTED CABBAGE BUTTERFLY. (*Pieris rapae* Linn.)

This insect in the mature state is a white butterfly with black tips to the anterior wings and the male usually has four and the female six small black spots on the wings above as shown in the accompanying illustration.

The butterflies appear early in the spring and are ready to begin laying eggs on leaves of cabbages, cauliflowers, turnips and some other Cruciferous plants as soon as the plants are set out. The eggs are light yellow in color and are deposited singly. The worms, soon after hatching, assume a dark green color, almost identical with that of the leaves which serve as their food. Not infrequently the worms eat into the head of cabbages and ruin them for the market.

Fig. 43.—Imported Cabbage Butterfly: A, male; B, female. As seen from above, natural size. (After Riley.)

Remedies—Mix one pound of Paris green with twenty pounds of wheat flour and lightly dust the leaves while the dew is on. Apply freely up to the time the heads begin to form and after that use rather sparingly on cabbage heads and not at all on cauliflowers. Do not use nearer than ten days to the time when the cabbages are to be harvested. If used freely when the cabbages are small, there will be little need of much being applied when the heads are nearly grown. If used as above directed there will be no danger from eating the cabbages. Cabbage leaves are all the time opening out so that the leaves that are a part of the head one day will, a few days later, be standing up free from the head.

For those who object to using poison, I would recommend insect powder (Pyrethrum) which is the best used dry in a small bellows by means of which the powder is driven down among the bases of the leaves to reach all the worms. This substance must be put onto the worms in order to kill them.

If much poison has been used it will not do to turn stock into the patch to eat the leaves and stumps after the crop has been gathered.

THE CABBAGE PLUTELLA. (*Plutella cruciferarum* Zell.)

This insect is a small moth, less than half of an inch in length and with narrow wings that have a white inner margin and when closed make a conspicuous white line along the back as shown in the accompanying figure. The larvæ are correspondingly small and are very active, wriggling

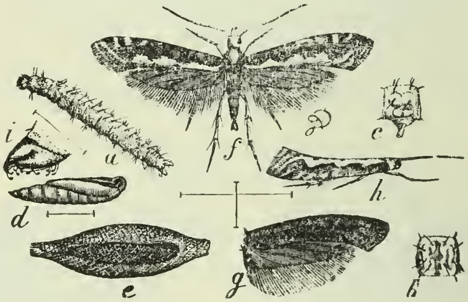


Fig. 44.—The Cabbage Plutella: a, larva; d, chrysalis; e, silken cocoon with chrysalis inside; h, moth with wings closed; f, moth with wings spread. All enlarged about twice. (After Riley.)

themselves quickly off the leaves when disturbed and dropping on a silken thread. When fully grown the larva spins a delicate white cocoon among the leaves. These I have found as early as June 10th at Fort Collins and the moths have appeared in our breeding cages as early as June 16th.

There are two, and perhaps three, broods in a season.

Remedies—The same as for the preceding species. Apply early so as to kill the first brood.

There are three other "worms" that feed upon cabbages to some extent in the state, but I will not give them special mention as the remedies are the same as for the species above mentioned.

CUT-WORMS.

Some dingy colored larvæ that burrow in the ground and have the pernicious habit of cutting off young plants of corn, beans, cabbages, tomatoes, etc., during the night.

There are a large number of species of these worms, each changing, finally, to a particular species of night-flying moth. It is very largely these moths that fly about lights in the evening.

Remedies—These worms are usually worst on newly turned sod. Probably the best field remedy is to plow late in the fall and then, in the spring, keep down all growing

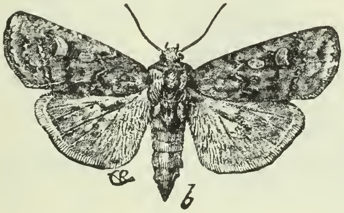


Fig. 45.—Cut-worm Moth. (Riley, Rep. U. S. Dep. of Agr., 1884.)

vegetation and scatter over the field a large number of small bunches of green vegetation (alfalfa, grass, cabbage leaves, weeds, etc.,) that has been thoroughly dusted with Paris green or London purple.

In gardens, individual plants of cabbage, tomatoes and the like may be protected by wrapping about them stiff paper or cylinders of scrap tin. The latter may be cut about five inches long by three inches wide and then wrapped around a hoe handle or similar object to give them form. Then separate the sides of the cylinder enough to admit the plant and crowd the tin into the ground enough to hold it firmly. Stiff paper may be used instead of the tin. Do not hoe the garden too clean of weeds while cultivated plants are small as the cut-worms like the weeds as well as anything for food. If the latter are all cut down there is nothing but cultivated plants for them to feed on. This may seem to be questionable advice, but it will work well if the weeds are not neglected too long, so as to choke the other plants.

GRASSHOPPERS.

The loss to crops from the attacks of grasshoppers is annually very large in this state. Even the dry pasture lands in many places support a horde of these greedy marauders that would be appalling to an eastern agriculturist. No description is necessary to enable my readers to recognize a grasshopper. The species that does by far greatest harm to farm and garden crops in Colorado is the large two-stripped grasshopper (*Melanoplus bivittatus*).

This and several closely related species deposit their eggs in little pouches or pockets in the ground in the man-

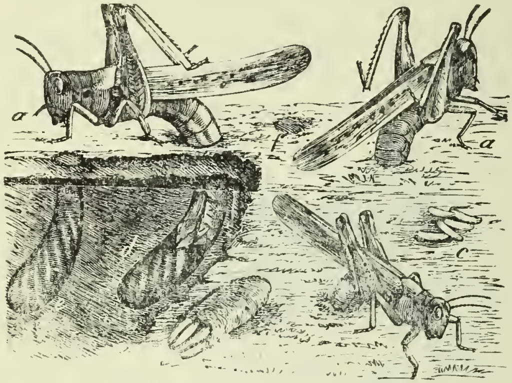


Fig. 46.—Rocky Mountain Locust laying eggs: a, a, females with their abdomens inserted in the ground; b, an egg-pod broken open; c, scattered eggs; d, egg-packet being formed by female; e, egg packet completed. (After Riley.)

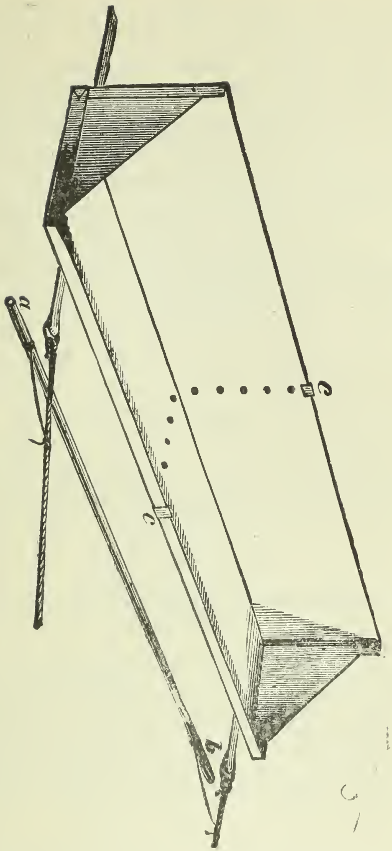


Fig. 47. Hopper pan or "hopperdozer." (After Riley.)

ner shown in Fig. 46. These eggs are mostly deposited about the borders of the fields, along ditch banks and along road sides where the earth is rather firm. They are deposited in the fall and the little hoppers hatch out early the following spring. There is but one brood a year.

Remedies—Where it can be used, the hopper pan or "dozer" is one of the best means of destruction. Fig. 47 will give an idea how these can be made. Make the bottom of the pan eight to twelve feet long, about eighteen inches wide and two inches deep. Have a back to the pan about eighteen inches to two feet high of canvas to prevent the grasshoppers from jumping over. Mount the pan on low runners and draw it over the field with horse power where the grasshoppers are most abundant, first putting in the pan a strip of cloth reaching the whole length and pouring upon it at least a pint of kerosene. The canvas at the back of the pan should also be kept wet with the oil. This plan of using the hopperdozers is as used by Dr. Lugger who has had a large amount of experience with them in Minnesota. Every grasshopper that comes in contact with these cloths and gets the oil upon any portion of itself will soon die. As the oil evaporates more must be added.

In orchards, vineyards and gardens where the pans cannot be used, poisoned baits made by mixing one pound of Paris green with six to ten pounds of bran, with just water enough to moisten the whole, may be prepared and scattered about in small quantities where the hoppers are thickest. Many will eat the poisoned bran and die. Paris green or London purple may also be sprayed on the food plants of the grasshoppers where it is safe to use it. Care must also be exercised in the use of poisoned bran that chickens and other domestic animals may not be poisoned.

THE MEDITERRANEAN FLOUR-MOTH. (*Ephestia kuhniella* Zell.)

This insect has attracted attention in this country and in Europe almost exclusively as a pest in flouring-mills. My attention was first called to the insect in Colorado on September 14th, 1893, when I received some honey comb from Mr. R. C. Aikin of Loveland, which was very badly infested with the larvæ and webs of this insect. The moths were also appearing at the time. The moth is gray in color with narrow wings and spans about three-fourths of an inch and is very well represented, at Fig. 48. Fig. 49 shows the appearance of the webs on a frame of honey comb.

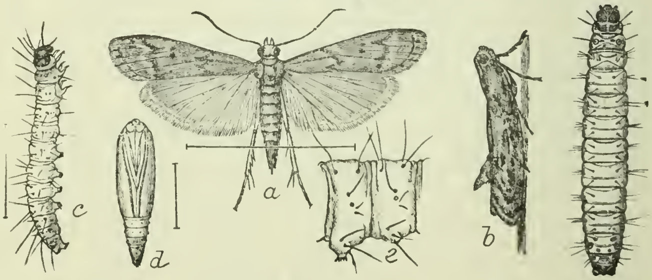


Fig. 48.—Mediterranean Flour-Moth: a, moth with wings spread; b, moth with wings closed; c, larva; d, chrysalis; e, two segments of the larva greatly enlarged. All somewhat enlarged. (Riley & Howard, Insect Life, Vol. II, U. S. Dep. of Agr., Div. of Entomology.)

The larvæ seem not to feed upon the honey or wax but upon the old pollen left in the cells, though they will often gnaw through the thin walls of the cells to get from one into another. This insect does not trouble the combs in hives occupied by bees but only combs that have pollen and are stored away for future use.

Remedy—Inclose the infested combs in a tight box with carbon bisulphide. Use a teaspoonful of the liquid to each cubic foot of space in the box.

To destroy the worms in mills, use about one quart to each 1,000 cu. ft. of space. Always be careful not to bring fire in contact with the fumes as they are explosive when mixed with air.

ANTS.

Ants often become troublesome in the pantry, the lawn or the apiary and many inquiries are received as to how they may be destroyed. Where the hill can be found, thrust a stake into it to the depth of about a foot, pour in two or three ounces of carbon bisulphide, stamp the hole full of dirt, and then throw a damp blanket over the hill to hold down the fumes. The fumes of the carbon bisulphide are explosive when mixed with air, so care must be used not to bring fire in contact with this substance unless for the purpose of exploding the fumes in the ant hill.

If the ants are troubling in the house, thoroughly dust the ants and their run-ways with insect powder (Pyrethrum.)

THE BED BUG. (*Acanthia lectularia* Linn.)

I take it for granted that this unwelcome guest of some of the homes of this country is not familiar to all my readers and so briefly describe it as a light yellow to dark brown bug, without wings, about one-fourth of an inch in length when fully grown, and very flat. The color and shape together has suggested to someone the very polite name "mahogany flat." Like other evil-doers, it avoids the light and is often unseen and not suspected in sleeping apartments where it is present in large numbers. Its hiding places are usually in cracks of the bedstead, under the binding of matresses, under wall-paper and similar places of concealment. In these places the eggs (nits) which are elongate white objects, of very small size, are deposited, sometimes in great numbers.

Fig. 50.—Bed Bug, much enlarged. (Osborn, Bull. 5. New Series, U. S. Dep. of Agr., Div. of Entomology.)

Fig. 51.—Bed Bug, young. (Osborn. Bull. 5, New Series, U. S. Dep. of Agr., Div. of Entomology.)

Remedies—Use bedsteads that will offer as few places as possible for the bugs to hide in. Have no loose paper on the walls under which the bugs can crawl. Put bedding and carpets and every other infested article, so far as possible, in boiling water. Pour boiling water into all places that can furnish concealment for the bugs so far as possible. By means of an atomizer or a small brush or feather apply gasoline, benzine or turpentine to cracks and crevices where the bugs or their eggs might be concealed. If these means have not been sufficient, fumigate the house with sulphur or with carbon bisulphide. Candles for the purpose of fumigating houses can be obtained at almost any drug store.

It will not do to make one treatment of any kind and then think no more is to be done. Make several careful searches a few days apart and continue the warfare 'till no more vermin are found.

CLOTHES MOTHS.

There are few insects that give housekeepers more annoyance than the clothes moths. There are but two species that give much annoyance in houses in this country and they are of a yellowish or buff color, with narrow wings and slender bodies, and when spread will span but little more than half an inch from tip to tip of the wings. They are often seen as very small moths flying about the room after lamps are lighted. The large moths that often fly to lights in our houses and flutter about on our windows, are frequently supposed to be clothes moths, but they are not.

The clothes moths feed upon animal tissue as hair, feathers and wool, but do not attack cotton or linen goods.

Remedies—The frequent airing and beating of garments and carpets is one of the most effectual remedies. When clothing is laid away for the summer it may be put in tight paper sacks or in pasteboard boxes made tight by wrapping, or in any other moth-tight receptacle where the moths or their eggs are not already present. To make sure that no eggs were deposited on the clothing before it is put away, it should be examined once or twice to see that it is all right. The lighter the room where the clothing is stored the better, as clothes moths delight to work in dark rooms and closets, but seldom do much harm in rooms that are well lighted and aired. If clothing is thought to be infested, all moths, eggs and larvæ can be killed by placing the clothing in a tight box and pouring in carbon bisulphide and then closing tightly for a few hours. If the moths in any stage are about the borders of the carpet, they may be destroyed by spreading damp clothes over the infested places and then ironing them with hot flats.

Moth balls, camphor, tobacco and cedar wood are used to repel the moths and are quite useful for this purpose, but if the insects are already present these things do not prevent their living and doing their usual injuries.

THE CARPET BEETLE. (*Anthrenus scrophulariae* Linn.)

A small, dark-colored beetle, about three-sixteenths of an inch long and marked on the wing covers with white and a slight amount of reddish. The larva is dark brown in color and is rather heavily fringed with hairs, especially at

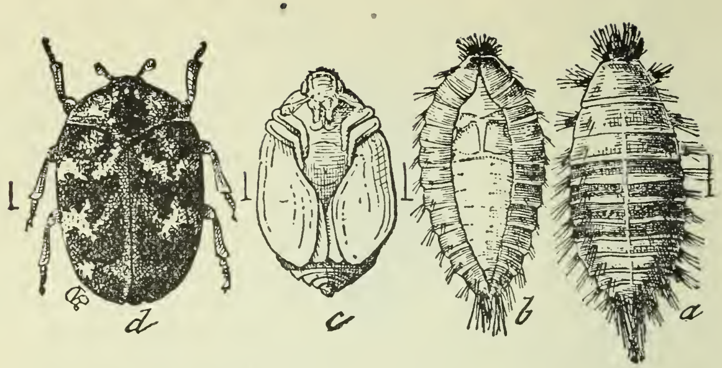


Fig. 52.—Carpet Beetle or Buffalo Moth: a, larva; b, pupa within the larval skin; c, pupa removed from larval skin; d, adult beetle. All greatly enlarged. (After Riley.)

the tail end end of the body. It works most about the borders of carpets and along cracks in the floor. It is most commonly known as the "Buffalo Moth," but it is not a moth at all but a beetle.

Remedies—This household pest is more difficult to rout than the clothes moths above mentioned. The treatment is the same but needs to be more vigorously and persistently applied. If very troublesome it will be found best to do away with carpets and use rugs instead, the rugs to be frequently removed from the house and beaten.

INSECTICIDES.

An insecticide may be defined as any preparation which can be used for the destruction of insects. Insects are animals and the substances that will kill animals of large growth will, as a rule, kill insects also.

In order to apply insecticides intelligently one should know the principle underlying their use, then he does not have to be bound by any fast rule. These principle are so simple that I will give them.

We may separate the insect-destroying substances into

THREE CLASSES,

depending upon the manner in which the death-dealing work is done.

First, and most important among these, are the food-poisons, or those substances which kill by being eaten. It must be evident to all that these can only do harm to insects that devour the tissue of the plant, nearly always the leaves. Those insects that feed by inserting a sharp beak and sucking the sap of the plant can not be successfully combatted by the use of food poisons. Against them we must, as a rule, use some substance that will kill by external contact. There are, of course, a great number of preparations that would kill in this way but we have to use something that will destroy the insect without serious injury to the plant on which it is feeding.

It is not necessary that one be versed in the science of entomology in order to be able to determine into which of these two classes an insect that is doing damage to his plants belongs. If the foliage of the plant is being removed, or if the leaves are full of holes or ragged as the result of the insect attack, it is reasonably certain that the marauder has a good pair of jaws and is devouring the solid parts of the leaves; but, if the leaves only turn pale or brown and curl, and are not eaten into, it is then quite certain that the insect is doing the damage by extracting the juices of the plant. Examples of such insects are Plant Lice, Scale Lice, the Squash Bug, Chinch Bug, etc. Examples of the former class are Grasshoppers, Potato Beetles, Leaf Rollers, the Codling Moth, etc.

Then there are insects in both of the above classes that are best destroyed by the use of certain volatile substances which kill by being inhaled. As examples I might mention certain grain-eating weevils, ants, root-infesting lice, vermin in houses as Bed Bugs, and Clothes Moths, etc.

In its broadest sense the term insecticide is also made to include certain substances which are used only as repellants. These do not kill and are of much less value than either of the other classes. Napthaline, camphor and carbolic acid are examples of such substances.

PREPARATION AND USE.

It will be understood that almost any insecticide may need to be used in different strengths under varying conditions. In the following formulæ I give the ordinary prepations.

FOOD POISONS.

PARIS GREEN ; WATERY MIXTURE.

Paris green, ... 1 pound.
Lime (unslaked,) .... 1 pound
Water, ... 160 gallons.

First thoroughly mix the poison in a small quantity of water and then add the remainder of the water. Slake the lime in a small amount of water and add to the mixture. If the lime is lumpy after slaking, strain it to avoid clogging the spraying nozzle.

PARIS GREEN ; DRY MIXTURE.

Paris green .... 1 pound.
Wheat flour, ... 20 pounds.

Apply, if possible, when the foliage is moist with dew and when there is no wind. If the plants are low, the mixture may be easily applied by inclosing it in a muslin sack which is shaken over the foliage.

Plaster, or lime may be used as a dilutent in place of the flour but the flour is considered best as it sticks the poison to the leaves causing it to remain longer.

LONDON PURPLE.

Prepared in the same ways as Paris green. It is somewhat cheaper than that poison but it is not considered quite as effective in destroying insects.

KEDZIE'S ARSENITE OF LIME.

Dr. R. C. Kedzie, chemist of the Michigan Agricultural College and Experiment Station, has given directions for making arsenite of lime and some who have used it prefer it to either Paris green or London purple. When prepared it is the same as the latter substance except the small amount of coloring matter which is accidental and serves in the London purple to distinguish it from substances that might be mistaken for food. Dr. Kedzie's directions are as follows :

"Boil two pounds of white arsenic and eight pounds of salsoda for fifteen minutes in two gallons of water. Put into a jug, label '*poison*' and lock it up. When ready to spray, slake two pounds of lime and stir it into forty gallons of water, adding a pint of the mixture from the jug."

As white arsenic, salsoda and lime are all cheap substances, this is a very economical mixture. It may be used as a substitute for either of the preceding.

ARSENIC-BRAN MASH.

This preparation has been used almost exclusively for the destruction of grasshoppers in places where hopper-dozers can not be used. Prepare by taking

White arsenic (or Paris green)	1 pound.
Wheat bran	10 pounds.
Water................	enough to make moist.

Scatter in small quantities in places where they will be most likely to find it.

Care must be used not to place the bran where it will be devoured by domestic animals.

BORDEAUX MIXTURE AND THE ARSENITES.

Bordeaux mixture is a fungicide and is the substance most often used for the destruction of fungi that attack the the surface of plants. It has also been found to be of value for use against flea-beetles and the writer also demonstrated its value a number of years ago as a medium in which to spray Paris green or London purple. These poisons can be used very strong in this mixture without injury to foliage and they do not, in the least, lessen its effects as a fungicide. Such a mixture would destroy both insects and fungi with one application.

The Bordeaux mixture may be prepared as follows: Take of

Copper sulphate....................	6 pounds.
Quicklime..........................	4 pounds.
Water	45 gallons.

Dissolve the copper sulphate in a gallon of hot water, slake the lime in another gallon of water and then add the milk of lime slowly to the copper sulphate solution while the latter is being constantly stirred. Then add 43 gallons of water.

If insects are to be killed at the same time, add to the above quantity of Bordeaux mixture, one-third pound of London purple or Paris green.

HELLEBORE.

Powdered white hellebore has been found particularly useful for the destruction of certain insects and may be applied dry or in water. If applied dry it may be used pure or diluted a few times with flour. I prefer to use the powder pure when the slightest dusting over the leaves in the evening when the dew is on is usually effectual. Inclose the powder in a cheesecloth sack and shake it over the plants.

If applied in water use

Hellebore	1 ounce.
Water	3 gallons.

EXTERNAL IRRITANTS.

It should be borne in mind that, in order to destroy an nsect by an external irritant, the substance must be put upon the insect's body. Spraying the food will not answer.

KEROSENE EMULSION.

This preparation has no equal for the destruction of insects by external contact, so far as we know at present. The substances of which it is composed are always obtainable and the emulsion is not difficult to make after one has learned how. For the ordinary strength the proportion of the ingredients is as follows:

Soap	1 pound.
Kerosene	2 gallons.
Water	28 gallons.

Prepare by dissolving the soap in a gallon of water; while the soapy water is boiling hot, remove from the fire and immediately add two gallons of kerosene and agitate briskly for a few minutes. If a large amount is being made, use a force pump and forcibly pump the mixture back into the receptacle that contains it until all is a frothy creamy mass. If such a mixture is not obtained the first time, put the whole back over the fire until boiling hot and then repeat the pumping and the emulsion will almost surely form. If put back for reheating watch very closely to see that it does not boil over and take fire.

After the emulsion is made add the remaining 27 gallons of water and all is ready for use.

When small quantities are made, emulsify with an ordinary egg-beater.

To be sure of success, use clean dishes and clean water.

WHALE-OIL SOAP.

This substance stands close to kerosene emulsion in importance as a destroyer of soft bodied insects. It is used in various strengths, but the ordinary preparation is:

Whale-oil soap........................1 pound.
Water..............................8 gallons.

As a winter wash, it is sometimes used as strong as two pounds in a gallon of water for the destruction of San Jose and other scales. A pound to eight gallons destroys the eggs of plant lice or of the Brown Mite.

TOBACCO.

Tobacco has long been used in one way or another for the destruction of insects. Its chief use seems to be for the destruction of animal and plant lice. When slowly burnt, the smoke may be utilized for the destruction of lice on plants in green-houses or window gardens. In the form of a fine dust it is often effectual in ridding plants of flea-beetles and in the form of dust or stems is probably the best remedy we have for Wooly Aphis on the roots of apple trees.

I have a letter from the A. B. Mayer Manufacturing Co., of St. Louis, Mo., offering tobacco dust at $20.00 a ton f. o. b. cars in that city.

PYRETHRUM (Buhach, Persian Insect Powder.)

This substance, under one of the above names, can be obtained at almost any drug store. It consists of the dried flowers of two species of plants of the genus Pyrethrum which are ground into a very fine powder. The powder has the peculiar property of killing almost any insect that it comes in contact with while it is not poisonous to other animals. If applied in water use

Pyrethrum..............................1 oz.
Water..............................3 gallons.

In most cases I prefer to use this substance dry and undiluted and it may be distributed by means of blowers made for the purpose or by inclosing in a cheesecloth sack and shaking it over infested plants.

Its chief uses are for the destruction of plant lice, cabbage worms, flea-beetles, squash-beetles, ants, cockroaches and house flies.

LIME, SULPHUR AND SALT WASH.

The following preparation is a favorite one on the western coast for the destruction of scale insects and the Brown Mite. For the latter insect it is reported to be entirely successful about Grand Junction in this state. The following formula and method of preparation I quote from Circular 3, Second Series, Division of Entomology, Washington, D. C. The paper is by Dr. L. O. Howard:

Unslaked lime	10 pounds.
Sulphur	5 pounds.
Stock salt	4 pounds.
Water to make	15 gallons.

This wash will do great damage to the trees if applied during the growing season, and should be used only in winter. All the sulphur and half of the lime are placed in a kettle and 8¼ gallons of water added, after which the contents of the kettle are boiled briskly for about an hour. The solution, which at first is yellow from sulphur, will turn very dark brown, assuming more or less of a reddish tint, and will finally change from a thick batter to a thoroughly liquid condition, the product being ordinary sulphide of lime. All the sulphur is added to the remaining five pounds of lime and the latter slaked, after which the slaked lime and salt are added to the sulphide of lime already obtained, the whole being then diluted with water to make 15 gallons. This should be strained before application, as it does not form a perfect liquid solution."

INSECTICIDES THAT KILL OR REPEL BY BEING INHALED.

CARBON BISULPHIDE.

This is an extremely volatile liquid having a very disagreeable odor and its use must be attended with a good deal of caution as it is explosive when mixed with air and brought in contact with fire. It can be used to destroy any insect that can be got into a tight receptacle as a box, jar or room. It is also destructive to root-infesting insects and ants in hills when injected into the ground in proximity to the insects. When employed for the destruction of insects in tight receptacles, use about one quart to every 1,000 cubic feet of space and continue the treatment for 24 hours at least. If used in a building that is not very tight a somewhat larger amount might be required. For fumigating large rooms it is better to place dishes containing the liquid in the upper part of the room as the fumes are heavier than air and settle.

HYDROCYANIC ACID GAS.

This is a very successful remedy against scale insects in California and is used in the following proportions :

Cyanide of potassium, 60 per cent.,.... 1 ounce.
Commercial sulphuric acid,.... 1 ounce, (fluid).
Water.............................3 ounces.
Space inclosed,.................150 cubic feet.

The fumes given off are extremely poisonous and care must be taken not to inhale them. The tree to be treated is first inclosed in a tent or box, the water and sulphuric acid poured into a dish and set in, and then the cyanide added and the tent or box quickly closed and kept so for about one-half hour.

Figure 12.

Apple Plant Louse: Twig showing eggs. (From photograph by the author.)

Figure 29—A.

A twig of soft maple showing the cottony scales covering it along one side, the under side of the limb. (From photograph by author.)

Figure 29—B.

Cottony Maple Scale: Female scales on leaf and twig with the cottony secretion protruding. (Riley, U. S. Dep. of Agr., Rep. 1884.)

Figure 31.

Trunk of cottonwood tree showing the dark patches on the bark caused by the souring sap from the burrows of the Cottonwood Borer. (From photograph by the author.)

Figure 32.

Elm Leaf-cluster (*Schizoneura americana*): a, b, c, d, successive stages in the early development of the gall; e, the louse covered with cottony secretion at the base of the bud which is just beginning to curl. All natural size. (From photograph by the author.)

Figure 33.

Elm Leaf-cluster (*Schizoneura americana*): a, a, etc., a number of the clusters on an elm limb. Very much reduced. (From photograph by author.)

Figure 34.

Pine-leaf Scale (*Chionaspis pinifoliae* Fitch): A, the scales on leaves of silver spruce; B, scales on leaves of pine. (From photograph by the author.)

Figure 35.

Egg patches of plant louse (*Chermes sp.*) on Douglass Spruce. Each patch of eggs covered by a cottony secretion from the adult louse. Somewhat reduced. (From photograph by the author.)

Figure 36.

Injuries to small locusts trees by *Tetraoesp femoratus*: a, a, etc., gashes cut in the stems by the jaws of the beetle; b, b, beetles at work. (From photograph by the author.)

Figure 49.

A frame of honeycomb showing the cocoons and webs of the worms that were feeding on old pollen. (From photograph by the author.)

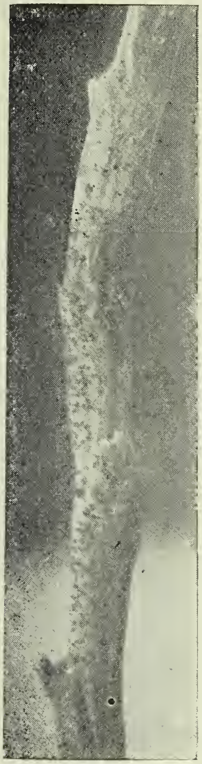


Fig. 12.

Fig. 29 B.

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Fig. 29 B.

Fig. 34.

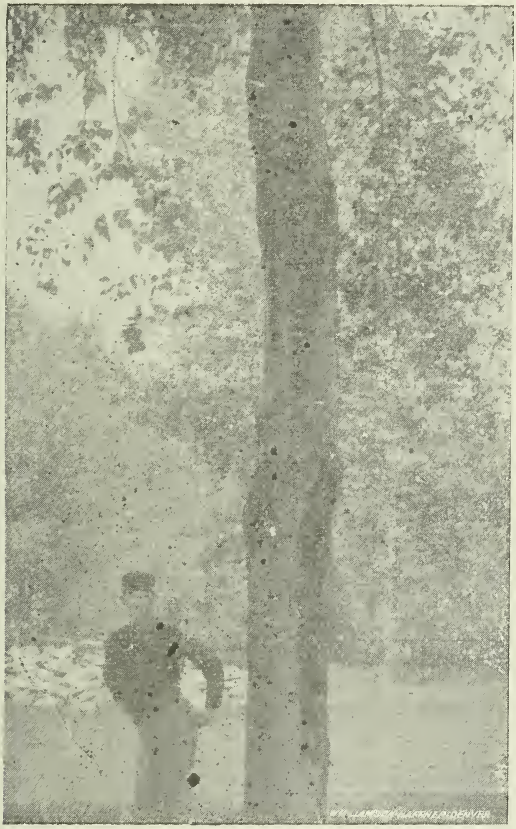

Fig. 31.

Fig. 32.

Fig. 35.

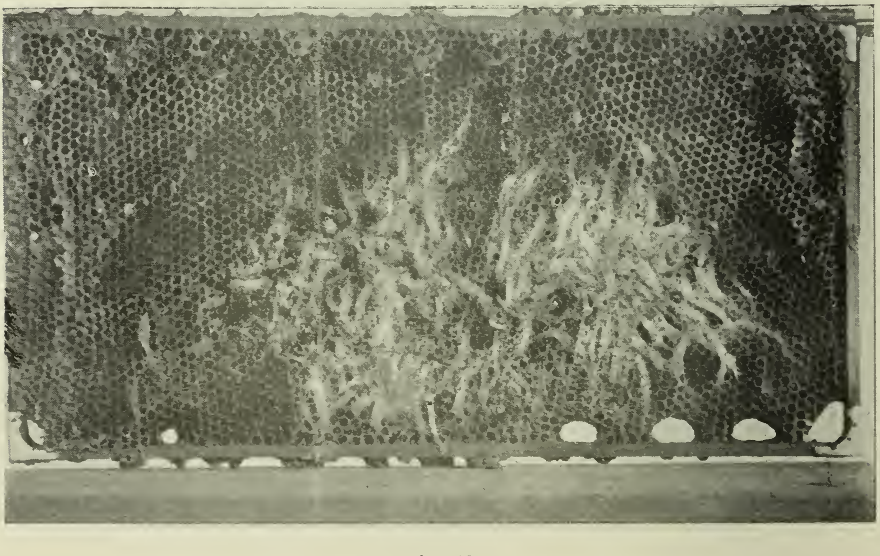

Fig. 49.

Fig. 33.

Fig. 36.

THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO 48.

Losses from Canals from Filtration or Seepage.

Approved by the Station Council,
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

JULY, 1898.

Bulletins will be sent to all residents of Colorado, interested in any branch of Agriculture, free of charge. Non-residents, upon application, can secure copies not needed for distribution within the State. The editors of newspapers to whom the Station pubications are sent are respectfully requested to make mention of the same in their columns. Address all communications to the

DIRECTOR OF THE EXPERIMENT STATION,
Fort Collins, Colorado.

EXPRESS, FORT COLLINS

THE AGRICULTURAL EXPERIMENT STATION,

FORT COLLINS, COLORADO.

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ON THE LOSSES FROM CANALS FROM FILTRATION OR SEEPAGE.

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The present bulletin is one of a series bearing on irrigation questions, and while suggested by the conditions in Colorado, it is not limited in its application to that State. The author has kept steadily in view the fact that Colorado has a limited supply of water and that the success of her individual farmer, as well as her agricultural extent, depends upon a clear understanding of the means of using water properly, of saving useless losses, and of the prevention of waste. While the author has believed that there are questions which might be more immediately useful to the individual farmer, he is fully convinced from a study of the development of other irrigated countries, that in the formative period of our development a more lasting benefit will accrue to the agriculture of the State by considering certain fundamental questions not so immediately applicable to individuals.

The present bulletin, however, has its immediate individual application. It is to some extent complementary to bulletin 33, on seepage or return waters from irrigation. While the earlier bulletin discussed the seepage or return waters entering streams, the present bulletin considers the losses from canals which, there is reason to think, is the principal source of the gain in the streams. If the connection between the canals and the streams is an intimate one, we may finally expect to find an approximate equality between the losses from the canals and the gains in the streams.

But more suggestive, the measurements here reported give an idea of the extensive losses involved in the carriage of water. The amount has been believed to be large, but when it is found that the leakage may become as much as 20 or even 30 feet in depth per day, it suggests the importance of taking steps to lessen the amount.

By stating the loss in the depths lost per day, a better idea can be obtained even by those familiar with the terms of water computation.

The loss of water from canals and distributaries seems to be greater than the loss from irrigation into the soil. Many cases of leakage can be lessened with profit, thus saving considerable water, and much more water can be saved when its value is enough to warrant the expense.

While the author's conclusions are necessarily influenced by the cumulative effect of numerous observations difficult to fully summarise, the measurements throwing light on the subject under discussion, are presented with sufficient fullness to enable the reader to disagree with the writer if the facts do not warrant his conclusions.

The loss from canals is known to be large, and often produces a serious problem in their management. This loss is often the cause of unnecessary scarcity in the water supply, especially at the lower end of the canal during the season when water is low. It has sometimes been enough to cause canals or laterals to be abandoned. It has many times led to failure of crops and has always made a material decrease in the water supply. The serious nature of the loss has been understood by the farming community, and associations have sometimes discussed methods by which it might be lessened. But I am unaware of any serious attempt to locate the loss or to determine the amount.

While we have made occasional measurements on the losses from canals, the past year (1897), has been the first when systematic measurements could be made. Without attempting to develop the general law of the loss, the measurements on a number of canals under different conditions are given with such conclusions as the data seem to warrant. A knowledge of the facts is the first step toward finding the remedy, or even to decide whether a remedy need be sought.

It is hardly necessary to observe that the cases here given are specific ones, and the losses found in these cases, may or may not be the same on other canals. The similarity of conditions, especially the similarity of the canal bottom, gives a basis for judgment. In many cases the loss is undoubtedly less, in others more. Hence the need of caution in hastily assuming that these measurements apply to all cases. So far as the canals chosen represent average conditions, the measurements may be considered as averages. From these and from a larger number of cases we may hope to determine the probable losses and from more extensive investigations obtain principles which may be applicable under new conditions.

The canals measured include stretches of canals in the Platte Valley and Cache a la Poudre valley near Fort Collins, and several in the San Luis valley, and one canal on which automatic records were kept for two years. The method of measurement was essentially the same in all cases, namely, to measure the amount flowing in the canal at different points, and then to compare the increase or decrease in the amount of water in the canal after allowing for the water taken out by laterals between the points of measurement. The measurements show that many of the canals, especially those deep in the ground, serve as drains during a portion of the year or for a portion of their course. This is often true where there are other canals on higher ground whose seepage drains into the lower canal. Some canals lose water in places and gain water in other places. We have thus found some stretches where the results differ from those anticipated. In some cases the loss from the canals was found to be very large.

The results suggest that it is desirable for many of the larger canals to determine their loss from seepage throughout their length and thus determine whether unreasonable losses take place in any portion. It is true that some sections are much more subject to loss than others, in fact that much of the loss is apt to be in a comparatively short distance. When such is the case it may be profitable for the company to take steps to lessen the amount of loss.

The loss of water from canals has been considered an incident necessary to the carriage of water. To a limited extent this is true, but where the loss is more than moderate, it may be considered as due to defective conditions, and generally can be lessened. The loss from the canals is a pure evil. It lessens the amount of water available for use and in so much lessens the productive power of the land under the canal. In some cases it may be sufficient to cause the damage or loss of crops. More than that, the seepage is undesirable to the lands below the canal. In most cases it is a positive injury, leading to the water-logging of tracts of land, and frequently results in troublesome claims for damage against the canal company.

METHOD OF EXPRESSING THE LOSS.

For the present I prefer to express the loss as the depth over the surface of the canal, lost in one day, rather than in per cent. of the water in the canal. The losses from different canals are then more easily compared, and cases of unreasonable loss sooner recognized. In ditch management the tendency is to express the loss in per cent. in which case the loss suggests nothing as to the economy of water. To say, without other information, that a canal loses 25 per cent., gives no indication whether the carriage is economical or not. In a long canal the managers could congratulate themselves that it is no more; in a short canal it might be excessive and should set the officers to determining the location of the losses and to seek a remedy.

For those unaccustomed to this form of calculation, it is convenient to remember that the amount of water given by one cubic foot per second in 24 hours is enough to cover two acres one foot in depth (correct within less than 1 per cent.), and hence a daily loss of two feet over an acre would require the constant flow of one cubic foot per second to make good. The deeper the water in the canal the more rapid is the leakage, but with our ignorance of the exact relation we neglect the depth and consider only the surface of the canal. In the table full data is given and if the connection is subsequently determined, the data should be sufficient for the later investigations. It would doubtless be better to consider the wetted area of the canal rather than the width as a factor. As the canals are shallow and broad it matters little whether the surface area of the canal or the wetted area is used.

EVAPORATION RELATIVELY SMALL.

In considering the losses from canals, it is common to consider the loss from seepage and evaporation together. In most cases the evaporation is small in comparison with the loss from seepage. In ten years record of an evaporation tank freely exposed to the sun and wind, at the State Agricultural College, Fort Collins, Colorado, the annual evaporation has averaged but 41 inches.*

The temperature of the water surface in the tank is, however, lower than in many of the canals. As evaporation increases with the temperature of the water, the evaporation from some canals would be correspondingly

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*Annual reports Colo. Agricultural Experiment Station, 1889 and 1890. Monthly evaporation given in full, table 4, p 18, bulletin 45, on Losses from Reservoirs.

greater. Nevertheless, only on specially favorable days can the evaporation from a canal surface amount to as much as one-half inch for the twenty-four hours. But the loss from seepage is rarely less than one foot and more often twice that in the same time, hence the evaporation is relatively small and may be left out of consideration in this connection without affecting our conclusions.

CANAL SEEPAGE IN THE CACHE A LA POUDRE VALLEY.

The Pleasant Valley and Lake Canal is an old canal taking water from the south side of the Cache a la Poudre river near the canon. It was originally built to supply lands in Pleasant valley, a glade of several hundred acres formed by the faulting and erosion of the rocks, principally the red sandstone, between the Dakota sandstones and the primitive rocks. The general course of the river is to the southeast; the canal sweeps to the south in a long curve, mounting the first and second benches and skirting at places the bluffs which form the edge of these benches. The ridge of Dakota sandstone confining the river between cliffs on either side, forces the canal back to the river, and its course almost overhangs the bed of the river. Through this ridge the canal is through and over the rock on a steep grade with some tunnels. The bank is often rockwork, with some soil. After passing this ridge the canal bends abruptly south, leaving the river at a large angle, and skirts the foot of the hog-backs formed of the ridge of resisting Dakota sandstone. It is thus the highest ditch on the south side of the river and like such ditches, is known locally as the "Highline." There is no irrigation of any extent above the canal. In several places a few acres are watered from reservoirs filled from small mountain streams. There can be no seepage into the canal except as furnished by the natural rains. The drainage of about 35 square miles is cut by the canal, but except in or after storms there are no surface streams. There are several small streams above the line of the ditch, but all disappear before reaching the line of the canal. Plum thickets show that spring waters appear near the surface in many places. The observers passed on foot along the bank of the ditch and thus could not miss any of the lateral headgates.

The conditions were favorable for loss by seepage. Much of the soil is of coarse gravel and sand, and the canal skirts the edge of the benches, across sandstone ridges with the strata exposed and with a decided dip offering an easy course for descending waters.

The measurement showed a loss in 7 miles of over 15 cu. ft. per second; or, starting from the river with 22.09 cu. ft. a little over 2 cubic feet being withdrawn by lateral ditches, there were left but 4.54 cu. ft. or there was a loss of a little over 15 cu. ft. per second.

In the portion outside of the foothills occasional gains were found. In most cases the gains were found to be associated with drainage areas of some extent. The soil is largely disintegrated granite, coarse and porous, and absorbs rain very readily.

TABLE I a.

PLEASANT VALLEY AND LAKE CANAL.

Measurements made by R. E. Trimble and J. C. Mulder.

No. of Measurement.	Date and Hour.	Place of Measurement.	Amount.	Outtake.	Gain or Loss.	Dist. in Miles.	Notes.
	1897—						
1	Oct. 23, 9:20-9:50 a. m.	Canal near headgate	22.09				
	" 10:20 a. m.	Lateral		0.16			Gravelly and sandy; near river.
2	"	Canal (near Capt. Post's upper place)	17.23		-4.70	1.30	
	" -- 11:40 a. m.	4 Laterals		.69			
3	" 11:50-12 m.	Canal (point of bluff below school house)	10.64		-5.90	1.31	" " "
	"	6 Laterals		.02			
4	" 1:20-1:55 p. m.	Canal at road crossing	7.85		-2.77	2.39	West of Bellevue, clayey sand.
		10 Laterals		1.51			
5	" 3:10 p. m.	Canal (near C. E. Pennock's)	7.17		+0.83	1.45	Crosses several lines of drainage.
		Lateral		0			
6	" 3:55-4:00 p. m.	Canal (50 ft. below 1st tunnel)	6.29		-0.88	.82	Stratified slope; rocks inclining.
		Lateral		0			
7	" 4:30-4:35 p. m.	Canal (200 yds above 2nd tunnel)	5.65		-0.64	.72	" " "
8	" 4:55-5:00 p. m.	Canal (at end of rock work on Bingham hill)	6.41		+0.76	.50	Crosses some of the glades of ridge.
		Lateral		0			
9	" 5:20-5:30 p. m.	Canal (near Claymore lake)	4.54		-1.87	.30	Along outer side ridge near junct'n of earth and rock.
9	30, 8:30-8:40 a. m.	At same place	17.98				
	"	2 Laterals		Trace			
10	" 9:20-9:30 a. m.	Canal (west of Michaud's)	19.07		+1.09	1.04	In excavation.
	" —	7 Laterals		1.19			
11	" 10:55-11:10 a.m.	Canal (west of Prendergast's)	16.53		-1.35	2.50	Crosses ridge of sandstone.
	" —	2 Laterals		1.16			
12	" 11:40-11:55 a.m.	Canal (west of cemetery)	13.57		-1.80	1.41	Along side hill, moderate slope.
	" --	2 Laterals		0.15			
13	" 1:15-1:25 p. m.	Canal (west of Loomis' farm)	13.42		0	1.94	Some seepage showing below ditch.
	" --	5 Laterals		6.19			
14	" 2:35-2:45 p. m.	Canal (west of B. B. Harris' farm)	11.73		+4.50	2.55	Some land irrigated above ditch from Dixon canon.
	" --	3 Laterals		0.16			
15	" 3:45-3:55 p. m.	Canal (west of Rugh Farm)	13.02		+1.45	1.75	Crosses some lines of drainage.
	" —	11 Laterals		2.82			
16	" 5:25-5:30 p. m.	Canal (west of Cunninghams)	9.95		-0.25	2.64	More gravelly, some irrigated land above ditch from Spring canon.

Measurements by R. E. Trimble and J. D. Stannard.

12	1898— April 23, 8:55 a. m.	Canal west of Cemetery	17.26				10:10 a. m. at starting point, no change noticed.
		2 Laterals		1.25			
	" 9:45–9:57 a. m.	Canal near west end of bend about ½ mile.	17.56		+1.55		
13	" 10:25–10:38 a. m.	Canal west of Loomis' farm	17.97		+0.41	1.94	At 2:00 p. m. the water had fallen ⅝ in.
		8 Laterals		6 62			
14	" 12:02–12:12	Canal west of B. B Harris' farm	12 67		+1.32	2.55	Water fallen ½ inch since noon.
	" 2:30–2:41 p. m.	At same place	11.69				
		6 Laterals		0.61			Water had fallen 2 inches by 4:25 p.m.
15	" 3:40–3:50 p. m.	Canal west of Rugh farm	8.53		-2.55	1.75	Water had fallen ½ inch by 6:10 p. m.
		10 Laterals		3.31			
16	" 5:38–5:45 p. m.	Canal west of Cunningham's	5.91		+0.69	2.64	

TABLE I b.

PLEASANT VALLEY AND LAKE CANAL.

Place of Measurement.	Temp. of Water.	Area of Section. Sq. Feet.	Average Depth in Feet.	Greatest Depth in Feet.	Surface Width. Feet.	Gain or Loss. Sec. Feet.	Distance in Miles.	Equivalent depth of Loss in ft.
1	42°.7	21.23	1.34	1 72	15.9	....	0	....
2	43°.9	18.74	.90	1.26	18.9	-4.70	1.30	-4.7
3	44°.5	7.20	.64	0.81	11.2	-5.90	1.31	-5.1
4	48°	7.26	.63	0.87	11.5	-2.77	2.39	-1.7
5	48°	4 89	.54	0.75	9.0	+0.60	1.45	+0.7
6	48°	3.93	.44	0 65	8.8	-0.71	.82	-1.6
7	48°	3.68	.50	0.72	7.4	-0 64	.72	-0.4
8	48°	4.90	.65	0.97	7.5	+0.76	.50	+1.7
9	47°.5	12.63	1.09	1.59	11.6	-1.87	.30	-3.2
9	39°	18.40	1.36	2.07	13.5	....	0	....
10	39°.5	13.71	.64	0 79	21.5	+1.09	1.04	+1.0
11	41°	14.40	1.00	1.27	14.3	-1.35	2.50	-0 5
12	42°	12.56	.70	1.12	16.3	-1.80	1.41	-1.4
13	44°	13.73	84	1.10	16.3	0	1.94	0
14	44°.2	12.40	.84	1.42	14.8	+4.50	2.55	+1.9
15	44°.5	11.01	.77	1.02	14.4	+1.45	1.75	+0.9
16	....	9.98	1.00	1.45	10.0	-0.25	2.64	-0.1
12	50°	15.45	1 13	1.39	13.7	0	....	....
13	51°.8	13.60	1.07	1.35	12.7	+1.55	....	....
13	53°.0	13.92	.97	1.26	14.4	+0.41	1.94	+1.3
14	55°.0	12.24	.84	1 25	14.6	+1.32	2.55	+0.6
14	55°.0	11.99	.79	1.34	15.1	....	....	....
15	55°.8	9.11	.67	0.88	13.5	-2.55	1 75	-2.7
16	55°.0	5.90	.62	1.01	9.5	+0.69	2.64	+0.4

SEEPAGE FROM CANALS IN THE SAN LUIS VALLEY.

Measurements were made to determine the loss by seepage and absorption on a number of canals and on laterals, approaching canals in size, in the San Luis valley, and the measurements are given in the following tables. These include measurements of the losses on the Empire canal, on the Blackmore or Fisk Ditch, on the Prairie Ditch, on a branch of the Rio Grande canal, known as the North Farm lateral or ditch, and on other laterals of the company known as the 1F and 1C laterals.

The conditions in the San Luis valley are somewhat different from those in most places of the state, but the conditions causing the loss or gain by canals are necessarily the same.

The San Luis valley is one of great extent—nearly the size of Connecticut. In Geological times it was the bed of a lake. Its surface is of very uniform and moderate slope, so that canals often pass for long distances in straight lines. The Prairie Ditch, for example extends nearly twenty-six miles on a straight line without turn or bend. The fall of the country is moderate, though large for canal purposes. It decreases from about fourteen feet per mile near the rim east and west, to half as much as the center of the valley is reached. A map of the valley showing these contour lines has been prepared and will be published in connection with a bulletin giving further results of investigations in the valley.

A large part of the valley is irrigated by sub-irrigation which consists in filling the sub-soil by water from the canals and laterals. The slope of the land is so uniform and gentle that the water does not find low places in which to appear in the form of seepage as in an undulating region.

The general process of irrigation in these regions is to run water into the laterals and allow it to soak away, and by so doing fill the sub-soil until the water is at a moderate distance from the surface, about eighteen inches being desired during the growing period of the grain crops. The soil of the valley is very deep, but is everywhere underlaid with coarse gravel which becomes finer as the distance from the mountains increases. Most of the ditches are excavated into this gravel.

The irrigated region includes most of the valley east of what is known as the "Gun-barrel road"—which extends directly north from Monte Vista—and the tract in which sub-irrigation shows, includes a portion of this region. In places irrigation extends west of the road. It may be expected that as long as the surface of the underground water is below the bottom of the canal there will be loss of water by seepage. Where the ground water rises above the bottom the canal may then act as a drain and carry away a portion of the ground water, and the canal is thus found to increase in volume by seepage.

Circumstances prevented making as extensive measurements of canals as desired, but a distance of some forty miles has been measured, which is sufficient to reveal the extent of the losses and some of the conditions.

The Empire canal is one of the largest canals taken from the Rio Grande river. It heads on the south side some miles east of Monte Vista. It is cut rather deeply in the plain. In the first five miles there is found a gain of six-cubic feet per second.

The Blackmore ditch is a small ditch on the north side of the river, heading nearly opposite the town of Monte Vista and extending east. It starts above the region that is showing sub-irrigation and for a portion of its length its channel is a little above the plain. It was found to lose nearly four cubic feet per second in two miles.

The Prairie ditch was measured for some miles from its headgate directly east. The change in volume seems to be irregular, there being a gain of 1.42 feet in three miles, passing across the river bottom, then a loss of 1.80 feet in one and one-half miles through a gravelly soil; then as it strikes the region that is more or less sub-irrigated, a gain of a little over two feet in the first two miles and a gain of a little over a foot in the next two miles. The last mile measured showed a loss of nearly two cubic feet per second.

The North Farm lateral is a branch of the Rio Grande canal. The Rio Grande canal takes water from the Rio Grande river near Del Norte and with a northeast course runs almost at right angles to the river to Saguache, forty-five miles northeast. The North Farm lateral passes nearly parallel to the river. Its course is through the gravelly soil and the excavation extends into the boulder gravel for most of the length measured. Mile posts are placed along the ditches belonging to the company, so that distances could conveniently be told. The first measurement was made at the second mile post from the main canal and then at each subsequent mile post along the line of the lateral. Two measurements were made at different times, on July 6th and August 3rd. At the first date the amount of water in the lateral was nearly twice as great as at the last date, and the loss of water was found to be about twice as much. The measurement was carried on until the canal reached the border of the sub-irrigated region.

Laterals 1F and 1C, which were measured, are branches of the same system.

A measurement was made on the loss of water from the Blackmore ditch early in May, in a stretch east of the "Gunbarrel road" and included in the measurement otherwise reported. The amount of water in the lateral was measured by floats at two points nearly one-half mile apart. The discharges were found to be 2.85 and 2.43 cu. ft. per second in two places, or a loss of .93 cu. ft. per sec. per mile of ditch, or equivalent to a depth of 3.72 feet over the surface of the ditch. If the gravel consists of one-third voids this would be equivalent to a velocity of 12 feet per day through the soil.

TABLE II a.

LATERAL 1C RIO GRANDE CANAL SYSTEM.

Measurement by R. E. Trimble.

Date and Hour.	Place of Measurement.	Amount Measured Sec. Feet.	Outtake. Sec. Feet.	Gain or Loss. Sec. Feet.	Distance in Miles.
August 2, 4:30 p. m	3½ miles	18.79	....	....	....
" 4:00 p. m	4th mile post	21.17	....	+2.38	0.5
" 3:45 p. m	5th mile post	17.56	....	-3.51	1.
" 3:20 p. m	6th mile post	15.06	....	-2.60	1.
" ——	Lateral 100 yards below 6-m	....	7.56	....	....
" ——	Lateral ½ mile below 6-m..	....	0	....	....
" 2:30-2:45 p. m	At 7th mile post	7.30	....	-0.20	1.

PRAIRIE CANAL.

Date and Hour.	Place of Measurement.	Amount Measured Sec. Feet.	Outtake. Sec. Feet.	Gain or Loss. Sec. Feet.	Distance in Miles.
1897—					
July 13, 3:20 p. m	Ne r headgate	36.41	....	....	....
" "	McDonald lateral	....	2.25	....	....
" "	Small ditch	....	.08	....	....
" " 4:20 p. m	1½ mi. west Gunbarrel road	35.50	....	+1.42	3.5
" "	Lateral	....	1.79	....	....
" "	Lateral	....	0.13	....	....
" "	At Gunbarrel road	31.91	....	-1.80	1.5
" 14, 8:20 a. m	At Gunbarrel road	29.25	....	....	....
" " 9:10 a. m	North of North Farm	31.39	....	+2 14	2.
" "	3 Laterals	....	2.81	....	....
" " 10:25 a. m	4 miles east	29.62	....	+1.04	2.
" " 11:00 a. m	5 miles east	27.80	....	-1.80	1.

TABLE II b.

LATERAL 1C RIO GRANDE CANAL SYSTEM.

Date and Hour.	Temp. of Water.	Area of Section. Sq. Feet.	Average Depth. Feet.	Greatest Depth, Feet.	Surface Width, Feet.	Gain or Loss. Sec. Ft.	Distance in Miles.	Corresponding Depth of Loss.
Aug. 2, 4:30 p. m.	70° 8	10.48	.65	0.89	16.	....	....	....
" 4:00 p. m.	72°.3	9.38	.59	0.90	16.	+2.38	0.5	+4.95
" 3:45 p. m.	75°.4	6.94	.73	1.10	9.5	-3 51	1.0	-2.88
" 3:20 p. m.	78°.0	8 96	.75	1.04	12.	-2.60	1.0	-3.60
" 2:30 p. m.	81°.0	10.04	.89	1.32	11.3	+0.35	1.0	+.48

PRAIRIE CANAL.

Date and Hour.	Temp. of Water.	Area of Section. Sq. Feet.	Average Depth. Feet.	Greatest Depth, Feet.	Surface Width, Feet.	Gain or Loss. Sec. Ft.	Distance in Miles.	Corresponding Depth of Loss.
July 13, 3:20 p. m.	....	38 30	1 38	1 70	27.7	....	0	....
" " 4:20 p. m.	....	17.42	.67	1.40	26.	+1 42	3½	+.85
" " 5:15 p. m.	....	19.60	.98	1.28	20.	-1.80	1¼	-.86
" 14, 8:20 a. m.	62°	18.32	.92	1.20	20.	....	....	....
" " 9:10 a. m.	65°	14.20	.42	0.80	23	+2.14	2	+.79
" " 10:25 a. m.	67°.5	12.30	.57	0.65	21.6	+1.04	2	+.38
" " 11:00 a. m.	71°	15.12	.57	0.65	26.	-1.80	1	-1.24

TABLE III a.

NORTH FARM LATERAL.

First and Second Measurements.

Date and Hour.	Am't.	Out-take.	Gain or Loss.	Distance in Miles	Place of Measurement.	Date and Hour.	Amt	Out-take	Gain or Loss.
July 6, 1897.						Aug. 3, 1897			
11:00 a. m....	199.50	.....	.....	......	150 feet above mile post 2*....	9:45 a. m.	90.50	.....	......
11:30 a. m....	......	85.085	......	......	North branch..................	11:00 a. m.	.....	40.75	......
11:40 a. m....	123.81	......	+9.41	2.	South " near 4th mile post	....	53.29	.....	+3.52
1:10 p. m....	124.45	0	+0.63	1.	5th mile post..................	11:30 a. m.	52.14	.....	-1.15
2:15 p. m....	117.55	0	- 6.90	1.	6th mile post..................	12:50 p. m.	49.33	.....	-2.81
2:45-3:00 p.m.	103.32	0	-14.23	1.	7th mile post..................	1:30 p. m.	44.92	.....	-4.41
....	......	23.00	.....	......	Lateral......................	1:50 p. m.	.....	12.76	......
3:40 p. m....	89.38	......	+9.06	1.	8th mile post..................	2:10 p. m.	5.96	.....	+3.80
4:00 p. m....	78.50	......	-10.88	1.	9th mile post..................	2:35 p. m.	34.10	.....	-1.86
....	......	29.33	......	......	Lateral about ¼ mile below	....	.....	7.67	......
....	......	2.11	......	......	" " ⅜ " "	....	.....	.01	......
....	......	4.72	......	......	" " ½ " "	....	.....	0.60	......
....	......	10.10	......	......	"	....	.....	1.70	......
....	......	......	......	......	....	....	.....	.....	......
5:00 p. m....	32.54	......	+0.30	1.	10th mile post..............	3:35 p. m.	22.92	.....	-1.14
....	......	0.43	......	......	Lateral 200 yards below.....	....	.....	.39	......
....	......	1.51	......	......	" " " "	....	.....	.01	......
....	......	.22	......	......	....	....	.....	.02	......
5:30 p. m....	30.44	......	.06	1.	11th mile post..............	4:20 p. m.	20.89	.40	-1.21
					* Bottom of boulder gravel, size of man's fist.				
					Gage height .13				

TABLE III b.

NORTH FARM LATERAL.

First Measurement.

(By R. E. Trimble and J. D. Stannard.)

Date and Hour.	Temp. of Water.	Area of Section. Sq. Feet.	Average Depth in Feet.	Greatest Depth in Feet.	Surface Width in Feet.	Gain or Loss. Sec. Ft,	Distance in Miles.	Corresponding Depth of Loss.
July 6.—								
11:00 a. m......	....	69.16	1.47	2.00	47.		....	....
11:40 a. m......	61°.5	34.55	1.19	1.65	29.	+9.41	2.	+2.04
1.10 p. m......	65°	36.70	0.92	1.40	40.	+0.63	1.	+.3
2:15 p. m.....	....	35.15	1.40	1.90	25.	- 6.90	1.	-3.0
2:45 p. m......	....	31.30	1.30	1.70	24.	-14.23	1.	-9.6
3:40 p. m.. ...	....	23.15	0.93	1.20	25.	+9.06	1.	+6.1
4:00 p. m......	68°	25.02	1.32	1.85	19.	-10.88	1.	-8.1
5:00 p. m......	....	11.95	0.80	1.25	15.	+0.30	1.	+.3
5:30 p. m.....	....	12.95	1.44	1.10	9.	+0.06	1.	+.08
Average.........	....	....	1.20	....	26.	....	....	....
Total loss.......	....	....	....	....	....	-12.55	....	....

Second Measurement — By R. E. Trimble.

Aug. 3, 1897.—								
10:10 a. m.......	62°.0	33.56	1.12	1.95	30.0	....	....	....
11:00 a. m.......	64°.0	20.64	0.94	1.85	22.0	+3.53	2	+.62
11:30 a. m.......	65°.2	21.97	1.04	1.41	21.2	-1.15	1	-.88
12:50 p. m.......	67°.3	22.54	0.88	1.26	23.0	-2.81	1	-2.1
1:30 p. m.......	71°.0	20.23	0.91	1.75	22.2	-4.41	1	-3.2
2:00 p. m.......	70°.2	14.68	0.67	0.89	22.0	+3.80	1	+2.85
2:35 p. m.......	71°.8	15.73	0.94	1.28	16.7	-1.86	1	-1.6
3:20 p. m.......	72°.3	9.36	0.67	1.03	14.0	-1.15	1	-1.2
4:20 p. m.......	72°.0	11.06	0.74	.95	15.0	-1.23	1	-1.4
Average.........	....	18.86	0.88	....	20.7	....	....	....
Total loss.......	....	....	....	....	....	-5.28	9	....

TABLE IV a.

EMPIRE CANAL.

Measurement by R. E Trimble and R. D. Blakey.

Date and Hour.	Place of Measurement.	Amount	Outtake	Loss or Gain.	Distance.
1897—					
June 11, 2:40 p. m	At head	124.99			
	Davis lateral		1.90		
	Davis No. 2		0		
	Metzger No. 1		0		
	Metzger No. 2		0		
	Metzger No. 3		3.12		
June 11, 4:35 p. m	Above Loveland lateral	135.97		+16.00	5

BLACKMORE DITCH.

Date and Hour.	Place of Measurement.	Amount	Outtake	Loss or Gain.	Distance.
June 17, 2:40 p. m	At bridge	11.54			
June 17, — p. m	At lateral		1.16		
June 17, 3:30 p. m	South of North Farm	6.78		-3.60	2.03 m
May	At bridge	2.85			½ "
"	½ mile east by floats	2.43		-.42	

LATERAL 1 F.

Date and Hour.	Place of Measurement.	Amount	Outtake	Loss or Gain.	Distance.
Aug, 4, 10:30 a. m	At head	12.93			
10:10 a. m	2½ miles from G. B. road	11.29		-1.64	2¼ m.
	Lateral		1.67		
	"		0.37		
	"		0.39		
9:25 a. m	1 mile	8.82		-.04	1½ m.
	Lateral		1.70		
	"		0.51		
	"		.01		
9:00 a. m	Near Gunbarrel road	7.84		1.24	1 m.

TABLE IV b.

EMPIRE CANAL.

Date and Hour.	Temp.	Area.	Average Depth.	Maximum Depth.	Breadth.	Gain or Loss.	Corresponding Depth in Feet.
1897—							
June 11, 2:40 p m		79.5	1.82	2.41	44		
4:35 p m		70.2	1.40	1.70	50	+16.00	+1.1

BLACKMORE DITCH.

Date and Hour.	Temp.	Area.	Average Depth.	Maximum Depth.	Breadth.	Gain or Loss.	Corresponding Depth in Feet.
June 17, 2:40 p. m		10.35	.94	1.21	11.0		
3:30 p. m		4.61	.62	.84	7.4	-3.60	-7.2

LATERAL 1 F, RIO GRANDE CANAL SYSTEM.

Date and Hour.	Temp.	Area.	Average Depth.	Maximum Depth.	Breadth.	Gain or Loss.	Corresponding Depth in Feet.
Aug. 4, 10:30 a. m	67°.2	6.24	0.48	0.80	13.		
10:10 a. m	67°	6.30	0.63	0.86	10.	-1.64	-.95
9:25 a. m	65°	5.93	0.66	0.99	9.	-.04	-.05
9:00 a. m	63°.2	4.20	0.54	0.76	7.8	+1.24	+2.4

OTHER CASES.

The loss on a section of the Fort Morgan canal given in table V, is the loss in a section between the headgate and Bijou creek, some ten miles down the line of the canal, and about four miles from Fort Morgan.

The canal is on the south slope of the Platte valley and for much of the way is a loose sandy soil. It is in partial excavation and with an embankment on the lower or northern side.

The loss in this canal amounted to twenty cubic feet per second in 1895 in a distance of 7.4 miles. In 1896 the upper measurement was made nearly two miles further up the canal, and the lower measurement at the same place as in 1895. The loss amounted to 23.11 cu. ft. per second.

These measures are referred to later, as they afford a basis for seeing the effect of slightly silting the canal.

TABLE V.

Date and Hour.	Temp. of Water.	Area of Section Sq. Ft.	Aver'ge Depth in feet.	Greatest Depth in feet.	Surface Width in feet.	Gain or loss. Sec. Ft.	Distance in Miles.	Corresponding Depth in Feet.	Notes.
FORT MORGAN CANAL.									
1895—									
Oct. 25, 7:30-8:25 a.m.	41°	108.9	2.42	3.20	45	....	....	....	Opposite Shaffer's Ford.
" " 11:00 a. m	44°	69.	1.82	2.34	38	-20.08	7.4	-1.1	Head Bijou flume. 10,100 ft. new channel; 400 ft. is flume. No leak from flume.
" " 12:30 a. m	....	110.	2.55	3.65	34	-11.48	2	-2.6	
FORT MORGAN CANAL.									
1896—									
Oct. 23, 9:15-10 a. m	48°	67.60	2.01	2.05	33.7	....	0	....	At rating flume.
" " 3:05-3:50 p.m	....	110.20	2.75	3.40	40	....	....	....	Opposite Shaffer's Ford.
" " 3:30-4:00 p.m	49°	95.6	2.45	3.50	39	-23.11	9.3	-1.0	Head of old flume.
" " 4:20-5:00 p.m	....	102.3	2.38	3.59	43	- 5.70	2	-1.1	At lower end old flume, 10,100 feet used one year. As ditch changed slightly during night measure at Shaffer's Ford is not used.
HOOVER DITCH.									
1895—									
Oct. 22, 7:30 a. m	....	5.45	.65	.85	8.4	....	....	....	
....	....	10.2	1.4	1.80	7.4	-0.15	¼	-1.2	Fine sand of Platte river bed.
GREELEY NO. 3 CANAL.									
1895—									
Oct. 16	....	17.49	1.03	1.56	17	....	....	....	Above and below gully in west part of City of Greeley. Instance referred to in bulletin 33 pp. 49-50.
....	51°	21.03	1.45	1.65	14.50	5.06	760 ft.	-55.0	

In the case of the ditch of the City of Fort Collins, carrying water from the Cache a la Poudre river to the city water works, a distance of 4100 feet, the ditch lost 4.34 cu. ft. per sec., equivalent to a loss of 5.7 feet in depth per day. The ditch runs through the bottoms and along the side of a hill rising some 20 feet above the bottom lands below. Immediately above the city ditch, as near the slope as the embankment will permit, is another canal, the New Mercer ditch, which, at the time of measurement, was dry. The Pleasant Valley and Lake canal is still higher, over one-half mile distant, but the seepage from this canal is carried in another direction by the local configuration of the country.

The loss from canals has not been extensively studied and there seem few instances available where the results of measurements are given. In bulletin 33 several cases are referred to.

MISCELLANEOUS OBSERVATIONS.

The following cases are derived from other observers:

On the Muzza canal, Italy, the loss is equivalent to a depth of 1.7 feet in 24 hours.* The canal is the first built near Milan solely for irrigation purposes, the other large canals including navigation as an object in their construction. The Muzza has a heavy fall, giving the current too large velocity for navigation. The canal carries several thousand cubic feet of water per second, and under conditions as seen by the writer in 1892, that would seem favorable to percolation, so that the reported loss seems small.

The Naviglio Grande loses 10 inches daily in depth. This canal was built over 700 years ago, about the same time as the Muzza. The canal Martesana loses 1.5 feet daily.*

The Centreville and Kingsburg canals, California, in a stretch of six miles lost a depth of 6 feet per day. The King river and Fresno canal lost in different portions depths of 1.5 feet, 1.7 and .6 feet.

Portions of the Fresno canal lost depths of 2.8 feet, .25 ft. and .4 ft. in depth, and some laterals from 1.2 to 6.4 feet.†

In the case of several canals in Kern county, California, the loss was found to be from .39 to 2.6 feet in depth in 24 hours, ranging from 1 to 2 feet in sandy soils and averaging 1.6 feet; in sandy loam and firm, compact alluvial soil, from .39 to 1.30 feet averaging .87 feet in depth.‡

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* Baird Smith, Italian Irrigation.

† On authority of C. E. Grunsky, C. E. of San Francisco, given in Bulletin 33

‡ Report Cal. State Engineer, 1880, App. B, by J. D Schuyler p 92 The results are changed to depths by the writer.

Mr. J. Keelhoff made some experiments on the absorption of small ditches.*

From the facts given by him, we find that the loss in the sandy soil of the Campine from irrigation ditches, 10 inches wide with water 11 inches deep, was over 10 feet in depth in 24 hours; but when the depth of water in the ditch was but two i ches, the loss was reduced to six feet per day. In the distributing laterals, 10 inches deep and two feet wide, the loss was over four feet in depth per day. In the principal lateral, with water 2 feet deep and 8 feet wide, the loss was over 2 feet per day. One reason for less loss in the last case, though the water was deeper, is that the bottom remains undisturbed from year to year. At the time of the test the silt had not been removed for four years. The other ditches were cleaned annually, thus giving a raw surface for the water to pass through.

Geo. W. Rafter, C. E. in a report on the water supply of the W stern division of the Erie canal,† refers to a number of determinations of the losses from seepage and evaporation on stretches of that canal.

On a section of 18 miles near Schenectady through an alluvial soil containing a large proportion of vegetable matter, and leaky in places, the loss as measured by J. B. Jervis in 1824, was 2 cu. ft. per second per mile. The canal was 28 feet wide on bottom, 40 feet wide on top and 4 feet deep. This is equivalent to a loss in depth of 10 inches in 24 hours over the whole surface.

Mr. David S. Bates in 1823 concluded that a mile of new canal, such as the Erie then was near Brockport, would require 1⅔ cu. ft. per sec. per mile. This included evaporation. The dimensions of the canal are presumably the same as the above, in which case the loss would be equivalent to 8 inches in depth per day. On the Chenango canal in Aug. 1839, the amount was found to be 1.09 second feet per mile, corresponding to a depth of 6 inches in 24 hours.

On the Erie canal near Wayneport, in 1841, in a distance of 8 miles, when the soil was open and porous, the loss was 1.8 cu. ft. per second per mile; on the Clyde level, a length of 28 miles, with more retentive soil, the loss per mile was only .6 cubic feet per second. These correspond to depths of 9 inches and 3 inches per day respectively.

In comparing with the results found on irrigation canals, it should be remembered that the conditions on the

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* Traite Pratique de l'Irrigation des Prairies. 2d ed.

† Report of the State Engineer and Surveyor of N. Y., 1896.

Erie canal are more favorable to small losses than are those of irrigation canals. The Erie canal is in a more humid climate, with a rainfall about 2½ times as great as that of Colorado and this tends to keep the water table nearer the surface and thus lessen the percolation. More than that, the Erie canal in this stretch is almost level (3 ft. fall in 60 miles) and the slow movement of the water is favorable to silt deposition. The irrigation canals have falls ranging from 2 ft. upward per mile, and the beds are scoured by the running water.

Mr. Walter James, who has been for many years the engineer of the canals in Kern county, California, writes* that their experience shows that they deliver 70 per cent of the water turned in at the head of the canals at the lateral side gates, measurements sometimes being made from one to three miles from the main ditch at the lands where the water is used. There is one point on the Calloway canal where there is a loss of 75 cu. ft. per sec. in a distance of half a mile.†

The canals referred to by Mr. James are from 6 to 25 miles in length, and from two to three feet in depth. In their experience they find that an allowance of 2 per cent. per mile of main canal approximates fairly well to the loss to be counted upon.

On the Carpentras canal of Vaucluse in France, taking water from the Durance, the loss was found to be great, though the waters of the Durance are thick with mud ordinarily. The canal passes along the flank of calcareous slopes. The soil is generally thin. The banks were walled and the canal paved in many places. After these remedies, the loss is still considered to be about 30 per cent of the amount taken by the canal.‡

The canal carries 210 cu. ft. per second. The loss corresponds to a depth of 1.2 feet over the length of the canal, which is 40 miles.

The Marseilles canal in Southern France, which had cost $9,000,000 up to 1878, at first lost about 20 per cent., notwithstanding that the water supplying the canal is exceptionally muddy, so much so that it was necessary to build settling basins at considerable cost. The loss was reduced to 10 per cent. by works protecting the banks, made at a

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*June 13, 1898.

†This is equivalent to a daily loss of 30 feet in depth.

‡Salvador, Hydraulique Agricole, (1898) 2:492.

cost of $400,000.* The loss under these favorable circumstances still amounts to about 5 inches in depth per day.

Where the Cavour canal crossed the valley of the Dora river it was confined by artificial banks and the losses at first were found to be enormous, being not less than 210 cu. ft. per sec. in a distance of but little over one mile.† This corresponds to a depth of 20 feet per day over the entire width of the canal.

This great loss was remedied by using sand in the bottom, using water made muddy with clay, and lime water, and after repeating the application several times the losses were found to be much less. After continuing the application for a couple of months, keeping the water stagnant to allow the material to settle, the losses were very much reduced.

CONTINUOUS RECORDS.

For two years a self recording nilometer was maintained on a ditch four miles long, belonging to the North Poudre Land and Canal company. The lateral had no outlets for that distance. Weirs were placed at the upper end near the reservoir from which the water was drawn, and also near the lower end about four miles from the reservoir. No water was used at intermediate places. The record was made to ascertain the loss there might be from seepage and evaporation during the time. The lateral is built in a soil mostly of clay, which does not wash unless the velocity is considerable. The seepage was not expected to be great because of the character of the soil. Two weirs were put in place and instruments were put in place at the side of the ditch, with floats so arranged that as the water rose or fell a pen rose or fell on the paper correspondingly. The clockworks would run a week without rewinding. At the end of each week the instruments were visited, the clock rewound, the papers changed, and check readings of the height of water over the weirs taken.

After the instruments were in service it was found that about ten acres of ground was supplied from the lateral above the lower weir. The cases when water was drawn for this tract are eliminated from the table, but the conditions were not entirely satisfactory, and, as the funds to meet the small expense of removing the weir above this lateral were not available for the department at that time, the measurement was dropped. A ditch in the southern part

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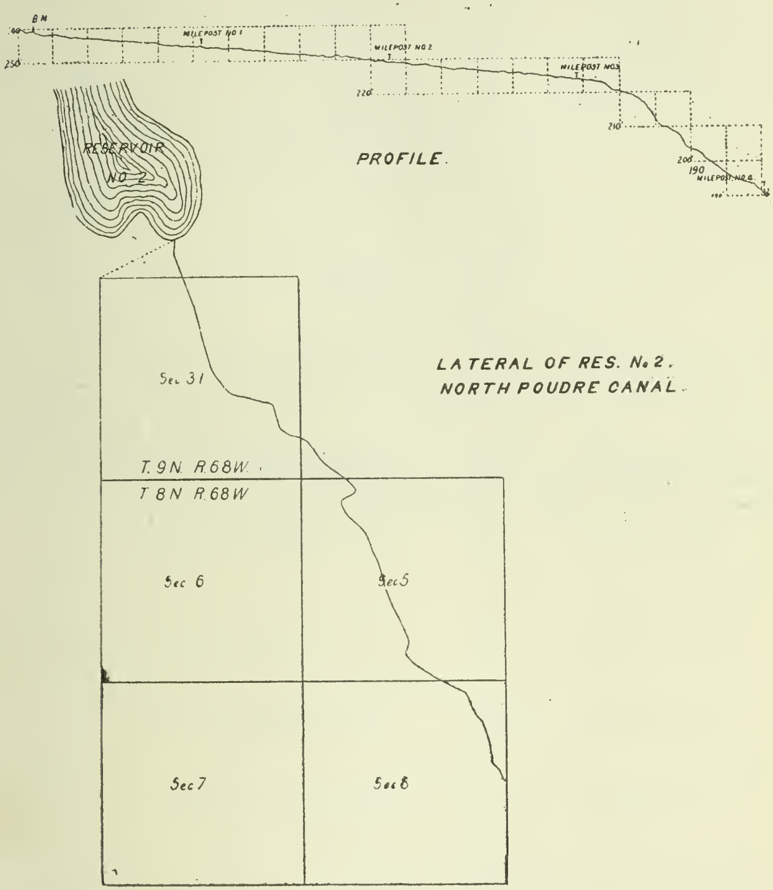
*Salvador, Hydraulique Agricole. 2:42.

†Herrisson, Les Irrigations de la Vallee du Po. p. 77.

of the state, 40 miles in length without an outlet, has been put at our service and records are to be made on it, giving, it is hoped, information on a more extensive scale.

The line and profile of the canal is shown in the figure.



For the first mile the canal had a fall of 5.4 feet, in the second mile 4.8 feet, in the third mile 5.8 feet and in the last mile 34 feet. The reason for this rapid increase of grade is, that for the first three miles the ditch skirts the side of a divide, while a short distance after passing the third mile post it reaches the ridge of the divide and descends with the slope of the country which is quite abrupt.

The soil through which the canal runs may be termed a heavy clay. Where the water is rapid, as during the last mile, the sides of the channel become smooth with the action of the water and comparatively little washing takes place. In the course of years, however, the washing is sufficient to deepen the channel several feet below the surrounding country. As the water comes from a reservoir, it is clear except for the turbidity due to a slight amount of organic matter. The water retains its clearness for the greater length of the canal, but at the lower end contains some sediment from the scour of the channel. The soil is probably underlaid with sand and gravel at a depth of 8 or 10 feet—true of most of the surrounding country—but no opportunity to test was afforded along this line.

For the first three miles the seepage would be to the west; for the remainder of the distance it might take place both to the right and left of the channel. Some seepage showed near the northeast corner of section 8 where an area of a few acres gave evidence of water-logging. Because of the sand carried by the rapid fall at the lower end, the space in front of the lower weir is filled with sediment. This increases the discharge by increasing the velocity of approach. Near the lower end of the canal a small lateral irrigating about 10 acres of land conveyed water to the north. When water was running in this lateral notes were taken and this time was not taken into account.

TABLE VI – FROM CONTINUOUS RECORDS ON DITCH, 4 MILES LONG.

1893. June.	Av. Flow per Sec. over Weir. Upper.	Av. Flow per Sec. over Weir. Lower.	Av. Loss per Sec. cu. ft.	Loss per Cent.	Maximum Flow over Weir. Upper.	Maximum Flow over Weir. Lower.	Minimum Flow Over Weir. Upper.	Minimum Flow Over Weir. Lower.	Air Temperature at College. Average.	Air Temperature at College. Max.	Av. Rel. Humid'y at College.	Wind at College. Miles per Day.	Notes on Weather.
14	4.42	4.31	0.11	2.4	4.72	4.57	4.13	4.16	69.0	80.0	47.0	165	Sunshine to 3 p. m.
15	4.04	3.87	.17	4.2	4.72	4.17	4.13	4.13	62.0	81.8	56.5	138	Sunshine all day.
16	4.51	3.79	.83	18.0	4.72	4.10	4.51	3.74	64.5	85.2	47.9	155	Sunshine nearly all day.
17	6.65	5.21	1.44	21.6	8.95	7.18	4.43	3.74	68.7	90.9	53.9	163	Sunshine all day.
18	8.77	6.91	1.86	21.2	8.95	7.18	8.52	6.77	71.0	93.7	45.1	167	" " "
19	8.12	6.48	1.64	20.2	8.52	6.77	7.68	6.37	72.0	94.0	44.9	158	" " "
20	6.20	6.02	.18	2.8½	7.67	6.37	3.47	5.69	68.8	92.3	49.3	285	" " "
21	7.35	5.47	1.88	25.6	7.43	6.13	5.83	4.79	74.7	87.4	28.9	236	Sunshine nearly all day.
22	5.12	4.25	.86	16.9	5.83	4.79	4.57	3.81	67.6	90.8	50.6	164	" all day.
23	4.42	3.67	.75	16.9	4.57	4.36	4.17	3.40	74.3	91.1	19.3	257	" nearly all day.
24	6.26	4.80	1.46	23.4	7.76	5.57	4.57	4.36	64.1	80.2	48.0	212	" most of day.
25	5.92	4.94	.98	16.6	6.62	5.57	5.23	4.29	68.0	88.3	58.9	171	" all day.
26	3.78	3.32	.46	12.2	5.23	4.29	1.90	1.62	67.5	84.7	54.4	147	Rather cloudy.
27	1.82	0.96	.86	47.1	1.90	1.62	1.73	.34	67.7	88.1	40.6	144	Sunshine most of day.
28	1.81	.47	1.34	74.0	1.73	.82	1.47	.22	70.1	92.0	49.1	148	" " "
29	1.11	.41	.70	63.1	1.47	.70	.12	.28	65.2	73.6	71.8	192	Rather cloudy.
30	.63	.51	.12	19.2	1.13	.58	.25	.31	65.7	83.9	49.8	190	Sunshine nearly all day.
1894. June.													
22	3.73	3.47	.26	6.9	3.83	3.62	3.72	3.32	65.9	81.9	65.2	143	Rain T. cloudy after 11 a. m.
23	3.72	3.30	.42	11.3½	3.72	3.42	3.72	3.13	64.6	80.7	53.7	163	" T. partly cloudy after 9 a. m.
24	3.72	3.24	.48	12.9½	3.72	3.22	3.72	3.06	63.2	77.4	58.0	188	" .10 in partly cloudy.
25	2.10	2.06	.04	2.0	3.72	3.13	....	....	63.2	80.4	58.6	138	" T. partly cloudy.
July.													
16	2.55	0.77	1.78	69.9	4.79	3.32	2.99	2.99	71.5	90.0	53.5	126	Partly cloudy in p. m.
17	5.68	4.04	1.64	28.8	7.14	5.55	4.14	2.99	74.0	89.0	59.7	128	Partly cloudy all day.
18	6.44	5.55	.89	13.7	7.02	5.55	6.17	5.55	68.3	79.7	75.1	121	Rain .15 in., cloudy.
19	6.15	5.55	.60	9.8	6.29	5.55	5.73	5.55	68.6	77.6	74.3	120	Cloudy p. m.
20	6.12	5.72	.40	6.5	7.39	6.29	5.73	5.55	66.7	82.7	69.4	131	Partly cloudy in p. m.
21	6.18	5.99	.18	3.2	6.53	6.29	5.64	5.55	67.8	87.8	48.8	160	Rain T. partly cloudy in p. m.
22	2.49	2.77	Gain	Gain	6.29	5.55	0	0	67.6	89.2	54.8	159	Gain from saturated banks.
30	2.19	1.49	.70	32.3	4.90	3.52	4.46	3.42	69.5	90.4	52.5	166	Partly cloudy p. m.
31	4.33	3.52	.80	18.7	4.46	3.52	4.25	3.52	71.2	59.2	61.4	194	Rain .19 in. p. m., partly cloudy.
Aug. 1	2.85	2.73	.12	4.5	4.25	3.52	2.02	1.85	68.0	82.2	58.5	205	Rain T. cloudy.
Ave.	**4.49**	**3,73**	**.80**	**20 9**	....	....	....	....	**68.1**	....	**53.5**	**169.**	....

The average loss amounts to .80 cu. ft. per sec. As the amount turned into the ditch averaged 4.49 cu. ft. per sec. the loss amounted to 18 per cent. on this basis, or 22 per cent. by taking the average of the losses by days.

As the surface of the water of the canal was about three acres in area, this amount of loss corresponds to a depth of slightly over 6 inches per day.

The variations in the loss on different days is noticeable. A part of the difference is due to the fact that a fluctuation in the amount of water in the canal does not affect the lower weir until a couple of hours after the upper weir has been affected, and as the civil day was used with both weirs, some discrepancy is due to this fact. The days when the changes were noticeable were excluded from the table though the effect is not thereby entirely elminated from the individual day's record.

The days when water was used through the small lateral above the lower weir could easily be detected by comparison of the records at the two weirs, and are likewise excluded from the table.

Showers affected the record to some extent in 1894, and while the amount of rain entering the canal is unknown, there is reason to suppose that its effect caused the apparent losses to be less than in 1893, whose record for the time reported was free from such disturbance.

RECAPITULATION OF CASES OF LOSS.

Pleasant Valley and Lake Canal: Loss of 11.46 sec.-ft. in 23 miles, after being increased by over 8 ft. gain.	Depth.
Average depth of loss, with low head.......	0.66 ft.
Excluding gains, loss of over..............	1.00 "
At places, over...........................	5.00 "
North Farm Lateral: Lost 12 5 ft. in 9 miles, with head of 200 sec. ft.	
Average depth of loss.....................	0.80 "
With head of 90 ft. lost 5.28 sec. ft. or depth.	0.43 "
Fort Morgan Canal.........................	1 to 2.60 "
Hoover Ditch..............................	1.00 "
Greeley No. 3, special case...............	30.00 "
" " " July 20, 1898..................	18.00 "
North Poudre Lateral...............6 to 1.00	0.80 "
Muzza Canal, Italy........................	1.70 "
Naviglio Grande...........................	0.80 "
Martesana.................................	1.50 "
Centreville and Kingsburg.................	6.00 "

King's River and Fresno	6 to 1.70	"
Fresno Laterals	1.2 to 6.40	"
Kern county canals	.39 to 2.60	"
Kern county, sandy soils	1. to 2.	1.60 "
Kern county, sandy loam	.39 to 1.3	0.87 "
Campine, Belgium, sandy	2 to 10.00	"
Erie Canal	.25 to .80	0.60 "
Carpentras Canal, France		1.20 "
Marseilles Canal		0.40 "

GAINS FOUND IN CANALS.

In many cases the canals serve as drainage ditches and are found to gain in volume instead of loss. Several examples may be noticed in the tables, as the Empire canal, the North Farm lateral for a portion of its length, the Prairie Ditch, the Pleasant Valley and Lake canal, etc. It is frequently noticed that some canals have water even when their supply from the river is shut off. This is often found to be true with the ditches in river bottoms, originally built to take water from the river, but which, with the irrigation of the upper lands, have now become practically drainage ditches. Every old irrigated valley in the state has such instances.

In the case of the Hottel mill race at Fort Collins, not elsewhere mentioned, which was measured in the fall of 1897, a gain of over 4 sec. ft. was found in a distance of two miles.

The gains are manifestly more likely to be found in deep canals than in the shallow laterals.

VARIATION OF LOSS WITH DEPTH.

The amount of seepage increases with the depth of water in the channel. This is principally from theoretical considerations, but has observational confirmation. The exact relation must depend on the relative losses through the banks and through the bottom or on the relative width and depth of the channel. As the soil is rarely uniform for any considerable distance, the results from theoretical considerations can only be a guide as to what to expect. When the loss is solely through the banks there is reason for thinking it may vary nearly as the cube root of the square of the depth, that is, on doubling the depth, the loss would be nearly three times as much; on quadrupling the depth the loss would be nearly eight times as much.

Some interesting observations by J. C. Trautwine, Jr., Chief of the Bureau of Water of Philadelphia, are given in

Bulletin 45, on Losses from Reservoirs, page 12. It was found when the water was 20 ft. deep, the loss amounted to .15 inches per day; when 25 feet to .24 inches; when 30 ft. to .46 inches, but on lowering the water it was found that the loss did not become as small as the same depth before the reservoir had been filled. The loss at 20 ft., after the reservoir had been full, remained at .28 inches instead of reducing to .15 inches observed before.

Some observations by Keelhoff on small ditches have already been mentioned. In these more loss was found when the water was 10 inches deep than when 2 inches deep.

In the case of the North Farm Lateral, where two measurements were made with different amounts of water in the canal, a greater depth of loss is shown with the larger head. The depth of loss averages .8 with the head of 200 sec.-ft., and .4 ft, with a head of 90 sec.-ft.

By arranging the losses according to the amount of water in the canal, we find that the observations given in table VI show clearly that the smaller the amount of water the less is the depth of loss, though the greater the per cent. the loss is to the amount in the ditch.

Omitting the days on which the water had dropped, in which cases the water returning from the saturated banks reduces the apparent loss, and likewise leaving out of account those days in 1894 on which doubt is cast by showers, the following table is obtained:

Amount of Water. in Ditch.	No. Cases Taken.	Loss in Carriage. per Cent.	Loss in Depth. Inches.
0 to 2 sec. ft.	4	50	4.5
2 to 4		estimated 26	6.3
4 to 6	6	19	7 5
6 to 9	6	17	8.5

THE EFFECT OF TEMPERATURE ON LOSSES.

It is undoubtedly true that the amount of seepage will be affected by the temperature of the water, and though the temperature was always taken, no attempt is made to allow for the temperature in the present report. The effect of temperature is evident in the increased flow into streams as shown in Bulletin 33, in drains, and it causes a corresponding effect on the loss from canals.

Using the equation representing the effect of temperature on the velocity of flow as given in bulletin 33, p. 46, and considering the amount of seepage at freezing temperature as unity, the loss at other temperatures may be expected to be approximately as the following amounts:*

* Note in Engineering News, by L. G. Carpenter, 39:422. Also note 40:26, July 14, 1898, by Allen Hazen, giving practically same ratios from his own measurements.

Temp., F.	Velocity.	Temp., F.	Velocity.
32°	1.000	72°	1.860
42°	1.195	82°	2.109
52°	1.403	92°	2.372
62°	2.109	102°	2.649

In warm weather the loss is therefore greater than in cold, and the loss at 80° temperature of the water would be twice as much as if it was at freezing temperature; or the loss at 70° would be about one-third more than at 50°.

LESSENING SEEPAGE.

Of the conditions affecting seepage, the one which can most readily be controlled, and in fact the only one, is the character of the canal bottom or the bottom and sides. No soil is absolutely water-tight, but there is a great difference between the perviousness of the different soils, which range through all degrees of clay to sand and gravel. Clay of the quality known as adobe, essentially a clay from which all vegetable matter has been extracted by action of alkaline carbonates, is well known to be nearly water-tight.

A layer of fine material, as of fine silt, makes the passage of water so much more slow and difficult, that its effect is well known and is shown in a number of cases in the measurements reported in this bulletin. Even water that is apparently clear contains enough matter to lessen the rate of filtering in a few weeks time in the large filters for city water supplies.

The silt carried by canal waters is sufficient to greatly lessen, and in many cases to practically stop the seepage, but to do this the velocity of the water must be slow enough to permit the silt to be deposited.

A constant current tends to prevent the settlement of sediment. If the current is swift enough to erode the bed then not only is the sediment kept from dropping and filling the pores, but the surface is swept and the losses will remain large.

Hence defective alignment of the canal, too sharp curves causing the current to strike and erode the banks, are conducive to losses. Some canals have found it desirable to straighten the line of their canal to lessen the troubles of maintenance, and in so doing have also lessened the loss from seepage.

Any way in which the canal may be silted up, or be permitted to form a layer of silt, thin though it be, will tend to lessen the seepage.

Hence checks which some canals have found it necessary to construct for water distribution, cause slack water and thus permit the deposit of silt. There are many places where the effect has been immediately shown. The water-soaked lands become dryer and land which had been impassable became dry enough for passage and cultivation. So as silting lessens the seepage, on the other hand the reremoval of the silt coating may cause the leakage to be as great as ever.

A case in point is the Greeley canal No. 3, as mentioned in Bulletin 33, pp. 49-50. When first built considerable damage was done from the rising of the ground waters and flooding of cellars in some parts of the town. After a few years the cause of complaint disappeared, silt having filled the bottom of the canal. In 1895 sand was obtained for building purposes from the bottom of the ditch at the crossing of a ravine. The top layers of the ditch bottom were found to be partially cemented. Within a few months after water was again turned into the ditch complaint arose regarding the influx of water in the town cellars. When water was turned out of the canal, the water in the cellars began to go down within ten days and in three weeks had fallen 6 inches, and in two months 18 inches. A measurement made above and below the suspected point showed a loss of 5.06 sec. ft. in a distance of 760 feet, or equivalent to a depth of 30 feet per 24 hours over the surface covered by the canal.

A drain sewer had been built by the City of Greeley to drain the region below this part of the town. It was stopped up at the time of the measurement, but v hile thus failing to remove the water, the loss from the canal was excessive as shown by comparison with the losses from other canals. The damage led to requests from the people in that part of town to correct the defects in the ditch. The city feared that an attempt to remedy the condition would be a confession that it was to blame. In 1896 a team worked for part of a day in hauling in clay and puddling this section of the canal, and the complaint in 1896 and 1897 was small.*

In the case of the Fort Morgan canal, given in table 5, there is an opportunity to compare the losses from a channel when freshly used, and after having been used for a year, silt presumably having settled.

In 1895, at the time of measurement, water had been turned into a new section two miles long for a couple of weeks. The loss was found to be 11.48 cu. ft. per second.

*July 20, 1898, this portion was again measured and loss still is a depth of over 18 feet daily.

Almost a year later the same section gave a loss only one-half as much, the change being ascribed to the silting which had taken place in the meantime.

The use of sediment is the most practicable method of reducing the loss from seepage. In California both the main ditches and the laterals are often cemented, as they are in Mexico. Their canals are much smaller than the canals in Colorado, the value of water is much greater, and hence the amount which could be expended for the saving of water would be greater than could be profitably expended under Colorado conditions.

On some California canals the channels have been lined by cementing directly on the earth. This would not be possible to do successfully under the colder winters of Colorado.

Under some conditions, as where water is exceptionably valuable, it may become profitable to go to considerable expense to save the loss from seepage; to pave the sides or bottom if necessary, to concrete the canal through in our climate this is not likely to be satisfactory, or to pipe the ditch.

Evidently the question returns to the value of water and the amount of loss. The commercial value of a cubic foot per second of water is not less than $500 in any place in the state, and in few places would it be considered as high as $3,000. This is the nominal second-foot which actually is not constant in flow. Under farming conditions $1,200 would probably represent the average value. The annual value may be considered as not less than $50. To the farmer using the water its productive value is far more; or the individual who uses the water can profitably expend more than any one else.

The farmer who could thus save as much as 2 cubic feet per second could afford to expend $100 per year if necessary for that purpose. But until fully convinced of the efficacy of methods of saving water, few would care to risk so much.

In many cases the losses are excessive. Under fair conditions they be as much as two feet per day.

The losses vary with the different formations through which the canal passes, or the different character of the soil. Porous gravels are notoriously leaky, while the clayey soils, or gravel with a suitable admixture of finer material and clay, may hold water satisfactorily. In some cases the section of the channel can be enlarged at the leaky place and filled with finer material, or silt allowed to settle, for in most cases a thin layer is sufficient to check the leakage very much.

LOSSES AT DIFFERENT FORMATIONS.

The effect of different strata is shown in the measurements of the seepage increase of streams. In the case of the Cache a la Poudre there are several stretches in which, notwithstanding the large gains in the river as a whole, there is an apparent loss of water.

In the Rio Grande river in Colorado marked losses were found for a portion of its length in the San Luis valley, amounting to 75 cu. ft. per second in a distance of 15 miles. The loss was noticed in 1896 and verified in 1897.

Similarly in the case of the Arkansas river, a loss is found in several places, but of less amount than found in the Rio Grande.

EFFECT OF PREVIOUS CONDITION ON LOSS.

The previous conditions of the bed of the canal, or stream, will materially affect the loss experienced in the canal or river bed. If the bed has been dry and has become heated as well, the amount of water which is absorbed by the bed when water is turned into the canal, is surprising to one who is not acquainted with the peculiarities of the flow of water under such conditions. The layer of dry soil absorbs the water with avidity. It will take up about one-third of its volume of water, and the amount of water thus absorbed is in addition to the amount which is flowing through the soil under steady conditions. The effect is to greatly increase the time required to send water through a ditch after having been dry, and on the longer ditches days may be taken to send water through the ditch, while when already soaked up a very slight change at the headgate is quickly felt throughout the length of the canal. It is because of the loss from this source that the attempts to run a moderate amount of water through streams with sandy beds have not been successful.

On the other hand, with falling water, a considerable amount of saturated soil is exposed. Water oozes from the banks and the supply thus received retards the fall of water. Sometimes when the banks are gravel, the outflow appears in streams and is so rapid and abundant that it may cause a slipping of the bank. Experienced canal men have a well founded objection to lowering water suddenly and considerably and though some, mistakenly, think that the pressure of the water holds the gravel in place, the effect observed is a real one.

In consequence a canal with rising water will have more and with falling water less than the normal loss, or more than the normal gain. This is shown in numerous cases with the records on the North Poudre canal. The length of time during which this will affect the conditions depends on the area and extent of the gravel beds near the channel. The principal effect passes off in a short time, for as the line of saturated soil becomes further removed from the channel, the movement of water is much more slow.

One consequence often realized in practice is that if water is to be run through a long canal, the division can be made better and fairer if the water is run completely through the canal before opening the lateral gates. The whole of a small stream of water may be required to satisfy the thirsty sand. A large stream may accomplish the same purpose in a shorter time and with less loss. Hence often it is better to use the whole stream if necessary to wet the bottom of the canal for its whole length, before beginning the division of water, and if the canal is run in sections, to begin the distribution at the lower end of the canal is the better way. If a small stream only is used, nearly all may be taken to wet up the channel and leave little for the lower users.

CONCLUSIONS.

1. The losses from evaporation are relatively insignificant compared with the seepage losses from most canals. In the cases most favorable to evaporation and least favorable to seepage the evaporation is not over 15 per cent. of the seepage.

2. In the case of reservoirs it was concluded in bulletin 45 that the seepage was less important than the evaporation. This is different from the results found in ditches, not because the evaporation is less, but because the seepage is much more.

3. The losses are sometimes enough to cover the whole canal 20 feet deep per day.

4. The loss in clay soils is less than in sandy or gravelly soils, but rarely as small as 3 inches daily.

5. The loss is greater when water is first turned in than after the bed has become saturated.

6. Sometimes the canals are found to gain for the whole or part of their length, or the canals may act as drains. This is more likely to be the case when the canal

is deep in the ground, when crossing lines of drainage, or when located below other ditches or irrigated tracts.

7. In the prevailing Colorado soil, when not intercepting seepage, the loss may be put provisionally at from 1 to 2 feet per day over the whole surface of the canal. In clay soils it is less, but still nearly one-half as much.

8. The loss in carrying water in small quantities, is relatively larger than in carrying large amounts. The increased depth of water means increased leakage, but the carrying capacity increases faster than the leakage.

8a. From the standpoint of economy, it is wasteful to run a small head. It is more economical to run a large head for a short time. In the management of small ditches the time system of distribution can be introduced to advantage, saving time and labor as well as water.

9. It is wasteful to use two ditches or laterals when one would serve.

10. The loss increases with higher temperature, being about twice as much at 80° as at 32°.

11. The loss increases with greater depth of water, but the exact relation needs further investigation.

12. The loss will be lessened by any process which forms or tends to form an impervious lining or coating of fine material, as of clay or silt. The silt, consisting of fine sand, improves many soils. Clay is better and especially limy clay, the lime with the clay forming an almost impervious coating.

13. Cement linings as used in California and Mexico are not warranted by the conditions in Colorado, nor would the weather conditions be favorable. Nor is the use of wooden stave piping for this purpose likely to be profitable in many places in the State, if at all on the larger canals at present. The silting process applied with discrimination will accomplish much at smaller cost.

14. On small laterals glazed sewer pipes may save annoyance often connected with the carrying of water in laterals for considerable distances, which, with the saving of water, may make its use an object. One of the supply laterals of the Colorado Agricultural College is of vitrified sewer pipe, over 4,000 feet of 12-inch pipe being used.

15. Some particular sections in canals are subject to much greater loss than the canal as a whole. Hence water can be saved by locating the leaky place and remedying it. This may be desirable to do while it would be unprofitable to treat the whole canal.

16. There are many places where it would be advan-

tageous to combine two ditches, by this means saving not only the loss of water, but saving superintendence and maintenance charges. With increased confidence in the accuracy of water measurement, reluctance to such consolidations should lessen.

17. The depth of losses from laterals is probably greater than in the main ditches. The laterals are less permanent, are steeper, have less silt, and are more poorly cared for.

18. There must be some arrangement of ditches and laterals which is the most economical for given conditions, so that the aggregate of the losses of the whole system will be a minimum. Certainly the location and arrangement of the laterals for carrying water from the main ditch is worthy of consideration by the management of the main canal and the importance increases with the size of the canal and the width of the strip it serves.

19. It is not to be understood that the whole of the loss from the ditches is lost to the public wealth of the State. Some, perhaps much, of the loss, may re-appear as seepage in lower ditches or in the main stream and again be used. It is, however, lost to the particular ditch and incidentally is destructive to much land. With all practicable methods of prevention, there will still be abundant loss. It should be to the advantage of the individual ditch to prevent such loss as far as practicable.

20. A general statement of the total amount of loss of water must be made and accepted with reservation. It would appear that in the main canals from 15 per cent. to 40 per cent is lost, and in the laterals as much more. It would thus appear that not much over one-half, certainly not over two-thirds of the water taken from the stream, reaches the fields. In the most favorable aspect, the loss is great, and is relatively greatest when the loss can be least afforded, viz.: when the water is low and the ditches are running with reduced heads.

21. There are some 2,000,000 acres of land irrigated in Colorado and the value of the water rights at a low estimate is as much as $30,000,000. (The census estimates the water rights as worth $28.46 per acre.) On this basis, the capital value of the water lost by seepage in the canals and ditches may be put at from six to ten millions of dollars. From the evidence at hand at present this seems a low estimate.

PUBLICATIONS OF THE SECTION OF METEOROLOGY AND IRRIGATION ENGINEERING.

BULLETINS.

No. 13—On the Measurement and Division of Water. Oct., 1890, 46 pp.
Some principles applicable to dividing water. Conditions to be met by modules. Descriptions of weirs and their conditions for accurate use; first English description of the Cippoletti trapezoidal weir. Tables for the rectangular and trapezoidal weirs, with and without contractions.
Second edition July 1891. Editions exhausted.

No. 16—Artesian Wells and Their Relation to Irrigation. 1892, 28 pp.
Including maps showing the Denver and the San Luis basins, and indicating the probable limits of the latter, closely confirmed by the wells since sunk.
Edition exhausted.

No. 22—Preliminary Report on the Duty of Water. 1892, 32 pp.
Giving several years measurements on the amount of water used on crops of alfalfa, wheat, oats, native hay, and on canals irrigating many thousand acres, all in the Cache a la Poudre valley, with some discussion on the absurdly high duties sometimes reported. and on the ultimate duty of water.
Edition exhausted.

No. 27—On the Measurement and Division of Water. 1895, 42 pp.
Revised edition of No. 13, with additional matter, especially new tables computed for weirs of unit length and for depths measured in inches. Also tables for correcting for velocity of approach, so as to render the tables applicable to cases where the space in front of the weir becomes silted up.
Edition exhausted.
The tables have been reprinted in Report of the Colorado State Engineer for 1895-6.

No. 33—Seepage or Return Waters from Irrigation. Jan. 1896, 63 pp.
Reporting measurements in detail on the Poudre river and on the Platte river made to determine the increase in those streams from return waters from irrigation. Discusses the origin of that increase and the connection with the area irrigated and the amount of water applied in irrigation. Shows connection between the amount and the temperature, etc.
Copies still to be had on application.

No. 45—Losses from Reservoirs by Seepage and Evaporation. May, 1898, 32 pp.
Eleven years observations of evaporation at Fort Collins. and several years observations on floating tanks. Two winters observations on losses from seepage. Some discussion of economy of storage at high altitudes.

No. 48—On the Losses from Canals from Filtration or Seepage.

Annual Reports Forming Part of the Annual Reports of the Agricultural Experiment Station.

1888—First Annual Report of the Agricultural Experiment Station, 250 pp. C. L. Ingersoll director.
Report of Meteorologist and Irrigation Engineer, 70 pp.
Description with illustrations of instruments.
Meteorological observations in detail.
Table of observed sunshine by days and comparison with New York.
Table of soil temperatures.
(Tables reprinted in Report of Secretary State Horticultural Society, 1889.)

1889—Second Annual Report of the Agricultural Experiment Station, 1889, 136 pp. C L. Ingersoll, director.
Report of Meteorologist and Irrigation Engineer, 28 pp.
Table of extent of irrigated area in Colorado.
Monthly precipitation for several years and at various co-operating stations

Daily range of temperature.
Tables of amount of shnshine observed at Fort Collins, Rocky Ford and Del Norte.
Observed and computed evaporation from water surface.
Weekly means of soil temperatures at several places.

1890—Third Annual Report of the Agricultural Experiment Station, 228 pp. C. L. Ingersoll, director.
Report of the Meteorologist and Irrigation Engineer, 100 pp.
Table showing maximum and minimum flows of a number of streams for 1888 and 1890.
Table of the daily flow of the Cache a la Poudre.
Estimated amount required by months.
Notes on the duty of water.
Depths taken by the No. 2 canal.
Irrigation statistics, 1890.
Acres covered by ditch.
Mileage of canals.
Cost of irrigation works.
Irrigation bibliography, 10 pp.
Meteorological tables: Precipitation.
Daily dew point and relative humidity by days.
Evaporation, summary of results.
Evaporation at Del Norte.
Evaporation on a reservoir.
Sunshine by months at three stations, compared with New York.
Sunshine, forenoons and afternoons.
Sunshine for days, by sunrise to 9 a. m.; 9 to 12; 12 to 3; 3 to sunset.
Sunrise by days throughout the year, three stations.
Actinometer readings, 1890.
Daily temperatures, 7 a. m to 7 p. m., max., min., throughout the year.
Table of range, daily, throughout the year.
Table average and greatest range by months.
Weekly soil temperatures, depths from 3'' to 6 ft., three locations.
Table of extremes.
Daily mean barometer.
Annual summaries at Agricultural College, Del Norte, Rocky Ford.

1891—Fourth Annual Report of the Agricultural Experiment Station, 130 pp. W. J. Quick, director.
Reports of the Meteorologist and Irrigation Engineer, 69 pp.
Tables of precipitation for 15 years at Fort Collins, at 19 co-operating stations.
Change of precipitation due to elevation.
Dew point and relative humidity, 1891.
Return or seepage waters.
Evaporation, comparison of computed and observed.
Average daily evaporation.
Comparative evaporation at three stations.
Notes on duty of water. on actinometry.
Sunshine tables as in 1890.
Weekly means of soil temperatures.
Air temperatures by days.
Terrestrial radiation by days.
Average barometer by days.
Comparative tables observations at Fort Collins and Manhattan, 3,000 ft. higher.
Annual summaries, Fort Collins, Monument, Rocky Ford, Manhattan.

1892—Fifth Annual Report of the Agricultural Experiment Station, 68 pp. W. J. Quick, director.
Report of the Meteorologist and Irrigation Engineer. 6 pp.

1893—Sixth Annual Report of the Agricultural Experiment Station, 84 pp. Alston Ellis, director.
Report of the Meteorologist and Irrigation Engineer. 7 pp.

1894—Seventh Annual Report of the Agricultural Experiment Station. 112 pp. Alston Ellis, director.

Report of the Meteorologist and Irrigation Engineer. 6 pp.

1895—Eighth Annual Report of the Agricultural Experiment Station. 64 pp. Alston Ellis, director.

Report of the Meteorologist and Irrigation Engineer. 7 pp.

1896—Ninth Annual Report of the Agricultural Experiment Station. 113 pp. Alston Ellis, director.

Report of the Meteorologist and Irrigation Engineer. 5 pp.

1897—Tenth Annual Report of the Agricultural Experiment Station. 110 pp. Alston Ellis, director.

Report of the Meteorologist and Irrigation Engineer. 24 pp.

Discussion of operations of the year, results and investigations desirable to make.

The State Agricultural College.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO 49.

Meteorology of 1897, With Illustrations.

Approved by the Station Council,
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

SEPTEMBER, 1898.

Bulletins will be sent to all residents of Colorado, interested in any branch of Agriculture, free of charge. Non-residents, upon application, can secure copies not needed for distribution within the State. The editors of newspapers to whom the Station pubications are sent are respectfully requested to make mention of the same in their columns. Address all communications to the

DIRECTOR OF THE EXPERIMENT STATION,
Fort Collins, Colorado.

EXPRESS, FORT COLLINS

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FORT COLLINS, COLORADO.

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METEOROLOGY OF 1897.

With Illustrative Diagrams and Descriptions of Instruments.

BY L. G. CARPENTER AND R. E. TRIMBLE.

☞A table of contents is to be found at the back.

§1. The following bulletin gives the principal, though not all of the meteorological observations made at the Agricultural Experiment Station during 1897.

§2. The peculiarities of the climate are such, that while its vagaries give less cause for comment in Colorado than in a more moist climate, nevertheless the general characteristics are well worthy of understanding, and necessary, indeed, for one whose operations may be affected thereby. In general, facts given in tables are not easily apparent, hence the following tables have been retained until they could be accompanied by the diagrams here given. The tables with the diagrams, it is hoped, will show the course of the changes and reveal the general characteristics of the climate, and be more useful than as a mere record of the year.

§3. The great variation in altitude in the state, ranging from less than 4,000 feet at the eastern border to over 14,000 feet at the summit of numerous peaks, causes a change in climate greater than between New Orleans and Winnipeg, and while Colorado east of the mountains has a mean temperature the same as New York, the temperature of the high peaks is lower than that of Spitzbergen. Therefore, when we speak of the climate of Colorado we have great differences to consider. Still, cultivated and irrigated Colorado is of relatively small range in elevation, and fortunately Fort Collins is as typical as any single place which could be selected.

§4. Among the general characteristics of Colorado are:

The small rainfall—from one-half to one-third of that east of the Mississippi.

The dryness, indicated by the low relative humidity, promoting rapid evaporation, and causing an absence of sensible perspiration as a rule, and less oppression than accompany the same temperatures in a more moist region.

Greater range of temperature.

A large percentage of sunshine, of great intensity, which, as well as the great range, is a consequence of the great dryness and rarity of the air.

One of the marked features is the presence of warm westerly winds known as Chinooks, a type present in mountainous countries under various names. While cold waves are not absent, the intensity is less than in the Mississippi Valley states. The conditions which result in blizzards of great intensity in the states, cause westerly winds with us, and some of the most pleasant weather of winter.

DESCRIPTION OF THE STATIONS.

§5. The Agricultural Experiment Station, at Fort Collins, is located at the base of the Rocky mountains about four miles from the foot hills, beyond which the mountains rise to the summit of the range, fifty miles westward. It is located about one mile south of the Cache a la Poudre river, and about forty feet higher, on the bench lands which are supplied with water for irrigation from this same stream. The college is in the midst of an irrigated area, which extends about three miles farther west, while both east and south there is no unirrigated land for a number of miles. The nearness of the mountains affects the climate in the amount and character of the clouds, in the temperature, in the precipitation, and in the direction and character of the winds.

The elevation of the office barometer, which is ten feet above the ground, is 4,992 feet as found by connecting with the levels of the U. P. D. & G. R. R. The latitude of the college is 40° 34′; its longitude, 105° 6′ west of Greenwich.

§6. The station at Cheyenne Wells which has been termed, perhaps unfortunately, the Rain Belt station, is on the Great plains, on the Kansas Pacific Railway (Union Pacific), near the eastern border of the state. It is a point where wells were sunk to a great depth to procure water. The elevation above the sea level is 4,278* feet. Its latitude 38° 50′, and longitude 102° 20′. The station is nearly one-third of the distance between the Arkansas river on the

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* Preliminary unpublished results of the trans continental levels of the U. S. Coast Survey.

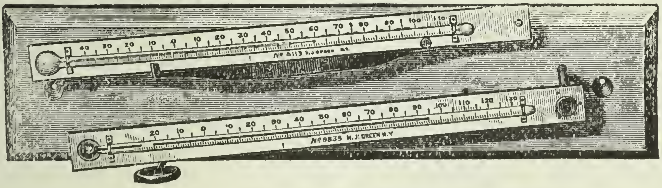
south and the Platte on the north, and it has the characteristic climate of the Great Plains. Mr. J. E. Payne has been the Superintendent and observer. The reductions have been made at the home station.

§7. The Arkansas Valley Experiment Station at Rocky Ford, is located on the south side of the Arkansas river, about 50 miles east of Pueblo and 240 miles from the central station at Fort Collins. This station is in the irrigated strip along the Arkansas, with uncultivated range extending south to the state line, and north to the Platte. The observations during the year have been interrupted by a change in the management of the station. Mr. P. K. Blinn severed his connection with the station the first of May, and Mr. W. F. Crowley took up the work the first of August. Observations have been carried on at this station since 1890, and most of the time continuously. The latitude of the station is 38° 3′, and the longitude 103° 45′, and the elevation above the sea level 4160 feet.

DESCRIPTION OF THE INSTRUMENTS.

§8. The standard for testing the thermometers is the Normal Standard Thermometer of Green, No. 5483. Besides the special care taken by Green in its manufacture, this was tested at the Yale Thermometric Bureau, and subsequently at the U. S. Weather Bureau The results not agreeing, it was afterwards sent to Professor W. A. Rogers of Colby University, who made a careful study of its peculiarities. All thermometers are tested at the freezing point, and those used for continuous observations are tested in comparison with 5483.

§9. The maximum and minimum thermometers are shown in Figure 1. The maximum thermometer is of the



(Fig. 1.)

Green pattern, in which there is a constriction in the tube just above the bulb. When the temperature rises, the mercury is forced past the constriction, but if the temperature falls, the constriction prevents the passage of the column of mercury, and the upper end of the column indicates the highest temperature since the last setting of the instrument. The minimum thermometer is the ordinary spirit thermometer with a sliding index in the tube. As the temperature lowers and the column shrinks, the index is pulled along by the surface of the liquid. When the temperature rises, the liquid flows past the index without carrying it along, and the upper end of the index thus indicates the lowest temperature since the previous observation,

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WET AND DRY BULB THEMOMETERS OR PSYCHROMETER.

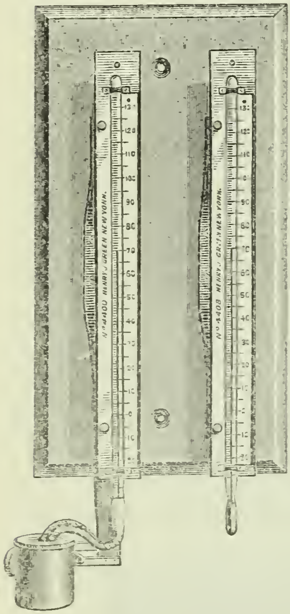


Fig. 2.

§ 10. For a portion of the time the ordinary pattern of stationary wet and dry bulb thermometers has been used. Since 1889 the sling thermometers have been used. In both cases the set consists of two thermometers as near exactly alike as possible, one of which is observed with its bulb dry, and the other, which has its bulb covered with thin muslin, is moistened with water. The ordinary set of wet and dry bulb thermometers is fixed in position, and the moistening of the bulb is accomplished by candle wicking which connects with a little water in a small vessel. The evaporation from the muslin cools the bulb so that the thermometer indicates the temperature of evaporation, which depends upon the amount of moisture that is contained in the air. The air next the bulb tends to become saturated, in which case the evaporation proceeds less rapidly, and the wet bulb does not fall so low as it would if a brisk wind were blowing. Hence the stationary psychrometer, where the air is more or less stagnant, is not as accurate as the sling psychrometer, which is essentially the same instrument, but is swung in the open air to obtain complete ventilation. In this case, the bulb is covered with thin muslin and water is applied before the observation. The stationary form of psychrometer is especially unsatisfactory in freezing weather because it is difficult to obtain sufficiently rapid evaporation from the film of ice.

THERMOGRAPH.

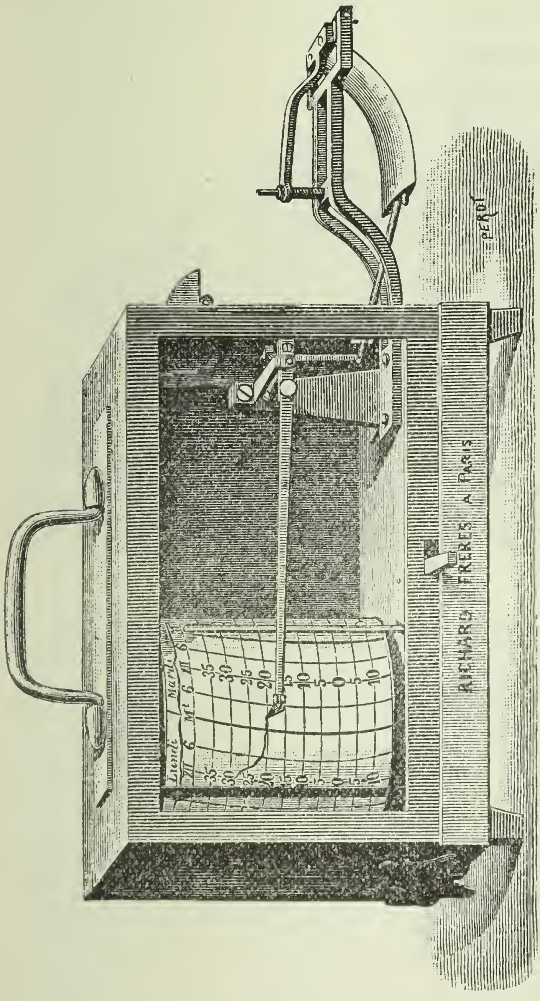


Fig. 3.

§ 11. Figure 3 represents the type of thermograph which has been used since 1890. This has been found to be a very satisfactory instrument in most respects. It is a pattern made in Paris by the firm of Richard Bros., from whom we have obtained a number of our self-recording instruments. The thermometer consists of a metallic tube, shown at the right of the instrument, which is filled with alcohol or ether. One end of the tube is fastened, the other free. As the temperature changes, the expansion of the liquid changes the curvature of this tube, and the movement of the free end acting through a series of levers, causes a pen to rise or fall according as the temperature increases or decreases. The pen records on a paper wound on a cylinder. The cylinder is caused to revolve once a week by clock work inside the cylinder, working through pinions at the base. The record of temperature by the instrument has been satisfactory, but the clock work in this and other similar instruments has not been a good time keeper.

THE REGISTERING PSYCHROMETER.

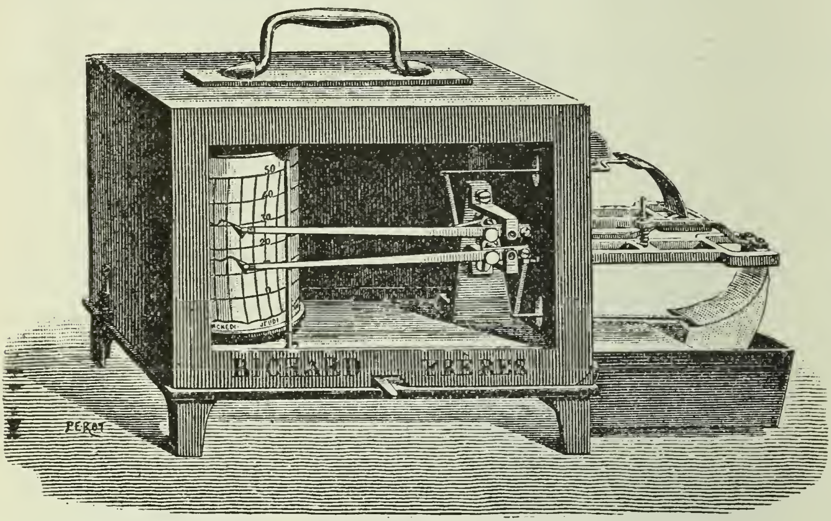


Fig. 4.

§12. This instrument, shown in Figure 4, is similar to the thermograph except that there are two thermometer bulbs instead of one, and two pens which record on the sheet. One of the bulbs gives the temperature of the air, while the other, covered with muslin moistened in water, records the temperature of evaporation. The two bulbs correspond to the wet and dry bulb thermometers of the ordinary psychrometer. To prevent interference with each other, the pen of the wet bulb is set about 10° lower than the other. The record of this instrument has been maintainded since 1891. The record of the wet bulb thermometer is not as satisfactory as that of the dry bulb, but affords an interesting indication of the changes in humidity between the regular periods of observation. Many times the changes which take place are sudden; sometimes currents of air pass, with very little change in the dew point. At other times the wet bulb thermometer will suddenly rise or fall, showing a marked change in the moisture conditions of the air without a corresponding change in temperature.

THE BAROMETER.

§13. The barometer which has been used was made by Green, and consists of a mercurial barometer with adjustable cistern. The height of the mercurial column is measured from the mercury in the cistern to the top of the mercurial column near the upper part of the tube. The mercury in the cistern is always brought to the same height by a screw in the bottom. The attached thermometer shows the temperature of the mercurial column. This is read at each observation, and as the mercury expands or contracts with change of temperature a correction is made to the readings of the instrument to allow for the expansion of the mercury, and also for the change in length of the brass scale at the side of the instrument. The heights given in the tables are the heights corrected for temperature, or are the pressures of the barometer for a uniform teperature of 32°, but measured by a scale of correct length at a temperature of 62°. The station has two barometers of this type, one of which was in use at the sub-station in the San Luis Valley for some years, until, with a change in location of the station, the barometer was injured.

BAROGRAPH.

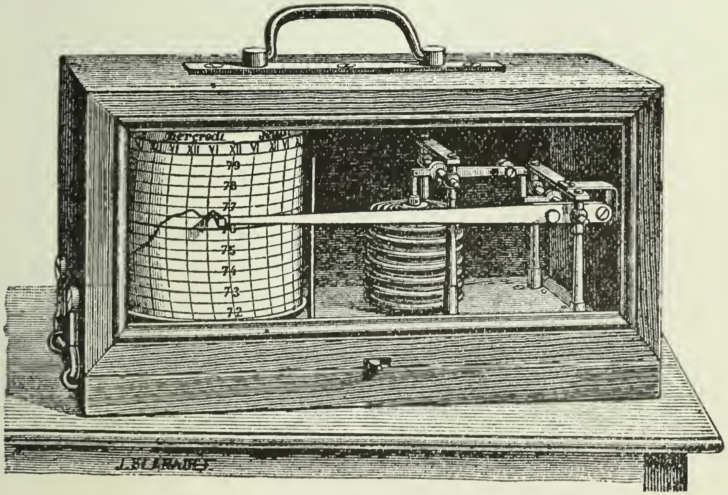


Fig. 5.

§ 14. Figure 5 shows the self-recording barometer which has furnished records since 1887. This is one of the instruments of Richard Bros., of Paris It consists of a series, eight in number, of hollow corrugated disks, the lower one fastened to the base of the instrument, the upper one to a lever connected with a pen. As the pressure increases, these disks are pressed together, and when the pressure decreases, expand, and thus, through a series of levers cause the pen to rise or fall. The instrument as a whole is a very satisfactory one. The instrument is supposed to be compensated for the effect of temperature by a little air left inside the disk. As a matter of fact the correction for temperature is incomplete, and varying temperature affects the indication of the instrument.

THE STATOSCOPE.

§ 15. The statoscope is essentially a magnifying barograph on the same principle as the one already described. It consists of one large, hollow disk which is connected with the exterior air through a tube closed by a stop-cock. In using this instrument, the pressures inside and outside the disk are equalized by opening the stop-cock. After closing the stop-cock the inside pressure remains as it was, and if the pressure outside increases the disk is compressed; if it diminishes, then the elasticity of the box causes the sides to expand. The disk is connected with the pen by levers, so that the pen rises or falls correspondingly. With change in temperature the pressure of the air in the disk alters, and the pen will rise or fall whether the outside pressure changes or not. A rise in temperature of the inclosed air gives an increased pressure in the disk, having the same effect on the pen as a decrease in pressure of the surrounding atmosphere. If the temperature lowers, then the inside pressure diminishes, or the effect on the instrument will be the same as an increase in the pressure of the outer atmosphere, and the pen will rise. The clock work makes one revolution in 52 minutes. During settled weather, or when there is little wind, this instrument shows that the pressure of the air changes steadily but without sudden fluctuations. In the case of heavy winds the fluctuations are very violent, as are shown in the diagrams here given.

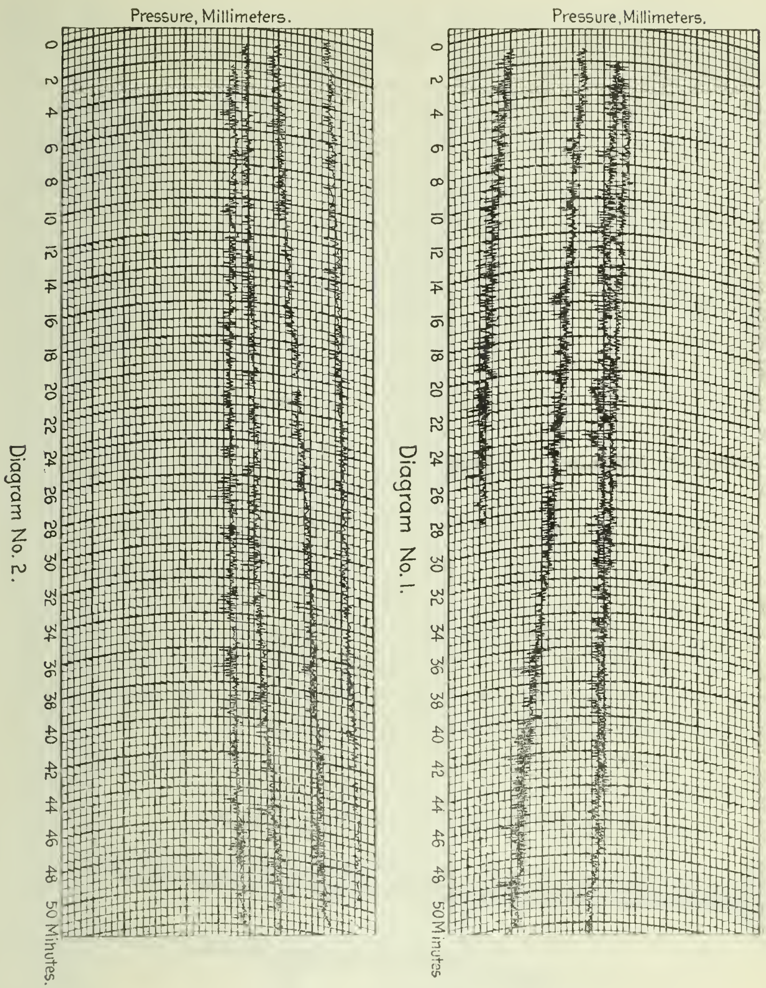


Fig. 6.

§ 16. On the diagram, Figure 6, the vertical scale indicates pressure, the horizontal scale, time. The heavier lines show periods of two minutes and the smaller ones 30 seconds intervals.

§ 17. Sheet No. 1, was placed on the instrument during a heavy wind from the west—known as Chinook—and the clock work started at 10:30 a. m. The clock work revolved five times before the sheet was removed, one revolution not recording owing to the exhaustion of ink in the pen. The second sheet was placed on at 2:45 p. m. During the time of the observation the wind velocity per hour was as follows:

10 to 11 a. m....48 miles	12 to 1 p. m....52 miles
11 to 12 a. m....49 miles	1 to 2 p. m....49 miles
	2 to 3 p. m....48 miles

During the time shown by the second sheet the velocity was nearly constant, and was 44 miles per hour.

§ 18. The abrupt changes in pressure are noteworthy, and indicate the frequency of the more violent gusts, which, during the heaviest wind, is from eight to ten variations in 30 seconds. As the wind becomes slower, its gusty character is lost, the variation of the pressure dissapears, and the record shown by the instrument is a straight line. In the second diagram are periods of from 30 seconds to 2 minutes where the line is smooth. During these times there was a lull in the wind. The greater irregularities indicate the violent gusts proceeding and following the calm periods.

The diagram well shows the character of the wind at such times, and that the velocity of the wind per hour does not necessarily indicate the power of the wind to do damage which would be measured by the most violent gusts. The greatest velocity is attained only for a few seconds at a time, and the strength of structures must be sufficient to withstand these gusts of short duration.

RADIATION THERMOMETERS.

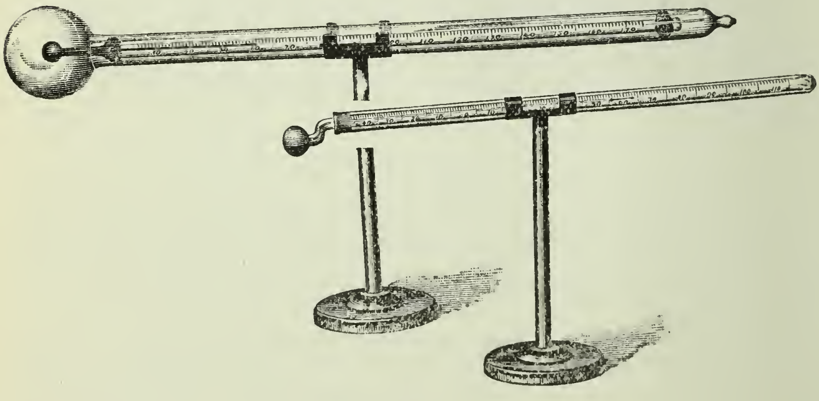


Fig. 7.

§ 19. The Maximum Solar, and the Terrestrial

Radiation Thermometers are shown in Figure 7. The solar instrument is an ordinary maximum thermometer with blackened bulb in a glass enclosure. The thermometer is measurably protected from the temperature of the air but without a corresponding instrument with a bright bulb, is of doubtful scientific value. We have found that it is difficult to obtain instruments of this pattern of sufficient range, the temperatures under our intense sunshine causing the breakage of the bulb. The principal reliance is now placed upon the Arago-Davy form of conjugate thermometers, or actinometer, consisting of two thermometers, each with a bulb one centimeter in diameter, placed in glass enclosures from which the air has been exhausted. The difference between the readings of the two instruments is not proportional to the radiation, but gives a means of determining the intensity after the constant of the instrument has been determined, as has been shown by Professor Ferrel. The convenience of these instruments is that they may be read as easily as an ordinary thermometer, and do not require the skill and special attention required by most forms of actinometers.

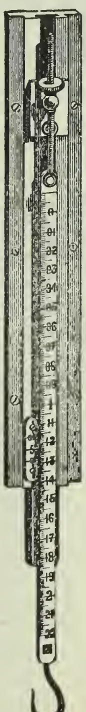


Fig. 8.

§ 20. The terrestrial thermometer is an ordinary minimum thermometer with the stem protected from radiation. It is placed near the ground, with the bulb exposed to the sky. The difference between its temperature and the readings in the instrument shelter, show to a great extent the effect of the cooling due to radiation. It is intended that it shall be placed over grass, but the changes in the location of the instrument plat have not always permitted this.

HOOK GAGE.

§ 21. The evaporation has been measured by the hook-gage shown in Figure 8. The hook is submerged, and the small elevation of the water surface produced as the hook approaches the surface permits the height of the surface to be determined within less than 1-1000 of a foot. Water is maintained in a tank three feet cube of galvanized iron, sunk flush with the ground. Observations are made twice daily during the summer season, April to September, when the early darkness interferes with the observation at 7 p. m. After the water freezes in November, the tank is not disturbed except at the end of the month, when the ice is broken and measurement made.

EVAPOROMETER.

§22. Figure 9 represents the evaporometer which has been used to determine the amount of moisture used by a plant in its growth. It is adapted only to small plants, but with them serves to show the varying demands of the plant from day to day.

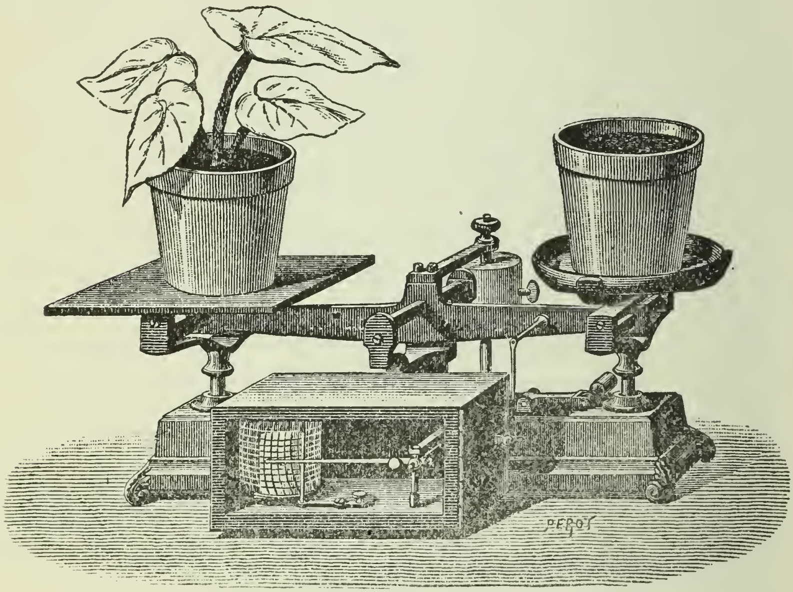


Fig 9.

SOIL THERMOMETER.


Fig. 10.

§23. Soil temperatures have been taken at different depths by thermometers with stems extending from the surface to the depth whose temperature is wanted. The thermometers, of the type shown in Figure 10, are of the pattern made by H. J. Green, Brooklyn, N. Y., protected by a wooden covering, which partly prevents the action of the temperature of the intermediate soil.

SUNSHINE RECORDER.

§24. The amount of sunshine is recorded by the Pickering sunshine recorder. This consists of two semi-cylinders—one for afternoons, and one for forenoons. They are essentially pin-hole cameras. The hole is in the flat surface and the image of the sun is cast on the curved side of the cylinder opposite, which is covered with a sheet of photographic paper sensitive to the light. We have added wires whose shadow indicates the noon hour. The face of the cylinder is moved a notch daily, bringing the trace of the sun's rays on a fresh surface of the paper. As long as the sun shines it makes a line, in which there is a break whenever clouds obscure the sun. Hence the record, after being fixed by a bath so as to be no longer acted on by light, consists of a series of broken lines, one line across the paper for each day, the extent of sunshine being shown by the lines, the amount of cloudiness by the breaks. The lines can then be measured and converted into hours and minutes. The sunshine near sunset and sunrise does not record for about half an hour, this is counted in our figures according to the character of the day.

EXPLANATION OF THE TABLES.

§25. A dry bulb temperature is that of the ordinary thermometer. This observation is made at 7 a. m. and 7 p. m. The instrument is placed in an instrumental shelter to shield it from wind and from radiation from the ground and outside objects. The wet bulb reading is that of a thermometer with the bulb covered with fine muslin and wet in water. The cooling caused by evaporation lowers the temperature of this thermometer below that of the similar dry bulb. This reading is sometimes spoken of as the temperature of evaporation. The drier the air, the lower does this thermometer read. In some of the summer months the difference is found to be as great as 15° or 20°. Attention has been called to the fact that this temperature would indicate approximately the temperature which the human body experiences, as the body is approximately in the condition of an instrument that is moist, and whose temperature is less than that of the air. It has therefore been proposed to call this the Sensible temperature. This term, which is free from objection during the summer months, is entirely misleading for temperatures below freezing. The observations are made by a Sling Pyschrometer consisting of two exactly similar thermometers placed side by side. These are swung in the air, in order to cause the rapid evaporation which will only take place by the renewal of air in contact with the bulbs.

§26. The dew point and the relative humidity are obtained by calculation from the observations on the dry and wet bulbs. This is done by the aid of tables, still in manuscript, prepared in 1889, and based on Ferrel's researches. By the temperature of dew point, is meant the temperature at which the air is saturated with the amount of moisture it contains. At all temperatures the air contains moisture. Ordinarily this is invisible, and the air does not contain all that it will hold, or it is not saturated. At low temperatures it will not hold nearly as much as at high temperatures. In consequence, when the air is cooled without loss of moisture, it approaches saturation, or the relative humidity is increased, while the dew point remains the same. When saturation is reached, (when the relative humidity is 100 per cent, or when the dew point is the same as the air temperature) any additional cooling will cause some of the moisture to be condensed into a visible form. When a large mass of air is cooled, it may be as a cloud ; or if the air is cooled by contact with some body below the dew point, it may be as dew or frost. The temperature of dew point thus indicates the temperature of the air at which the amount of moisture actually present causes saturation. Thus every time when the dew point is the same, the absolute amount of moisture present is the same. The relative humidity expresses the percentage that the moisture actually present bears to the amount of moisture which would saturate the air at the temperature shown by the dry bulb. A relative humidity of 100 per cent indicates complete saturation.

§27. The daily mean dew point and daily mean relative humidity are the means of the corresponding dew points and relative humidities from observations at 7 a. m. and 7 p. m.

§28. The maximum and minimum temperatures are obtained by self-registering thermometers, which record respectively the highest and lowest temperatures that take place between the times of observation. The mean temperature for the day is the mean of these two readings. In general, this is higher than would be obtained from the mean of the air temperatures at 7 a. m. and 7 p. m.

§29. As great variation in temperature is characteristic of the climate of the arid regions, a column showing the daily range is therefore given. It will be noticed that the average daily range for the year is nearly 30°, and that the range of certain days may exceed 50°, an amount which is unknown in the regions east of the Mississippi. It is in consequence of such variation, that while the temperature seems moderate, if not warm, it is not uncommon on days when the temperature has been below zero in the morning, to find an overcoat unnecessary at noon. The same valuable features are characteristic of the summer climate, for while the temperature of the day may rise to 90° or over, the range gives cool nights, and the conditions for physical rest.

§30. The barometer readings are those of the mercurial barometer, read twice daily. In addition to this a barograph is also used. It will be noticed that the barometer varies from day to day and from month to month.

§31. Terrestrial radiation serves to indicate the effect of radiation on the temperature of the air next to the earth's surface. The reading of the instrument gives the temperature indicated by the minimum thermometer placed with its bulb a few inches above the grass surface. This is nearly the temperature of the air at that point. This instrument is placed about six feet lower than the instruments in the shelter close by. The amount that the radiation thermometer is lower than the minimum thermometer in the shelter is placed in the column of radiation.

§32. The important effect of radiation is that it may cause frost to occur, even when the lowest air temperature is above freezing. It will be noticed, that during the months of April, May and June, the temperature near the ground becomes 4° or 5° lower than the temperature of the air six feet above the ground, and that at times it may descend 10°

or more below the air temperature. Hence it is not uncommon to find frost occurring, even when the lowest temperatures of the night, indicated by a thermometer at the ordinary height above the ground, has not descended below 40°.

§ 33. The precipitation is measured by the use of a standard rain gage exposing 50 square inches of surface. If the precipitation occurs as snow, the measurements are more unreliable, as the snow drifts and the rain gage does not give reliable results. Better results are obtained by distributing boards flat on the ground, and after the storm choosing one which seems not to be affected by air currents, obtaining from it, by inserting the rain gauge, the amount falling on a surface the same as the gage and melting the snow. There is a great difference in the amount of moisture in a given amount of snow according to its condition, whether light and powdery, or damp and heavy. On the average, the amount of moisture is 1–10 the depth of the snow.

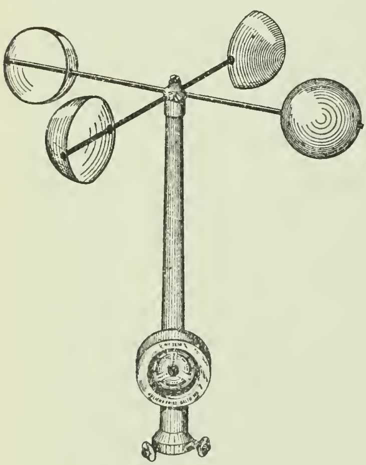


Fig. 11.

§ 34. The wind is measured by the Robinson Anemometer. The standard instrument is placed on top of the tower of the college building, and is connected by wires with the office of the Meteorological section, so that every mile of wind that passes is registered on the recording cylinder. The instrument is about 60 feet above the ground. Trees surround the campus with an elevation of about 40 feet. The tower extends about 20 feet above the roof of the adjacent building.

§ 35. Solar radiation is measured by means of the actinometer. This instrument is of the Arago-Davy form, consisting of two thermometers with spherical bulbs one centimeter in diameter, surrounded by a glass enclosure from which the air has been exhausted. These are placed with their bulbs uppermost exposed to the sky. One of the two has its bulb covered with lamp black and absorbs the radiations, and indicates a higher temperature. The readings of these instruments are given in Centigrade degrees, which may be put into Fahrenheit degrees by multiplying the reading in centigrade by 1.8 and adding 32°. By means of a special series of observations, indications of this instrument may be interpreted and expressed in calories, or units of heat.

§ 36. To say that the heat received is one calorie, is to say that the heat received on one square meter is sufficient to heat one kilogram of water one degree C. in one minute.

§ 37. The enormous force contained in the sunshine is not generally realized. If we express this in horse power per square yard, 10 calories is equivalent to nearly 8-10 (.82) of a horse power per square yard, or when the radiation amounts to as much as 12.8 calories, the solar energy which is being received, is equivalent to one horse power per square yard. An examination of the column shows that this often exceeds one horse power per square yard of surface perpendicular to the sun's rays.

§ 38. These observations have been carried on now for a number of years at this institution. They are the first, so far as is known, in this country. The instrument is read at noon on week days. The numerous blanks are due to the absence of the observer at outside observations.

§ 39. The column of frost or dew indicates the dates on which the frost or dew was observed. It does not denote that these were the only days. During the summer, it is probable that many days of dew have been overlooked, for the dew has time to evaporate before the observation at 7 o'clock is made. On nearly every morning, the reading of the terrestrial thermometer is lower than the dew point at the same time. If so, it may be certain that there has been dew or frost. If the radiation thermometer has been below 32°, it is frost; if above, dew. A comparison of the terrestrial radiation column and the dew point temperatures at 7 a. m. of the same day show a few such cases.

The summaries in tables 2, 3, and 4, show the number of days during the year on which frost occurs. The greater amount of moisture at Fort Collins over Cheyenne Wells is shown by the greater number of times that frost and dew were observed.

Table 5 gives the precipitation as observed at the Agricultural College by months. As before stated, the records previous to 1887 were scattered and lost, although the observations were taken for most of the months. The average of the different months is used as the normal precipitation, making the normal for the year 13.86 inches. It will be noticed, that during the last eleven years, six years have been above the normal, and one very much below.

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE,

	TEMP., DEW POINT AND RELATIVE HUMIDITY.								Daily Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Terrestrial Radiation	
	7 A. M.				7 P. M.											
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity							Instrument Reading	Radiation
	F°	F°	F°	Per Cent	F°	F°	F°	Per Cent	F°	Per Cent	F°	F°	F°	F°	F°	F°
1	31.7	25.8	14.2	47.6	27.7	23.3	14.2	56.6	14.2	52.1	34.0	27.5	30.7	6.5	25.0	2.5
2	22.0	18.2	8.4	55.4	23.6	17.3	-3 0	30.9	2.7	43.1	32.8	15.0	23.9	17.8	7.0	8.0
3	23.0	17.2	-1.0	34.9	19.8	15.6	-2.8	47.6	0.9	41 3	29.4	9.1	19.3	20.3	2.0	7.1
4	7.1	5.7	0.0	73.6	21.3	15.0	-8.3	25.9	-4.2	49.7	42.7	6.2	24.4	36.5	1.7	4.5
5	12.6	9.8	-0.3	56.6	32.3	24.3	5.2	31.2	2.5	43 9	46.2	11.1	28.7	35.1	3.8	7.3
6	18.4	16.0	9.6	68.6	35.7	27.0	8.5	31.7	9.0	50.2	47.3	15.8	31.5	31.5	10.4	5.4
7	14.2	13.3	10.6	86.6	23.1	19.9	12.5	63.4	11.6	75.0	54.9	13.7	34.3	41.2	7.8	5.9
8	14.0	12.0	6.0	70.2	46.6	32.2	1.2	15.3	3.6	42.7	64.0	12.2	38.1	51.8	5.9	6.3
9	14.4	13.7	11.7	89.6	33.1	25.0	6.4	31.9	9.0	60.8	53.3	14.1	33.7	39.2	9.3	4.8
10	16.1	14.9	11.7	83.1	21.1	17.8	9.3	60.0	10.5	71.5	44.0	* 16.0	30.0	28.0	7p.m. 11.4	4.6
11	15.7	14.1	9.7	77.3	23.2	23.1	12.0	50.4	10.9	63.9	48.1	13 0	30.6	35.1	7.1	5.9
12	22.8	21.4	18.7	83.7	29.8	25.6	17.8	60.6	18.2	72.1	47.7	20.4	34.0	27.3	16.2	4.2
13	13.0	12.7	11.8	95.3	29.8	24.7	14.5	52.2	13.2	73.8	42.6	13.2	27.9	29.4	6.7	6.5
14	24.1	23.8	23.5	96.6	22.1	20.9	18.5	85.8	21.0	91.2	34.0	23.8	28.9	10.2	24.0	-0 2
15	10.2	9.7	8.2	91.5	38.2	30.1	16.1	40.1	12.1	65.8	48.8	10.0	29.4	38.8	0 0	10.0
16	21.1	20.6	19.6	93.9	34.0	29.8	23.4	64.6	21.5	79.2	39.3	18.7	29.0	20.6	12.7	6.0
17	23.0	18.9	8.6	53.4	26.0	20.8	8.1	46.5	8.4	50 0	42.6	* 22.6	32.6	20.0	17 4	5.2
18	11.1	8.9	5.8	80.3	20.0	15.6	1.9	45.4	3.9	62.8	54.7	6.7	30.7	48.0	2 7	4.0
19	11.0	10.1	7.1	85.1	24.7	19.1	3.7	40.2	5.4	62.7	54.S	9.3	32.1	45.5	5.9	3.4
20	13.2	11.7	7.2	77.0	36.1	25.8	-0.5	20.9	3.3	48.9	49.1	12.2	30.6	36.9	7.7	4.5
21	23.8	20.1	11.5	58.8	43.4	32.7	14.4	30.7	13 0	44.8	56.8	20.0	38.4	36.8	16.0	4.0
22	28.1	27.0	25.3	88.8	30.0	25.9	18 4	61 7	21.8	75.2	54.6	26.2	40.4	28.4	23.2	3.0
23	21.8	20.0	16.3	78.4	9.0	7.8	3.4	78.8	9.9	78.6	59.0	19.8	39.4	39.2	16.9	2.9
24	-4.1	-4.3	-5.1	94.0	-0.2	-1.1	-4.6	79.7	-4.9	86.9	9.3	-5.0	2.2	14.3	-5.8	0.8
25	-6.0	-6.2	-7.0	93.5	-4.7	-4.9	-5.7	93.9	-6.3	93.7	1.2	-7.0	-2.9	8.2	-8.2	1.2
26	-6.8	-6.8	-6.8	100.	-17.0	-17.0	-17.0	100.	-11 9	100.0	5.3	* -17.0	-5.9	22.3	7p.m. -23.2	6.2
27	-23.0	-23.0	-23.0	100.	-14.4	-14.8	-18.3	81.3	-20.7	90.6	9.0	-26.0	-8.5	35.0	-30.0	4.0
28	-14.3	-14.6	-16.5	86.0	-3.8	-3.8	-3.8	100.	-10.1	93.0	19.2	-19.2	0.0	38.4	-21.2	2.0
29	-4.2	-4.8	-7.9	81.8	13.2	12.2	9.1	84.6	0.6	83.2	37.0	-8.8	14.1	45.8	-11.0	2.2
30	9.2	9.2	9.2	100.	33.0	30.7	27.4	79.8	18.3	89.9	39.7	8.0	23.9	31.7	4.8	3.2
31	10.0	9.6	8.4	93.1	31.7	28.8	24.3	73.9	16 3	83.5	44.6	7.8	26.2	36.8	5.7	2.1
M	12.04	10.47	6.31	79.83	22.37	549.4	6.84	56.95	6.57	68.39	40.19	9.33	24.76	30.86	4.90	4.44

* Minimum temperatnre of day occurred between 7 a. m. and 7 p. m.

The highest or lowest readings of the month are underlined.

TABLE 1.—Continued.

FORT COLLINS, COLO., FOR MONTH OF JANUARY, 1897,

Barometer, Corrected for Temperature and Instrumental Errors.			PRECIPITATION				Direction of Wind.		Total Movement, 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean.	Time of Beginning	Time of Ending	Total Am't Rain and M'lt'd Snow	Av'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins			Miles	C	C	C°	Cal	
24.788	24.992	24.890	......	......	......	....	n	n	228.7	......	......	......	......	......
25.083	25.054	25.069	......	......	....	....	n	n w	297.4	31.2	11.2	20.0	12.33	......
25.019	25.092	25.055	......	......	......	....	n w	n w	447.9	......	......	......	......	......
25.058	25.016	25.037	......	......	......	....	e	s	237.0	30.3	9.5	20.8	12.70	......
25.068	25.045	25.057	......	......	......	....	n e	n	152.2	28.2	18.3	9.9	6.20	......
25.062	25.102	25.082	......	......	......	....	w	w	106.6	......	......	......	......	......
25.161	25.140	25.150	......	......	......	....	n w	w	83.6	38.4	19.8	18.6	12.18	Lt F
25.091	25.134	25.113	......	......	......	....	n w	s w	130.1	42.7	20.3	22.4	14.95	Lt F
25.270	25.096	25.183	......	......	......	..	n	w	131.4	36.6	18.1	18.5	11.96	......
25.168	25.119	25.143	......	......	......	....	e	w	121.5	......	......	......	......	......
25.078	24.919	24.999	......	......	......	....	w	n e	114.7	34.5	17.2	17.3	11.05	......
24.625	24.580	24.602	Nt.	Nt.	T	T	s e	n	148.3	26.1	11.8	14.3	8.66	......
24.760	24.896	24.828	......	......	......	...	n	s	142.3	33.7	14.5	19.2	12.10	F
24.933	24.891	24.912	......	......	....	....	n e	n	89.5	8.1	1.0	7.1	3.80	......
24.851	24.714	24.783	8.20p.m	......	......	....	0	n e	153.8	37.7	17.8	19.9	12.90	F
24.519	24.580	24.549	......	......	T	..	n w	n w	459.7	......	......	......	......	F
25.047	25.197	25.122	......	......	......	....	n	s w	197.3	......	......	......	......	......
25.182	25.100	25.141	......	......	......	....	w	s	132.3	37.8	19.2	18.6	12.13	F
24.954	24.873	24.914	......	......	......	....	n w	s	150.0	23.5	13.7	9.8	5.92	F
24.910	24.947	24.928	......	......	......	....	n e	w	174.5	35.9	17.2	18.7	12.01	F
24.875	24.915	24.895	......	......	......	....	n	n w	230.1	9.1	4.8	4.3	2.37	......
25.155	25.078	25.117	......	......	......	....	s	n w	110.9	34.5	16.0	18.5	11.76	......
24.925	25.084	25.004	......	......	......	....	s e	s e	222.7	34.4	17.2	17.2	10.98	......
25.163	24.900	25.032	Nt.	Nt	T	....	s e	n e	115.6	......	......	......	......	......
25.048	25.034	25.041	9:30 a.m	......	.14	....	s	n e	126.6	......	......	......	......	......
24.994	25.008	25.001	......	7:40 a.m	.04	...	s e	n n w	116.5	31.4	2.1	29.3	17.48	......
25.019	25.108	25.062	......	......	......	....	n w	n w	92.4	28.7	1.6	27.1	15.96	F
25.140	25.096	25.118	......	......	......	....	.0	n w	80.5	31.4	5.4	26.0	15.70	F
24.905	24.756	24.831	......	......	......	...	n w	n w	70.6	36.1	11.8	24.3	15.31	F
24.764	24.927	25.845	......	......	......	....	n w	s	141.7	......	......	....	......	F
25.008	25.055	25.032	......	......	......	....	w	n e	91.9	......	......	....	......	F
24.988	24.982	24.985	......	......	.18	....	n	n w	163.2	30.97	12.79	18.18	11.35	......

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE.

	TEMP., DEW POINT AND RELATIVE HUMIDITY. 7 A. M. Dry Bulb	7 A. M. Wet Bulb	7 A. M. Dew Point	7 A. M. Relative Humidity	7 P. M. Dry Bulb	7 P. M. Wet Bulb	7 P. M. Dew Point.	7 P. M. Relative Humidity	Daily Mean Dew Point.	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Terrestrial Radiation Instrument Reading	Terrestrial Radiation Radiation
	F°	F°	F°	Per Cent	F°	F°	F°	Per Cent	F°	Per Cent	F°	F°	F°	F°	F°	F°
1	11.9	11.5	10.4	93.6	29.6	27.2	23.3	76.9	16.8	86.2	46.9	10.1	28.8	36.2	8.4	2.3
2	22.8	21.5	19.0	84.9	33.6	29.7	23.8	66.7	21.4	75.8	55.1	22.9	39.0	32.2	18.8	4.1
3	23.9	21.9	18.0	77.4	33.3	28.2	19.6	56.2	18.8	66.8	46.5	22.3	34.3	24.0	17.1	5.2
4	11.2	11.0	10.4	96.7	32.1	25.6	12.3	43.2	11.4	70.0	44.8	10.8	27.8	34.0	8.0	2.8
5	25.0	22.9	18.9	77.0	34.3	28.8	19 6	54.3	19.2	65.6	38.8	19.4	29.1	19.4	16.8	2.6
6	26.7	24.2	19.6	74.0	33.8	31.2	27.6	77.8	23.6	75.9	47.9	19.8	33.8	28.1	15.9	3.9
7	45.8	25 3	24.5	94.6	26 0	24.6	22.1	85.0	23.3	89.8	43.3	24.5	33.9	18.8	22.0	2.5
8	14.0	13 7	12.9	95.5	26.8	24.7	20.9	78.1	16.9	86.8	40.2	11.8	26.0	28.4	8.9	2.9
9	16.2	15.6	14.0	91.6	33.9	30.2	24.7	68.7	19.4	80.2	44.1	14.2	29.2	29.9	11.2	3.0
10	20.8	20.8	20.8	100.	20.2	19.9	19.3	96.2	20.0	98.1	29.4	20.0	24.7	9.4	16.7	3.3
11	20.0	19.6	18.8	95.0	27.2	25.3	22.0	80.4	20.4	87.7	43.7	16.0	29.8	27.7	11.2	4.8
12	24.7	22.1	16.9	71.5	30.8	22.9	2.4	29.4	9.7	50.4	50.8	21.9	36.4	28.9	17.0	4.9
13	10.4	9.9	8.4	91.5	19.2	14 0	-4.2	34.4	2.1	63.0	33.2	9.2	21.2	24.0	6.1	3.1
14	2.9	2.2	-0.7	84.4	24.7	18.7	1.3	36.1	0.3	60.2	37.0	0.1	18.5	36.9	-4.2	4.3
15	25.8	20.8	8 8	48.2	45.0	32.8	10.7	24.6	9.7	36.4	47.9	19.5	33.7	28.4	12.5	7.0
16	41.3	30.9	11.5	29.4	33.1	27.1	16.1	48.6	13.8	39.0	55.0	34.0	44.5	21.0	25.8	8.2
17	21.8	21.8	21.8	100.0	22.5	22 0	21.0	94.2	21.4	97.1	30.7	21.0	25.9	9.7	21.0	0.0
18	22.2	21.3	19.4	89.1	23.0	20 2	14.1	67.8	16.8	78.5	29.0	17.1	23.0	11.9	14.0	3.1
19	1.8	1.8	1.8	100.	37.8	28.0	7.2	27.5	4.5	63.7	39.7	4.9	22.3	34.8	-0.2	5.1
20	12.0	11.4	9.7	90.4	20.1	19.4	18.0	91.2	13.8	90.8	° 40.8	9.7	25.3	31.1	3.7	6.0
21	17.2	17.0	16.5	97.3	12.0	12.0	12.0	100.	14.3	98.7	29.4	* 14.4	21.9	15.0	9.2	5.2
22	3.4	3.4	3.4	100.	23.8	17.8	-0.5	34.6	1.4	67.3	31.2	0.3	15.7	30.9	-3.7	4.0
23	-3.2	-3.8	6.8	62.6	24.2	21.3	15.2	67.8	4.2	75.2	34.6	-5.3	14.7	39.9	-9.9	4.6
24	5.3	5.2	4.8	97.9	26.0	21.2	10.0	50.5	7.4	74.2	34.9	5.0	19.9	29.9	-0.3	5.3
25	15.4	15.1	14.3	95.7	24.9	22 0	16.1	68.5	15.2	82.1	37.2	12.9	25.1	24.3	8.0	4.9
26	13.8	13.3	11.9	92.5	18 8	18.0	16.1	89.5	14.0	91.0	29.9	11.0	20.4	18.9	5.9	5.1
27	15.1	14.4	12.5	89.8	42.6	32.1	13.7	30.8	13.1	60.3	59.5	7.8	33.7	51.7	5.9	1.9
28	25.9	23.4	18.7	73.5	27.8	26.8	25.2	89.7	22.0	81.6	44.0	22.9	33.4	21.1	19.2	3.7
M	16.93	15.65	12.86	86.22	28.11	23.99	15.34	63.17	14.10	74.69	40.90	14.24	27.57	26.66	10.18	4.06

* Minimum temperature of day occurred between 7 a. m. and 7 p. m.

° Maximum temperature of day occurred between 7 p. m. and 7 a. m.

The highest or lowest readings of the month are underlined.

TABLE 1.—Continued.

FORT COLLINS, COLO., FOR MONTH OF FEBRUARY, 1897.

Barometer, Corrected for Temperature and Instrumental Error			PRECIPITATION				Direction of Wind		Total Movement 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	Total Am't Rain and M'lt'd Snow	Av'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins			Miles	C °	C °	C °	Cal.	
25.127	25.036	25.081	....	Nt.	......	....	w	w	119.0	35.9	16.6	19.3	12.37	F
24.903	24.808	24.856	Nt.	....	......	....	w	n w	170.1	......	......	......	......	F
24.754	24.812	24.783	....	....	.02	....	s e	n	171.1	......	......	......	......	Lt Sn
24.879	24.753	24.816	....	....	.....	....	0	n e	132.5	34.0	15.2	18.8	11.90	F
24.673	24.600	24.636	....	....	......	....	e	0	99.4	6.5	3.5	3.0	1.63	......
24.632	24.826	24.729	5:30p.m	Nt.	T	0.7	w	n e	152.1	22.5	12.3	10.2	6.10	......
25.007	24.984	24.996	....	....	.04	....	n e	s w	131.7	......	......	......	......	Sn
24.902	24.773	24.837	....	....	.....	..	s e	s w	74.2	.....	......	......	......	F
24.795	24.881	24.838	6:45p.m	12 m.	T	...	n w	n e	122.7	35.0	16.1	18.9	22.05	F
24.963	24.908	24.936	Nt.	....	.02	....	s e	w	79.6	8.6	1.1	7.5	4.08	Sn
24.782	24.694	24.738	....	....	.....	....	e	n	98.4	13.4	4.1	9.3	5.21	F
24.508	24.524	24.581	12:10pm	....	T	....	s w	n w	370.6	38.8	20.3	18.5	12.16	F
24.726	24.845	24.785	....	....	......	....	s e	w	151.5	32.2	11.1	21.1	13.06	Lt F
24.823	24.770	24.797	....	....	......	....	n	n w	280.0	......	......	......	....	Lt F
24.737	24.669	24.706	....	....	......	....	s	s e	407.1	......	.....	......	...	......
24.613	24.654	24.733	....	....	....	2¾	s e	s w	367.1	39.7	22.2	17.5	11.63	......
24.874	24.996	24.035	Nt.	1:30p.m	.30	1¼	0	n w	70.0	25.1	8.2	16.9	10.05	Sn
24.942	24.916	24.929	Nt.	! 10 a.m	.07	1	n	e	67.3	....	....	......	......	......
24.715	24.613	24.664	Nt.	Nt.	T	....	n	w	216.7	32.2	14.3	17.9	11.21	......
24.690	24.675	24.683	2:30p.m	....	T	....	n w	w	133.0	......	......	......	......	......
24.651	24.704	24.677	Nt.	10 a. m.	.09	1¼	s e	n w	95.0	.....	......	......	......	Sn
24.794	24.926	24.860	....	....	......	....	s w	w	165.0	42.2	15.5	26.7	19.47	F
25.033	24.9 8	25.001	....	....	......	....	w	w	144 9	38.6	12.9	25.7	16.42	Lt F
25.055	25.022	25.043	....	....	.....	....	n w	s w	175.5	Cl'dy	......	......	......	Lt F
25.155	25.212	25.184	....	....	.....	....	s w	n e	172.3	27.1	10.2	17.3	10.47	......
25.310	25.214	25.262	....	....	T	....	0	n	169.1	35.7	11.8	23.9	15.03	Lt Sn
25.935	24.943	24.989	....	....	......	....	n w	s w	175.6	33.1	14.5	18.6	11.70	F
24.994	24.941	24.967	....	....	.....	....	n w	w	111.1	.....	......	......	......	......
24.866	24.845	24.853	....	....	.54	7	......	......	165.1	29.47	12.35	17.12	10.86	......

! Used to indicate approximate time.

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE.

	TEMP., DEW POINT AND RELATIVE HUMIDITY.								Daily Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Terrestrial Radiation	
	7 A. M				7 P. M.											
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity							Instrument Reading	Radiation
	F°	F°	F°	Per Cent	F	F°	F°	Per Cent	F°	Per Cent	F°	* F°	F°	F°	* F°	F.
1	21.7	21.1	23.1	9 .3	21.8	21.8	21.8	100.0	22.4	96.6	24.9	21.1	23.0	3.8	21.7	-0.6
2	21.1	20.8	20.2	96.3	27.2	25.3	22.0	80.4	21.1	88.4	36.1	18.9	27.5	17.2	16.1	2.8
3	25.8	24.4	21.9	84.9	31.1	29.1	26.1	81.4	24.0	83.1	40.1	20.0	30.0	20.1	13.7	6.3
4	22.2	21.8	21.0	95.2	35.8	27.8	12.1	37.1	16.6	66.2	43.0	17.3	30.2	25.7	14.0	3.3
5	26 2	24.0	19.9	76.7	34.3	28.1	17.2	48.7	18.5	62.7	46.9	21.8	34.3	25.1	17.0	4.8
6	24.2	23.8	23.1	95.5	32.3	30.2	27.2	81.1	25.2	88.3	42.6	20.7	31.7	21.9	18.7	2.0
7	25.1	25.1	25.1	100.0	42.1	32.1	15.1	33.1	20.1	66.5	54.0	24.0	39.0	30.0	24.5	-0.5
8	38.3	29.8	14.5	37.4	34.7	30.2	23.4	62.8	18.9	50.1	49.1	33.2	41.1	15.9	26.0	7.2
9	22.5	21.9	20.8	93.0	33.6	25.1	5.1	29.6	13.0	61.3	43.9	20.0	32.0	23.9	16.2	3.8
10	21.2	20.1	17.8	86.6	37.0	31.3	22.7	55.9	20.2	71.3	50.7	15.0	32.8	35.7	12.0	3.0
11	25.9	20.0	4.3	39.4	28.6	20.9	-1.2	27.0	1.6	33.2	37.1	22.5	29.8	14.6	17.0	5.5
12	15.4	15.2	14.7	97.1	19.9	18.2	14.5	78.0	14.5	87.8	23.9	15.0	19.5	8.9	14.2	0.8
13	9.2	9.2	9 2	100.0	14.6	12.9	8.1	75.0	8.6	87.5	27.0	3.7	15.3	23.3	-0.9	4.6
14	12.2	11.8	10.7	93.0	26.6	22.9	15.4	62.1	13.1	77.9	39.3	7.1	23.2	32.2	3.2	3.9
15	20.7	19.7	17.5	87.7	31.0	26.3	17.8	57.1	17.6	72.4	47.4	14.4	30.9	33.0	10.9	3.5
16	24.6	23.9	22.7	92.2	43.0	34.4	22.0	43.0	22.4	67.6	52.0	17.6	34.8	34.4	13.2	4.4
17	38.2	32.9	25.5	60.2	42.5	33.3	19.1	38·6	22.3	49.4	58.7	31.9	45.3	26.8	25.9	6.0
18	32.8	29 2	23.7	68.6	44.2	34.1	18.5	35.4	21.1	52.0	60.3	24.2	42.3	36.1	18.8	5.4
19	34.1	29.1	20.9	58.0	31.1	23.1	2.4	29.1	11.6	43.5	47.6	23.0	35.3	24.6	18.8	4.2
20	22.1	19.0	11.5	63.5	29.0	28.1	26.7	91.1	9.1	77.3	40.1	15.6	27.8	24.5	11.0	4.6
21	25.4	25.4	25.4	100.0	21.1	20.9	20.5	97.6	23.0	98.8	30.6	24.7	27.7	5.9	* 20.7	4.0
22	16.8	16.8	16.8	100.0	15.8	15.2	13.6	91.4	15.2	95.7	32.3	* 15.4	23.8	16.9	11.0	4.4
23	5.1	5.1	5.1	100.0	19.8	17.9	13.3	76.1	9.2	83.1	38.2	-7.0	15.6	45.2	-11.8	4.8
24	18.7	17.4	14.3	83.1	30.9	26.8	19.6	62.5	16.9	72.8	42.1	6.3	24.6	36.6	1.0	5.3
25	29.3	26.9	23.0	76.7	38.1	34.1	28.9	69.8	26.0	73.2	53.6	19.4	36.5	34.2	14.2	5.2
26	35.5	32.3	28.0	74.0	48.9	41.2	33.0	54.4	30.5	64.2	64.1	27.2	45.7	36.9	23.9	3.3
27	36.1	33.6	30.4	80.0	45.9	36.3	23.1	40.4	26.7	60.2	65.0	29.7	47.3	35.3	25.9	3.8
28	36.9	36.1	35.2	93.6	47.6	42.1	36.6	66.4	35.9	80.0	65.3	28.9	47.1	36.4	23.9	5.0
29	34.0	32.0	29.3	82.8	45 8	40.8	35.7	68.2	32.5	75.5	60.0	29.4	44.7	30.6	23.4	6.0
30	30.8	30 8	30.8	100.0	27.1	24.9	20.9	77.3	25.9	88.7	35.4	30.0	32.7	5.4	30.0	0.0
31	29.2	27.8	25.6	86.2	30.9	26.1	17.3	56.1	21.4	71.1	37.3	24.7	31.0	12.6	24.0	0.7
M	25.30	23 55	20.39	83.73	32.65	27.79	19 30	61.53	19.84	72.63	44.82	19.86	32.34	24.96	16.07	3.79

* Minimum temperature of day occurred between 7 a. m. and 7 p. m.

The highest or lowest readings of the month are underlined.

TABLE 1.—Continued.

FORT COLLINS, COLO., FOR MONTH OF MARCH, 1897.

Barometer, Corrected for Temperature and Instrumental Error.			PRECIPITATION				Direction of Wind		Total Movement 24 Hours following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	Total Am't Rain and M'lt'd Snow	Av'g Depth of Snow	7 A. M.	7 P. M.		Blak Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins.			Miles	C°	C°	C°	Cal.	
24.995	24.909	24.952	†	10:30 am	.01	....	s e	s e	166.8	Cl'dy	....	......	......	F
24.608	24.862	24.735	Nt.	Nt	.17	2½	0	w	125.5	31.8	11.2	20.6	12.73	Sn
25.050	24.821	24.93.	7:30 a.m	....	T	....	s	e	145.9	23.6	8.5	15.1	8.95	
24.574	24.637	24.606	2:40pm	....	T	....	n w	n w	223.0	30.0	14.5	15.5	9.63	F
24.814	24.823	24.818	....	....	......	....	s w	w	290.7	......	......	......	......	Lt. F
24.906	24.833	24.870	....	....	......	....	n	e	103.6	......	......	......	......	F
24.798	24.710	24.754	....	....	......	....	s e	w	287.5	......	......	......	......	Fog
24.827	24.824	24.825		†10 p m	......	....	s e	n e	259.8	36.6	18.5	18.1	11.71	
24.978	24.959	24.969	....	....	.01	....	s e	s w	291.6	35.0	15.6	19.4	12.34	
24.912	24.715	24.815	....	....	......	....	s	w	385.0	37.0	18.3	18.7	12.11	
24.746	24.749	24.748	Nt.	....	......	....	n w	s w	431.4	33.5	13.3	20.2	12.67	
24.804	24.793	24.798	Nt.	p. m.	.06	½	e	n	245.0	18.0	3.1	14.9	8.46	Sn
24.829	24.768	24.799	....	Nt	.01	....	s	s	149.0	29.6	6.7	22.9	13.80	Sn
24.798	24.920	24.859	....	....	......	....	0	w	121.0	......	......	......	......	F
25.031	25.004	25.017	....	....	......	....	0	n w	131.4	36.3	17.2	19.1	12.29	F
24.945	24.685	24.814	....	....	......	....	n	w	185.1	33.5	18.5	15.0	9.59	F
24.790	24.764	24.777	....	....	......	..	s e	w	215.1	......	......	......	......	
24.645	24.535	24.590	....	....	......	....	n e	w	212.1	42.6	25.1	17.5	11.89	Lt. F
24.514	24.683	24.599	12:10pm	....	T	....	n w	n w	256.9	17.3	10.7	6.6	3.85	
24.662	24.606	24.634	5:20 p m	....	.02	....	0	e	146.8	23.8	11.1	12.7	7.60	
24.703	24.940	24.821	....	....	.80	11	n e	e	141.5	......	......	......	......	Sn
25.066	25.072	25.070	....	Day	.08	1	n w	s w	106.2	47.3	19.2	28.1	19.02	Sn
24.975	24.996	24.985	....	....	......	....	w	s w	96.8	45.8	18.5	27.3	18.32	F
24.925	24.901	24.913	....	....	......	....	e	w	92.9	36.0	17.6	18.4	11.84	F
25.001	24.954	24.978	....	....	......	....	n w	s w	160.1	46.0	22.8	23.2	15.21	
24.928	24.868	24.898	....	....	......	....	s w	s	151.0	47.1	26.7	20.4	14.19	
24.886	24.823	24.854	....	....	......	....	n w	s w	231.7	42.5	25.7	16.8	11.43	F
24.812	24.522	24.667	....	....	......	....	e	n	170.8	......	......	......	......	Hv F
24.510	24.459	24.485	6:30 p m	....	T	sm	n	n w	265.6	44.4	25.7	18.7	12.82	F
24.432	24.674	24.553	....	10 a .m.	.99	7	n w	n w	854.0	25.6	10.5	15.1	9.08	Sn
24.718	24.965	24.841	....	....	......	....	n w	n	553.5	33.5	13.7	19.8	12.44	
24.812	24.799	24.806	....	....	2.15	22.	......	......	227.1	34.64	16.20	18.44	12.26	......

† Used to indicate approximate time.

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE,

	TEMP., DEW POINT AND RELATIVE HUMIDITY.								Dail Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Terrestrial Radiation	
	7 A. M.				7 P. M.											
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity							Instrument Reading	Radiation
	F°	F°	F°	Per Cent	F°	F°	F°	Per Cent	F°	Per Cent	F°	F°	F°	F°	F°	F°
1	37.2	28.7	12.5	35.6	36.2	32.2	26.6	68.3	19.5	51.9	48.6	28.7	38.6	19.9	23.0	5.7
2	29.2	29.2	29.2	100.	29.0	27.1	24.1	81.2	26.7	90.6	34.4	28.5	31.5	5.9	28.1	0.4
3	26.2	24.2	20.5	78.8	39.7	31.4	17.7	40.8	19.1	59.8	43.9	20.0	31.9	23.9	12.9	7.1
4	32.0	31.1	29.8	91.7	42.5	32.8	17.1	35.1	23.4	63.4	52.1	22.7	37.4	29.4	19.9	2.8
5	36.0	33.9	31.2	83.0	40.2	38.9	37.6	90.5	34.4	86.8	51.0	27.2	39.1	23.8	23.2	4.0
6	39.9	34.1	26.3	58.2	36.1	35.8	35.4	97.5	30.9	77.8	51.9	32.9	42.4	19.0	27.0	5.9
7	32.6	32.4	32.1	98.2	32.6	31.8	30.7	92.8	31.4	95.5	45.0	31.4	38.2	13.6	30.3	1.1
8	32.3	31.9	31.3	96.3	34.1	31.9	28.9	81.2	30.1	88.8	46.1	20.1	33.1	26.0	16.8	3.3
9	32.8	31.7	30.2	90.2	42.9	35.0	24.1	47.3	27.1	68.7	50 8	22.8	36.8	28.0	20.0	2.8
10	41.2	37.3	32.8	72.6	55.9	41.1	22.2	27.0	27.5	49.8	66.7	33.4	50.1	33.3	28.0	5.4
11	47 6	37.7	24.9	40.8	38.4	33.2	25.1	61.1	25.5	51.0	55.0	35.6	45.3	19.4	31.7	3.9
12	41.3	36.1	29.7	63.7	40.7	34.2	25.4	54.1	27.6	58.9	54.5	36.9	45.7	17.6	34.0	2.9
13	33.0	30.9	28.0	81.5	43.1	33.8	19 7	38.8	23.8	60.1	58.1	23.0	40.5	35.1	18.3	4.7
14	42.2	36.8	30.3	63.1	49.7	37.9	21.8	33.4	26.1	48.3	65.8	24.9	45.4	40.9	20.2	4.7
15	40.2	38.9	37.6	90.5	50.3	40.1	28.0	42.3	32.8	66.4	57.3	34.6	45.9	22.7	33.7	0.9
16	45.7	40.9	36.0	69.4	55.0	43.2	30.5	39.4	33.2	54.4	69.8	33.8	51.8	36.0	28.9	4.9
17	50.0	42.1	33.9	54.1	61.6	42.4	15.9	16.8	24.9	35.4	73.9	31.1	52.5	42.8	26.7	4.4
18	58.6	45.1	31.3	35.7	56.6	43.0	27.6	33.1	29.5	34.4	73.7	38.3	56.0	35.4	33.0	5 3
19	39.8	35.8	31.0	71.0	50.0	40.9	30.7	47.7	30.8	59 4	61 5	35.3	48.4	26.2	31.1	4.2
20	44.9	40.9	36.9	74.0	56.2	40.0	17.1	21.4	27.0	47.7	70.5	37.4	54.0	33.1	34.0	3.4
21	51.2	39.8	25.8	37.2	48.2	35.8	15.7	28.3	21.3	32.7	60.1	38.6	49.3	21.5	29.9	8.7
22	42.0	38.1	33.8	73.2	45.0	37.5	28.3	52.0	31.0	62.6	61.6	33.2	47.4	28.4	28.3	4.9
23	43.7	38.2	31.9	63.7	51.0	41.3	30.5	45.5	31.2	54.6	56.8	39.0	47.9	17.8	37.3	1.7
24	47.2	42.2	37.3	69.1	46.6	44.8	43.3	88.6	40.3	78.9	63.1	43.6	53.4	19.5	39.9	3.7
25	47.1	45.1	43.4	87.4	53.0	40.4	24.8	33.5	34.1	60.4	73.0	30.8	51.9	42.2	26.2	4.6
26	61.7	46.9	32.5	33.4	59.8	43.1	22.7	24.0	27.6	28.7	77.2	35.4	56.3	41 8	30.7	4.7
27	55.0	45.9	37.6	52.1	57.7	48.2	40.2	52.4	38.9	52.3	73.6	39.5	56.5	34.1	35.2	4.3
28	40.9	37.1	32.7	73.1	48.9	40.9	32.2	52.7	32.5	62.9	60.1	38.0	49.1	22.1	37.6	0.4
29	41.8	38.1	34.0	74.3	46.9	44.8	43.0	86.7	38.5	80.5	61.1	32.0	46.5	29.1	26.4	5.6
30	44.7	42.5	40.5	85.5	55.8	45.3	35.2	46.2	37.8	65.8	68.5	31.8	50.2	36.7	28.1	3.7
M	41.93	37.12	31.50	69.91	46.79	38.29	27.47	51.99	29.48	60.95	59.52	32.02	45.77	27.51	28.01	4.00

The highest or lowest readings of the month are underlined.

TABLE 1—Continued.

FORT COLLINS, COLO., FOR MONTH OF APRIL, 1897.

Barometer, Corrected for Temperature and Instrumental Error.			PRECIPITATION				Direction of Wind		Total Movement 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	Total Am't Rain and M'l'td Snow	Av'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins.			Miles	C	C	C	Cal	
24.918	24.886	24.902	....	....	....	....	n w	s e	236.0	37.0	19.0	18.0	11.69	....
24.828	24.871	24.849	Nt.	† 3 p.m.	0.36	1¾	e	n w	189.4	29.1	11.5	17.6	10.78	Sn
24.894	24.894	24.894	....	....	....	....	n	w	153.7	42.5	19.6	22.9	15.24	....
24.951	24.965	24.958	....	....	....	....	s e	w	296.2	....	....	....	....	Hv. F
24.978	24.922	24.950	3:30p.m	....	.04	....	n	s w	164.4	....	....	....	....	F
25.019	24.881	24.950	Nt.	Nt.	.11	....	n w	e	210.1	....	....	....	....	....
24.876	25.144	25.010	5 p. m.	Nt.	.34	2	n	n	204.4	40.8	19.8	21.0	13.88	Sn
25.165	25.199	25.182	....	† 5 p.m.	T	....	0	n e	146.2	19.0	11.0	8.0	4.70	....
25.186	25.066	25.126	....	3 p.m.	T	....	0	n w	220.9	25.5	14.2	11.3	6.89	Hv. F
25.041	24.814	24.928	....	....	....	....	s	w	300.3	43.0	26.8	16.2	11.09	F
24.680	24.872	24.776	....	....	....	....	w	n	490.1	....	....	....	....	....
24.984	25.117	25.050	....	....	....	....	n w	n w	378.0	....	....	....	....	....
25.255	25.109	25.182	....	....	....	....	s	s w	136.3	....	....	....	....	F
25.097	25.070	25.084	....	....	....	....	n w	n w	287.4	48.0	30.2	17.8	12.59	F
25.241	25.131	25.186	9:30p.m	Nt.	.16	T	s w	n	115.0	42.5	23.8	18.7	12.63	....
25.153	25.117	25.135	....	....	....	....	0	w	158.9	44.9	28.6	16.3	11.32	....
25.127	24.936	25.031	....	....	....	....	n	w	185.3	47.5	31.7	15.8	11.22	....
24.982	25.084	25.033	....	....	....	....	n w	n e	228.1	....	....	....	....	....
25.189	24.999	25.094	....	....	....	....	s e	n w	236.8	....	....	....	....	....
24.921	24.707	24.814	....	....	....	....	n e	w	262.6	....	....	....	....	....
24.759	24.842	24.801	....	....	....	....	n e	n w	350.9	39.0	24.4	14.6	9.75	....
24.871	24.864	24.867	5:20p.m	....	T	....	e	n w	275.2	35.7	21.7	14.0	9.14	....
25.029	24.994	25.012	....	....	....	....	n w	n w	132.6	39.3	23.0	16.3	10.84	....
25.073	25.126	25.099	5:30p.m	....	.02	....	s e	s w	128.4	....	....	....	....	....
25.275	25.130	25.203	Nt.	Nt.	T	....	s e	s	188.8	....	....	....	....	....
25.142	24.852	24.997	....	....	....	....	n w	s w	184.9	40.2	24.0	16.2	10.86	....
24.704	24.682	24.693	p. m.	p. m.	T	....	0	n	341.6	....	....	....	....	....
25.117	25.076	25.096	....	....	....	....	e	s e	217.7	40.3	23.5	16.8	11.24	....
25.056	25.195	25.126	3 p. m.	....	.36	....	0	n	133.5	....	....	....	....	F
25.236	25.08-	25.162	Nt.	Nt.	T	....	0	s	160.6	44.2	28.2	16.0	11.06	....
25.025	24.988	25.006	....	....	1.39	4.	....	....	223.8	38.74	22.41	16.32	10.88	....

† Used to indicate approximate time.

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE,

	TEMP., DEW POINT AND RELATIVE HUMIDITY								Daily Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Terrestrial Radiation	
	7 A. M.				7 P. M.											
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity							Instrument Reading	Radiation
	F°	F°	F°	Per Cent.	F°	F°	F°	Per Cent.	F°	Per Cent.	F°	F°	F°	F°	F°	F°
1	53.1	46.8	41.5	65.0	57.0	45.8	35.1	44.1	38.3	54.5	76.6	33.1	54.8	43.5	28.5	4.6
2	65.0	50.8	39.2	38.8	57.1	46.4	36.6	46.5	37.9	42.7	76.5	39.8	58.2	36.7	32.0	7.8
3	52.1	46.9	42.6	70.4	57.8	45.3	32.9	38.9	37.7	54.6	73.6	38.6	56.1	35.0	33.0	5.6
4	52.0	46.9	42.7	70.9	63.1	50.0	39.2	41.3	41.0	56.1	71.7	38.8	56.7	35.9	32.9	5.9
5	57.2	50.7	45.9	66.0	59.1	49.5	41.8	52.9	43.8	59.5	73.0	42.5	57.8	30.5	38.0	4.5
6	55.1	49.1	44.5	67.4	59.5	48.9	40.1	48.8	42.3	58.1	75.5	36.0	55.7	39.5	31.0	5.0
7	57.2	51.0	46.5	67.5	58.9	50.8	44.8	59.5	45.7	63.5	75.7	41.8	58.8	33.9	36.2	5.6
8	60.2	47.9	36.9	42.0	55.9	43.7	30.7	28.5	33.8	40.2	70.1	43.0	56.5	27.1	38.7	4.3
9	50.1	42.2	34.1	54.2	57.7	44.8	31.5	37.2	32.8	45.7	70.2	31.6	50.9	38.6	27.7	3.9
10	53.2	43.6	33.9	48.2	46.2	44.2	42.4	87.2	38.1	67.7	63.9	44.7	54.3	19.2	37.7	7.0
11	46.7	44.8	43.2	88.0	52.0	45.2	39.1	61.6	41.2	74.8	62.2	42.7	52.5	19.5	41.6	1.1
12	58.1	48.1	39.6	50.3	59.0	49.2	41.2	51.9	40.4	51.1	71.0	39.5	55.2	31.5	33.1	6.4
13	56.6	48.2	41.3	56.6	54.2	46.8	40.6	59.8	40.9	58.2	71.0	41.2	56.1	29.8	35.9	5.3
14	47.8	42.3	35.9	66.6	58.1	48.9	41.4	53.9	39.2	60.3	75.8	34.3	55.1	41.5	27.8	6.5
15	58.2	49.7	43.1	57.1	65.3	52.0	41.8	42.5	42.4	49.8	77.7	38.6	58.1	39.1	34.0	4.6
16	58.8	51.9	47.1	64.9	59.2	52.8	48.5	67.5	47.8	66.2	79.1	40.6	59.9	38.5	34.8	5.8
17	57.0	51.9	48.3	72.9	70.8	53.9	41.2	34.5	44.8	53.7	82.0	38.7	60.3	43.3	33.1	5.6
18	59.4	53.8	50.2	71.4	63.1	52.6	45.0	51.8	47.6	61.6	80.0	46.0	63.0	34.0	39.9	6.1
19	60.6	53.9	49.5	66.8	58.5	54.7	52.4	80.0	50.9	73.4	76.2	42.8	59.5	33.4	37.0	5.8
20	52.2	52.0	51.9	98.8	60.8	56.2	53.5	76.8	52.7	87.8	71.9	* 51.8	61.9	20.1	50.8	1.0
21	54.7	53.3	52.4	92.1	58.9	55.3	53.1	81.0	52.8	86.5	68.9	51.6	60.2	17.3	48.9	2.7
22	59.3	54.5	51.4	75.2	61.0	58.4	53.7	76.9	52.5	76.1	74.3	51.3	62.8	23.0	44.8	6.5
23	56.0	50.8	47.8	72.0	61.1	54.2	49.8	67.8	48.8	69.9	73.1	46.4	59.8	26.7	39.8	6.6
24	55.6	49.2	50.3	65.7	60.1	55.0	51.8	74.1	51.1	69.9	71.8	48.7	60.2	23.1	41.7	7.0
25	60.0	54.1	50.3	70.2	61.2	54.4	50.1	66.6	50.2	68.4	81.1	45.3	63.2	35.8	38.4	6.9
26	63.2	55.1	50.1	61.9	65.0	52.8	43.9	46.5	47.0	54.2	82.3	43.2	62.8	39.1	37.0	6.2
27	53.5	50.0	47.5	80.2	51.2	47.0	43.6	75.7	45.5	77.9	53.0	52.0	52.5	1.0	48.5	3.5
28	51.8	48.8	46.5	82.6	62.0	54.8	50.2	65.2	48.4	73.9	78.0	38.5	58.2	39.5	33.0	5.5
29	64.0	55.6	50.3	61.0	66.0	55.3	48.3	52.9	49.3	57.0	66.0	47.8	56.9	18.2	40.4	7.4
30	50.2	47.0	44.8	82.2	62.0	53.6	47.9	60.0	46.3	71.1	78.0	44.5	61.3	33.5	37.1	7.4
31	63.0	55.8	49.9	62.2	62.5	57.4	54.5	76.0	52.2	69.1	77.0	47.2	62.1	29.8	43.0	4.2
M	56.19	49.89	45.17	67.39	59.49	50.96	44.09	58.64	44.63	63.02	73.55	42.66	58.11	30.89	37.30	5.36

‖ Minimum temperature of 23 from thermograph.
‖ Maximum temperature of 27 before 7 a, m.
* On the 20th the lowest temperature was after the 7 a. m. observation.—51°

The highest or lowest readings of the month are underlined.

TABLE 1.—Continued.

FORT COLLINS, COLO., FOR MONTH OF MAY, 1897.

Barometer Corrected for Temperature and Instrumental Error			PRECIPITATION				Direction of Wind		Total Movement 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	Total Am't Rain and Mlt'd Snow	Av'g Depth of Snow	7 A. M.	7. P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins			Miles	C	C	C	Cal.	——
25.006	24.842	24.924	....	....	.. ...	....	0	w	133.6	......	......	......	......	......
24.940	25.031	24.985	....	....	......	....	n w	n w	220.9	......	......	......	......	......
25.088	25.034	25.061	....	....	......	....	n w	s	262.5	49.0	32.2	16.8	12.02	F
25.076	25.035	25.056	....	....	......	....	n w	s	173.5	......	......	......	......	......
25.128	25.109	25.118	....	....	......	....	n e	s	150.7	39.1	27.8	11.3	7.65	D
25.096	24.950	25.023	....	....	......	....	0	e	151.5	47.6	32.3	15.3	10.89	......
24.947	24.850	24.899	4:45p.m	....	T	....	0	n	203.8	49.0	32.8	16.2	11.61	D
24.927	25.080	25.003	....	....	......	....	n w	s	281.8	......	......	......	......	......
25.167	24.946	25.057	6:50p.m	....	......	....	n w	s w	170.8	......	......	......	......	......
25.049	25.047	25.048	Nt.	Nt.	T	....	n	n	139.7	......	......	......	......	......
25.062	24.953	25.007	†	1 p.m.	.10	....	s	s w	159.0	......	......	......	......	......
24.986	24.976	24.981	....	....	......	....	n e	s	199.4	42.5	28.2	14.3	9.82	......
25.024	25.073	25.049	....	....	......	....	0	n w	149.4	48.3	31.6	16.7	11.89	......
25.083	25.000	25.041	....	....	......	....	n w	n w	126.0	......	......	......	......	Lt. F
25.076	25.031	25.054	1:30p.m	....	.01	....	0	n e	119.8	36.6	27.0	9.6	6.42	D
25.065	25.080	25.072	†	1:30p.m	T	....	s	s w	155.6	......	......	......	......	D
25.087	24.983	25.035	7:10p.m	....	T	....	n	n w	131.6	52.6	37.0	15.6	11.53	Hv.D
25.063	25.072	25.068	4 p.m.	....	.03	....	n w	n	156.9	......	......	......	......	D
25.133	25.111	25.122	4 p.m.	5:40p.m	.19	....	s e	n w	183.6	49.6	34.5	15.1	10.92	D
25.171	25.049	25.110	Nt.	....	1.28	....	n w	s	128.7	47.0	29.1	17.9	12.56	......
24.981	24.839	24.910	† 8p.m.	10:40am	.03	....	s w	n e	......	26.7	20.9	5.8	3.65	......
24.983	24.914	24.948	3:30p.m	5:30p.m	.03	....	s w	s	*295.3	46.4	30.8	15.6	10.99	......
25.142	25.063	25.103	†	....	......	....	s w	s w	126.2	......	......	......	......	......
25.113	24.928	25.020	† 3:45p.m	5 p.m.	.01	....	n e	n w	172.8	49.1	32.2	16.9	12.09	......
24.948	24.913	24.931	Nt.	Nt.	T	....	n w	n	126.5	......	......	......	......	......
24.963	24.929	24.946	8 p. m	....	.11	....	e	n w	209.8	54.3	38.4	15.9	11.89	D
25.303	25.397	25.350	....	....	.08	....	n e	n w	112.4	12.2	9.0	3.2	1.82	......
25.334	25.157	25.245	1:30p.m	5 p.m.	.02	....	s e	s w	138.0	44.1	28.4	15.7	10.86	......
25.151	25.107	25.129	....	....	......	....	n	s	108.3	32.0	26.9	5.1	3.35	......
25.154	24.928	25.041	† 3 p. m	5 p.m.	.04	....	e	s w	148.3	32.0	26.9	5.1	3.35	......
24.787	24.728	24.758	† 9:30a.m	4 p.m.	.13	....	s w	w	132.0	......	......	......	......	......
25.066	25.005	25.035	....	....	2.06	....	....	.....	160.3	42.12	29.22	12.89	9.15	......

† Used to indicate approximate time.
* Record is for two days.

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE,

	TEMP., DEW POINT AND RELATIVE HUMIDITY.														Terrestrial Radiation	
	7 A. M.				7 P. M.				Daily Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range		
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity							Instrument Reading.	Radiation
	F °	F °	F °	Per Cent	F °	F °	F °	Per Cent	F	Per Cent	F °	F °	F °	F °	F °	F °
1	61.2	58.0	56.2	83.7	59.2	49.5	41.2	52.5	48.7	68.1	......	51.6	......	......	46.0	5.6
2	50.8	47.2	44.4	78.9	45.5	44.0	42.6	90.2	43.5	84.5	......	45.2	......	......	41.1	4.1
3	47.0	44.0	41.3	81.2	44.2	44.1	44.0	99.3	42.6	90.3	......	35.3	......	......	31.4	3.9
4	50.1	48.2	46.9	88.8	50.5	49.3	48.4	92.7	47.7	90.7	62.6	41.1	51.8	21.5	36.4	4.7
5	51.0	48.5	46.6	85.3	52.0	46.1	41.0	66.5	43.8	75.9	60.8	46.1	53.5	14.7	43.9	2.2
6	51.2	47.2	44.0	76 8	55.8	51.3	48.0	75.6	46.0	76.2	66.5	36.1	51.3	30.4	32.2	3.9
7	55.5	51.5	48.7	78.1	56.8	55.2	54.2	91.2	51.4	84.7	68.5	42.9	55.7	25.6	32.3	10.6
8	55.3	53.2	51.9	88.2	67.7	53.2	42.4	40.0	47.2	64.1	77.8	42.5	60.1	35.3	38.4	4.1
9	61.5	55.2	51.2	69.0	64.2	53.0	45.0	49.8	48.1	59.4	74.4	56.4	65.4	18.0	49.8	6.6
10	62.4	56.3	52 6	70.3	59.0	54.5	51.6	76.7	52.1	73.5	73.8	46.6	60.2	27.2	41.7	4.9
11	57.5	55.2	53.8	87.5	65.5	59.8	56.8	73.3	55.3	80.4	73.3	51.8	62.6	21.5	49.8	2.0
12	63.2	58.2	55.4	75.7	68.2	59.8	55.2	63.2	55.3	69.4	84.0	46.2	65.1	37.8	43.0	3.2
13	63.2	58.0	55.1	74.7	64.5	57.8	53.9	68.5	54.5	71.6	79.5	50.8	65.1	28.7	46.0	4.8
14	65.5	58.0	53.7	65.5	69.2	61.4	57.5	66.0	55.6	65.8	81.0	50.5	65.8	30.5	45.8	4.7
15	67.4	59.2	54.7	63.6	72.4	63.0	58.4	62.2	56.5	62.9	88.0	52.8	70.4	35.2	47.6	5.2
16	67.0	56.8	50.5	55.5	66.3	46.0	22.4	18.9	36.5	37.2	76.7	47.5	62.1	29.2	41.0	6.5
17	59.2	47.0	35.8	41.6	66.0	49.0	32.2	29.7	34.0	35.6	77.8	46.7	62.2	31.1	39.0	7.7
18	56.5	49 0	43.1	60.8	66.8	56.0	49.1	53.0	46.1	56.9	75.5	39.0	57.3	36.5	35.0	4.0
19	63.5	59.0	56.7	78.4	71.0	61.5	56.6	60.3	56.6	69.4	85.1	48.5	66.8	36.6	44.2	4.3
20	68.0	62.0	59.0	72 9	71.5	63.5	59.6	66.2	59.3	69.5	85.0	54.3	69.6	30.7	49.4	4.9
21	67.0	59.0	54.6	64.2	69.3	60.5	55.8	62.1	55.2	63.2	87.0	56.2	71.6	30.8	49.1	7.1
22	60.0	57.5	56.1	86.9	67.7	57.5	50.3	54.0	53.2	70.4	90.1	46.0	68.1	44.1	43.3	2.7
23	68.5	57.0	49.8	51.5	70.0	59.1	53.1	99.4	51.5	75.5	83.7	45.8	64.7	37.9	42.2	3.6
24	62.8	57.8	55.0	75.5	67.0	61.0	57.9	72.6	56.4	74.0	69.4	56.8	63.1	12.6	50.4	6.4
25	53.3	53.2	53.0	99.4	59.1	58.0	57.4	94.1	55.2	96.8	68.8	52.7	60.8	16.1	52.4	.3
26	60.2	57.8	56.5	87.4	69.0	57.0	49.5	50.0	53.0	68.7	76.5	55.0	65.7	21.5	50.8	4.2
27	63.0	58.0	55.2	75.6	66.0	57.2	52.0	60.5	53.6	68.0	78.1	48.2	63.2	29.9	44.0	4.2
28	67.2	57.2	51.1	56.4	69.5	55.3	45.6	42.4	48.4	49.4	84.8	53.8	69.3	31.0	48.0	5.8
29	68.5	58.2	52.2	56.0	70.5	59.0	52.3	52.8	52.2	54.4	80.5	51.8	66.1	28.7	46.4	5.4
30	63.0	59.0	56.9	80.3	73.2	59.8	52.2	47.7	51.6	64.0	85.4	49.1	67.3	36.3	44.5	4.6
M	60.35	54.88	51.47	73.66	63.92	55.41	49.54	64.38	50.47	69.02	77.58	48.24	63.14	28.87	43.50	4.74

The highest or lowest readings of the month are underlined.

TABLE 1—Continued.

FORT COLLINS, COLO., FOR MONTH OF JUNE, 1897.

Barometer, Corrected for Temperature and Instrumental Error.			PRECIPITATION				Direction of Wind		Total Movement 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Beginning	Total Am't Rain and M'ltd Snow	Av'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins	Ins.			Ins.	Ins.			Miles	C	C	C	Cal	
24.748	24.765	24.756	Showers in the afternoon.		.18	...	n w	w	170.5	......	.....	......	.....	......
24.882	24.975	14.929			.20	....	n w	w	131.3	31.9	25.6	6.3	4.11	......
25.138	25.101	25.119			.27	....	s w	s w	122.0	44.0	25.8	18.2	12.46	Lt F
25.168	25.120	25.144			.16	....	s w	n	148.6	44.6	27.5	17.1	11.81	D
25.090	25.098	25.094			.04	...	n w	s w	151.8	33.2	22.0	11.2	7.25	......
25.151	25.087	25.119			.04	...	0	s w	119.3	......	......	....	....	D
25.055	25.062	25.059			.31	...	e	n w	84.8	33.0	24.3	8.7	5.67	......
24.941	24.866	24.903			T	....	0	w	221.2	......	......	......	......	D
24.888	24.858	24.873	1:30p.m	2:20p.m	.01	....	e	e	123.7	......	......	......	.....	......
24.946	25.060	25.003	1:30p.m	3:00p.m	.01	....	e	w	133.9	51.8	34.6	17.2	12.55	......
25.113	25.021	25.067	7:30p.m	Nt.	.08	...	n e	s w	126.9	48.0	30.7	17.3	12.26	......
25.014	24.947	24.981	....	....	......	....	e	n w	104.6	50.7	31.3	19.4	13.92	D
24.933	24.882	24.907	....	....	....	....	0	e	93.9	......	.....	......	.....	.....
24.893	24.816	24.855	....	....	....	....	e	n e	148.5	52.4	37.2	15.2	11.23	......
24.792	24.650	24.721	....	....	....	...	0	n w	155.7	......	......	......	......	D
24.668	24.771	24.719	....	....	......	...	w	w	330.1	47.4	32.2	15.2	10.81	......
24.919	24.809	24.864	....	....	......	...	s w	n w	201.9	45.9	30.7	15.2	10.68	... ..
25.020	24.937	24.979	....	....	......	....	n e	n e	136.9	.....	......	.....	.....	D
25.067	25.068	25.067	....	....	......	...	n e	n w	105.3	49.4	35.0	14.4	10.43	D
25.229	25.114	25.172	....	....	......	....	e	n e	147.7	......	......	......	......	D
25.097	24.980	25.038	1:30p.m	2:35p.m	.11	...	s w	n w	91.3	43.8	34.7	9.1	6.44	Lt D
24.930	24.856	24.890	....	....	......	...	0	n e	135.2	......	......	.....	... ..	D
24.903	24.863	24.883	....	....	.....	....	e	e	142.2	47.8	35.4	12.4	8.93	......
25.007	25.066	25.037	8:30p.m	....	......	....	e	s e	169.3	28.6	21.9	6.7	4.26	D
25.124	24.926	25.025	....	7:00p.m	.28	...	s e	s e	123.2	......	......	...	....	......
24.984	24.801	24.892	....	2:00p.m	T	...	n w	s w	155.5	48.2	34.0	14.2	10.20	D
24.792	24.782	24.787	......	....	......	....	e	n w	112.1	......	......	.....	.....	D
24.887	24.902	24.895	Nt.	Nt.	T	....	n e	e	161.1	51.7	36.9	14.8	10.90	......
25.115	25.047	25.081	....	....		..	s w	s w	127.1	......	......	......	....	D
25.126	25.024	25.075	....	....		....	s w	s w	126.9	51.3	37.1	14.2	10.44	D
24.987	24.942	24.964	....	....	1.69	....	......	......	143.4	44.65	30.94	13.71	9.69	......

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE,

	TEMP., DEW POINT AND RELATIVE HUMIDITY								Daily Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Terrestrial Radiation	
	7 A. M.				7 P. M.											
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity							Instrument Reading	Radiation
	F°	F°	F°	Per Cent.	F°	F°	F°	Per Cent.	F°	Per Cent	F°	F°	F°	F°	F°	F°
1	63.0	58.2	55.5	76.5	72.0	59.5	52.3	50.1	53.9	63.3	88.8	50.4	69.6	38.4	44.5	5.9
2	69.7	60.0	54.7	58.9	57.5	54.0	51.8	81.2	53.2	70.0	86.5	51.0	68.7	35.5	47.0	4.0
3	53.3	49.0	45.7	75.8	59.0	47.0	36.0	42.3	40.9	59.1	72.6	54.0	63.3	18.6	50.9	3.1
4	59.5	50.5	43.6	55.7	64.0	51.0	40.7	42.5	42.1	49.1	76.3	41.4	58.9	34.9	35.5	5.9
5	61.0	51.8	45.1	55.9	70.1	65.0	62.7	77.4	53.9	66.6	89.9	42.9	66.4	47.0	36.3	6.6
6	69.0	58.8	52.9	56.6	72.0	63.0	58.6	62.6	55.8	59.6	90.6	51.4	71.0	39.2	44.2	7.2
7	66.2	54.0	45.5	47.4	75.0	64.0	58.7	57.0	52.1	52.2	94.8	51.0	72.9	43.8	43.8	7.2
8	73.0	63.8	59.4	62.7	61.5	61.0	60.7	97.4	60.0	80.1	89.3	55.4	72.3	33.9	49.0	6.4
9	59.3	59.2	59.2	99.4	58.5	56.0	54.5	86.7	56.9	93.0	66.9	57.9	62.4	9.0	56.4	1.5
10	56.0	54.0	52.9	88.9	63.5	58.0	54.9	73.5	53.9	81.2	74.5	47.4	61.0	27.1	43.2	4.2
11	63.5	57.5	54.0	71.2	72.0	60.0	53.3	52.0	53.6	61.6	82.0	48.0	65.0	34.0	43.3	4.7
12	64.6	59.6	57.0	76.1	72.0	62.8	58.3	62.3	57.7	69.2	84.1	51.7	67.9	32.4	46.5	5.2
13	66.2	60.6	57.7	74.0	72.4	61.8	56.4	57.1	57.0	65.6	93.0	50.0	71.5	43.0	44.8	5.2
14	63.0	57.2	53.9	71.9	61.0	56.5	53.8	77.3	53.9	74.6	77.0	64.3	70.6	12.7	45.2	19.1
15	61.5	57.5	55.2	79.9	70.0	59.2	53.1	55.1	54.1	67.5	83.8	45.4	64.6	38.4	41.1	4.3
16	69.0	59.8	54.7	60.4	69.0	57.0	49.5	50.0	52.1	55.2	82.3	50.5	66.4	31.8	46.1	4.4
17	63.0	56.2	52.1	67.4	66.0	59.3	55.7	69.2	53.9	68.3	85.2	49.8	67.5	35.4	44.9	4.9
18	59.6	55.2	52.5	77.4	58.3	56.0	54.6	87.7	53.6	82.5	74.6	52.5	63.6	22.1	48.2	4.3
19	52.3	49.7	47.8	85.0	53.7	51.2	48.8	85.8	48.3	85.4	62.1	48.1	55.1	14.0	46.6	1.5
20	54.5	51.5	49.4	83.2	64.4	57.4	53.3	67.2	51.3	75.2	76.9	38.9	57.9	38.0	36.0	2.9
21	62.0	56.3	52.8	72.0	66.0	61.0	58.5	76.6	57.7	74.3	85.0	44.8	64.9	40.2	40.2	4.6
22	61.2	56.2	53.2	75.0	68.0	59.3	54.5	61.9	53.8	68.5	84.1	52.6	68.3	31.5	45.9	6.7
23	64.0	59.2	56.6	76.9	60.0	58.3	57.3	91.0	57.0	83.9	83.0	51.3	67.2	31.7	45.7	5.6
24	58.2	56.6	55.7	91.3	62.0	57.8	55.5	79.1	55.6	85.2	76.0	54.4	65.2	21.6	51.0	3.4
25	63.0	59.3	57.3	81.7	72.2	57.2	47.6	41.4	52.4	61.6	87.0	48.1	67.5	38.9	44.0	4.1
26	64.3	58.1	54.6	70.6	72.1	55.2	43.2	35.5	48.9	53.0	87.1	48.4	67.8	38.7	41.8	6.6
27	62.3	56.7	53.4	72.6	71.8	55.8	44.8	38.1	49.1	55.4	88.6	48.4	68.5	40.2	42.8	5.6
28	64.5	59.0	56.0	73.8	69.5	61.0	56.5	63.3	56.3	68.5	94.0	46.9	70.4	47.1	40.1	6.8
29	65.8	59.5	56.0	70.8	71.0	60.3	54.5	56.0	55.2	63.4	90.9	49.3	70.1	41.6	41.9	7.4
30	66.5	60.0	56.5	70.2	76.8	60.0	50.1	39.2	53.3	54.7	85.0	57.9	71.5	27.1	49.0	8.9
31	71.0	62.3	58.0	63.3	71.5	61.2	55.8	57.7	56.9	60.5	89.0	57.8	73.4	31.2	50.9	6.9
M	62.90	57.01	53.51	72.34	66.86	58.28	53.10	63.68	53.30	68.01	83.25	50.38	66.82	32.87	44.74	5.65

The highest or lowest readings of the month are underlined.

TABLE 1.—Continued.

FORT COLLINS, COLO., FOR MONTH OF JULY, 1897,

Barometer, Corrected for Temperature and Instrumental Error.			PRECIPITATION.				Direction of Wind		Total Movement for 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	Total Am't Rain and M'ltd Snow	Ag'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins.			Miles	C	C	C	Cal.	
25.019	24.878	24.948	......	......	......	....	0	s w	118.9	43.5	34.6	8.9	6.29	D
24.726	24.677	24.702	7 p. m.	7.20p.m	.05	....	n e	n w	288.6	......	......	......	......	D
24.724	24.836	24.780	......	......	......	....	s w	n e	192.3	......	......	...	......	......
25.000	24.981	24.990	......	......	......	....	s w	n e	140.6	......	......	......	......	D
25.024	24.832	24.928	......	......	......	....	e	n w	158.5	48.7	37.0	11.7	8.51	......
24.942	24.742	24.842	......	......	......	....	n e	n w	149.1	......	......	......	......	D
24.964	24.875	24.920	......	......	......	....	s w	n w	140.8	56.8	42.7	14.1	10.82	D
24.991	25.135	25.063	1.30p.m	......	.28	....	s w	n	133.4	41.3	34.0	7.3	5.10	......
25.167	25.184	25.175	......	12.4p.m	.90	....	0	n e	85.9	......	......	......	......	......
25.285	25.249	25.267	Nt.	Nt.	.13	....	e	s w	113.3	45.0	30.2	14.8	10.34	......
25.290	25.233	25.262	......	......	......	....	0	s w	128.1	......	......	......	......	D
25.266	25.114	25.190	......	......	......	....	0	n e	113.2	50.0	35.4	14.6	10.61	D
25.063	24.951	25.007	......	......	......	....	s	s w	143.5	......	......	......	......	D
25.051	25.111	25.081	7 a. m.	10 a. m	.19	....	e	e	143.5	......	......	......	......	......
25.112	25.060	25.086	......	......	......	...	s w	s e	112.1	51.0	36.5	14.5	10.62	D
25.086	24.988	25.037	......	......	......	....	0	s w	126.2	40.7	31.4	9.3	12.96	D
24.988	24.931	24.959	Nt.	Nt.	......	....	0	s w	139.9	52.1	36.8	15.3	11.27	D
25.093	25.05?	25.076	4 p. m.	Nt.	.21	....	n w	n w	182.4	......	......	......	......	......
25.229	25.227	25.228	2 p. m.	4 00p.m	.68	.. .	s w	s e	130.5	44.7	27.4	17.3	11.95	......
25.188	25.074	25.131	......	......	......	....	s w	s w	149.6	......	......	......	......	Hv D
25.09	25.010	25.050	......	......	......	....	0	n w	114.1	51.7	37.7	14.0	10.34	D
25.024	24.936	24.980	......	......	......	....	s e	n e	96.7	47.0	34.8	12.2	8.74	D
25.029	25.130	25.080	6.30p.m	Nt.	.04	....	n e	w	160.8	57.7	40.6	17.1	13.12	D
25.065	25.037	25.051	2.30p.m	3 p. m.	.17	....	e	s w	121.0	50.1	34.2	15.9	11.51	......
25.154	25.204	25.179	......	......	......	....	0	e	115.7	......	......	......	......	D
25.249	25.262	25.255	2.30p.m	2.45p.m	T	....	e	w	136.2	44.9	35.9	9.0	6.42	D
25.233	25.140	25.187	......	......	......	....	n e	w	113.3	......	......	......	......	D
25.153	25.072	25.112	......	......	......	....	n e	n w	100.1	58.6	43.6	15.0	11·63	D
25.090	25.060	25.075	......	......	......	....	s w	e	151.6	......	......	......	......	D
25.171	25.090	25.131	......	......	......	....	e	s w	160.0	......	......	......	......	D
25.145	25.123	25.134	Nt.	Nt.	T	....	s w	s w	114.3	54.0	39.4	14.6	10.94	......
25.084	25.039	25.061	......	......	2.65	....	......	......	137.9	49.28	36.01	13.27	10.07	......

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE,

	Temp. Dew Point and Relative Humidity. 7 A. M.				Temp. Dew Point and Relative Humidity. 7 P. M.										Terrestrial Radiation	
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Daily Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Instrument Reading.	Radiation
	F°	F	F°	Per Cent.	F°	F°	F°	Per Cent.	F°	Per Cent.	F°	F°	F°	F°	F°	F°
1	66.0	61.3	59.0	78.0	70.0	58.1	51.0	51.0	55.0	64.5	86.1	53.6	69.8	32.5	48.2	5.4
2	65.5	59.8	56.8	73.3	65.0	61.3	59.4	82.2	58.1	77.7	82.1	55.9	69.0	26.2	48.3	7.6
3	61.0	58.3	56.8	86.2	60.0	58.8	58.2	93.7	57.5	90.0	74.2	56.8	65.5	17.4	52.5	4.3
4	58.8	58.2	57.9	96.7	61.2	61.2	61.2	100.0	59.5	98.3	68.7	57.4	63.1	11.3	52.3	5.1
5	61.0	59.5	58.7	92.2	69.0	65.3	63.6	83.2	61.2	87.7	82.4	58.8	70.6	23.6	58.1	0.7
6	65.1	61.1	59.1	80.8	62.0	61.2	60.8	95.8	59.9	88.3	86.6	54.5	70.5	32.1	49.7	4.8
7	58.5	57.0	56.1	91.9	66.2	61.1	58.6	76.2	57.4	84.1	85.5	52.8	69.2	32.7	46 3	6.5
8	64.6	61.5	60.0	85.0	67.0	61.1	58.1	75.0	59.0	79.0	80.3	54.2	67.2	26.1	48.0	6.2
9	59.5	59.5	59.5	100.0	66.5	61.5	59.0	76.8	59.3	88.4	81.2	55.7	68.5	25.5	49.5	6.2
10	62.3	59.3	57.7	85.0	67.3	63.2	61.3	81.0	59.5	83.0	77.0	53.7	65.8	23.3	49.4	4.3
11	60.1	60.1	60.1	100 0	67.0	59.2	54.9	65.0	57.5	82.5	85.8	55.4	70.6	30.4	49.3	6.1
12	62.8	58.0	55 3	76.4	68.1	58.1	52.2	56.9	53.7	66.6	89.2	49.6	69.4	39.6	44.0	5.6
13	69.7	58.1	51.2	51.9	68.1	59.0	53.9	60.4	52.6	56.2	87.0	54.5	70.8	32.5	49.5	5.0
14	60.9	56.3	53.6	76.9	68.7	60.7	56.5	65.0	55.0	10.9	78.9	54.6	66.7	24.3	49.7	4.9
15	59.8	53.1	48.6	66.4	61.0	56.2	53.3	75.9	51.0	71.2	75.5	56.9	66.2	18.6	52.1	4.8
16	60.8	56.9	54.6	80.2	67.1	59.0	54.5	63 8	54.6	72.0	84.7	48.8	66.8	35.9	44.7	4.1
17	61.1	56.1	53.1	74.9	62.1	56.2	52.6	71.4	52.9	73.1	80.8	47.8	64.3	33.0	45.4	2.4
18	56.8	53.1	50.7	89.0	60.0	56.8	55.0	83.5	52.8	81.8	77.1	47.9	62.5	29.2	43.1	4.8
19	58.0	53.2	50.0	74.8	59.9	54.4	50.9	72.2	50.5	73.5	79.1	43.2	61.1	35.9	40.1	3.1
20	58.9	53.9	50.7	74.2	60.9	53.7	49.0	64.7	49.8	69.4	83.0	42.7	62.9	40.3	39.9	2.8
21	56.1	53.1	51.1	88.6	62.1	54.0	48.6	61.3	49.9	72.5	77.0	45.0	61.0	32.0	40.9	4.1
22	58.9	54.9	52.4	79.2	63.3	55.9	51.3	64.9	51.8	72.0	82.6	46·0	64.3	36.6	41.7	4.3
23	64.8	53.9	46.3	51.4	63.8	55.8	50.9	62.7	48.6	57.1	80.9	51.1	66.0	29.8	44.2	6.9
24	57·8	53.2	50.2	75.7	66.3	55.0	47.5	50.9	48.9	63.3	91.1	45.1	68.1	46.0	41.0	4.1
25	58.9	54.1	51.0	75.1	73.3	53.2	36.8	26.7	43.9	50.9	93.5	45.0	69.2	48.5	40 2	4.8
26	63.0	54.9	49.7	61.8	61.8	54.3	49.2	63.4	49.4	62.6	76.8	59.7	68.3	17.1	51.7	8.0
27	60.0	55 3	52.4	76.0	66.7	57.4	51.8	58.8	52.1	67.4	83.1	48.3	65.7	34.8	44.0	4.3
28	63.2	57.9	54.9	74.3	70.6	56.1	46.4	42.2	50.7	58.2	83.6	50.8	67.2	32.8	45.9	4.9
29	53.8	53.5	53.2	98.3	63.9	55.7	50.6	61.9	51.9	80.1	78.7	54.8	66.7	23.9	50.8	4.0
30	59.1	55.1	52.6	79.2	70.1	58.0	50.7	50.3	51 6	64.8	87.7	46.8	67.3	40.9	43.7	3.1
31	60.1	53.7	49.5	67.9	65.2	51.7	41.2	41.7	45.4	54.8	91.3	46.0	68.6	45.3	43.0	3.0
M	60.87	56.58	53.96	78.95	65.30	57.84	53.19	66.98	53.58	72.96	32.31	51.40	66.85	30.91	46.68	4.72

The highest or lowest readings of the month are underlined.

TABLE 1.—Continued.

FORT COLLINS, COLO., FOR MONTH OF AUGUST, 1897.

Barometer Corrected for Temperature and Instrumental Error			PRECIPITATION				Direction of Wind		Total Movement 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	T. tal Am't Rain and Mlt'd Snow	Av'g Depth of Snow	7 A. M.	7. P. M.		Black Bulb	Bright Bulb	Diffe e ce	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins.			Miles	C	C	C	Cal.	
25.111	25.030	25.070	....	....	......	....	0	s w	167.6	......	......	......	......	D
25.083	25.070	25.077	Nt.	Nt.	......	....	e	e	131.6	51.2	37.1	14.1	10.37	D
25.162	25.173	25.167	Showers in	Afternoon.	.24	....	s w	n e	88.6	......	......	......	......	......
25.276	26.295	25.286			.06	....	n	s w	102.9	23.5	20.2	3.3	1.98	......
25.286	25.222	2 .254			.07	....	e	n	99.1	48.2	34.2	14.0	10.56	......
25.241	25.180	25.210			.06	....	s e	s w	109.6	52.4	37.6	14.8	10.95	D.
25.149	25.121	25.135			.24	....	n e	0	101.7	......	......	......	......	D
25.121	25.058 *	25.090			......	...	n e	n e	111.5	......	......	......	......	D
25.128	25.088	25.108	1:50p.m	2:10p.m	.13	....	s w	n w	105.1	49.4	34.9	14.5	10.50	D
25.201	25.155	25.178	Nt.	Nt.	.11	....	0	n e	74.1	......	......	......	......	......
25.162	25.071	25.116	....	....	......	....	0	n e	96 4	51.7	37.5	14.2	10.55	D
25.053	24.964	25.009	4:40p.m	4:55p.m	.03	...	0	n w	128.4	53.0	38.4	14.6	10.86	D
25.011	25.045	25.028	5:10p.m	....	T	....	n w	n w	134.1	......	......	......	......	D
25.136	25.115	25.125	....	....	......	....	n e	s w	108.8	48.6	33.8	14.8	10.63	D
25.234	25.163	25.199	....	....	......	....	n	n w	82.4	......	......	......	......	D
25.139	25.060	25.099	....	....	......	....	n	n	89.4	50.7	36.0	14.7	10.74	Hv D
25.132	25.207	25.170	shrs pm	....	.63	....	n w	s w	152.6	......	......	......	......	Hv D
25.283	25.249	25.266	3:50p.m	4 p. m.	.04	....	n w	e	102.0	47.1	32.0	15.1	10.71	Hv D
25.301	25.212	25.256	....	....	......	....	n	n e	97.0	49.7	34.5	15.2	11.00	Hv D
25.218	25.140	25.179	....	....	......	....	n w	0	106.7	......	......	......	......	Hv D
25.231	25.153	25.192	....	....	......	...	0	e	120.8	49.0	33.6	15.4	11.07	D
25.194	25.099	25.147	....	....	......	...	n w	w	132.7	......	......	......	......	D
25.200	25.170	25.185	....	....	......	...	n w	n w	118.4	51.0	35.8	15.2	11.11	......
25.143	25.002	25.072	....	....	......	...	0	n w	98.0	......	......	......	......	D
25.005	24.890	24.948	....	....	......	...	0	w	165.5	58.1	42.9	14.2	11.65	D
25.150	25.080	25.115	4 p. m.	....	T	....	s e	n	128.9	51.0	34.2	16.8	12.20	......
2 .047	24.981	25.014	....	....	......	....	s e	w	128.9	33.7	28.5	5.2	3.46	D
25.015	25.022	25.018	3 p. m.	....	.02	....	0	n w	148.7	34.7	28.0	6.7	4.46	D
25.258	25.141	25.200	6:50a.m	7:25a m	.11	....	n w	s	168.2	......	......	......	......	R
25.092	24.936	25.014	....	....	......	....	0	s w	105.7	53.0	38.7	14.3	10.65	D
24.931	24.866	24.898	....	....	......	....	s w	n	125.0	......	......	......	......	D
25.151	25.095	25.123	....	....	1.74	....	......	......	117.2	47.56	34.33	13.23	9.64	......

* The reading in original seems by the aneroid to be .5 inches in error and this is therefore corrected by that amount.

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE,

	TEMP., DEW POINT AND RELATIVE HUMIDITY.								Dail Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Terrestrial Radiation	
	7 A. M.				7 P. M.											
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity							Instrument Reading	Radiation
	F°	F	F°	Per Cent	F°	F°	F°	Per Cent	F°	Per Cent	F°	F	F°	F°	F°	F°
1	56.7	51.1	47.4	71.2	67.3	56.9	50.5	54.9	48.9	63.0	87.0	53.9	70.4	33 1	49.0	4.9
2	59.3	54.9	52.1	77.3	65.5	56.3	50.6	58.6	51.4	68.0	87.2	49.0	68.1	38.2	44.5	4.5
3	61.0	56.6	54.0	77.8	64.0	54.2	47.7	55.3	50.8	66.5	88.0	53.3	70.7	34.7	49.0	4.3
4	65.0	52.8	43.9	46.5	70 8	55.0	43.9	38.0	43.9	42.3	89.0	46.2	67.6	42.8	42.5	3.7
5	61.0	53.1	47.7	61.6	76.2	54.2	36.4	23.9	42.1	42.7	87.2	50.0	68 6	37.2	44.2	5.8
6	64.4	58.2	54.7	70.7	64.1	56.0	51.0	62.4	52.8	66.6	89.0	49.0	69.0	40.0	46.0	3.0
7	64.6	54.6	48.0	54.8	71.8	60.5	54.3	51.3	51.2	54.5	89.8	51 3	70.5	38.5	47.0	4.3
8	62.0	56.0	52.3	70.6	69.2	57.8	50.9	52.3	51.6	61.5	86.2	52.0	69.1	34.2	47.2	4.8
9	54.9	49.5	45.4	70.5	55 2	51.0	48.0	77.0	46.7	73.7	62 0	54.0	58.0	8.0	53.0	1.0
10	50.6	50.0	49.6	96.4	58.0	54.1	51.6	79.4	50.6	87.9	68.7	49.0	58 9	19.7	48.5	0.5
11	59.8	57.8	56.8	89.5	66.0	59.8	56.5	71.3	56.6	80.4	78.0	48.2	63.1	29.8	45.0	3.2
12	60.3	57.0	55.2	83.0	61.1	59.8	59.1	93.3	57.2	88.2	82.5	49.0	65.7	33.5	46.0	3.0
13	60.3	57.8	56.4	87.0	61.9	60.1	59.2	90.7	57.8	88.8	82.8	51 3	67.1	31.5	48.0	3.3
14	59.0	57.2	56.2	90.4	60.0	55.8	53.3	78.5	54.7	84.5	77.8	57.5	67.6	20.3	54 5	3.0
15	55.9	54.2	53.1	90.5	61.7	52.0	44.9	54.2	49.0	72.3	77.8	50 6	64.2	27.2	48.0	2.6
16	42.2	39.0	35.5	78.0	43.4	41.0	38.6	83 8	37 1	80.9	45.0	40.2	42.6	4.8	38.5	1.7
17	41.3	40.0	38.7	90.8	56.8	48 0	40.7	54.8	39.7	72.8	74.2	33.8	54.0	40.4	30.3	3.5
18	53.8	49.0	45.4	73.2	55.5	47.4	40.6	57.3	43.0	65 3	77.5	38.0	57.8	39.5	33.8	4.2
19	49.3	46.2	43.6	81.3	55 0	49.0	44.4	67.4	44.0	74.3	77.0	38.0	57.5	39.0	34.0	4.0
20	51.2	47.3	44.2	77.3	60.1	53.8	49.7	68.4	46.9	72.9	82.0	44.0	63.0	38.0	39.0	5.0
21	56.8	52.1	48.9	74.9	60.5	49.0	39.4	45.7	44.2	60 3	82.5	46.0	64 2	36.5	39 2	6 8
22	56.2	51.3	47.8	73.6	60.4	52.8	47.6	62.6	47.7	68.1	81.8	47.0	64.4	34.8	41.5	5.5
23	53.5	48.0	43.6	69.4	68.0	52.0	39.2	34.9	41 4	52 1	82.0	40.2	61.1	41.8	......	..
24	60.2	53.0	48.1	64.3	55.0	50.	47.4	75.8	47.7	70.1	75.5	56.0	65 8	19.5	49.0	7.0
25	53.4	50.0	47.5	80.7	57.8	52.2	48 3	70.7	47.9	75.7	79.0	45.0	62 0	34.0	39.0	6.0
26	58.0	52.5	48.7	71.3	61.3	51.8	44.8	54.8	46.8	63.0	82.8	48.6	65.7	34.2	43 6	5.0
27	54.2	49.4	45.8	73.4	64.0	54.2	47.7	55.3	46.7	64.4	82.0	45.0	63.5	37.0	40.0	5 0
28	48.8	45.0	41.8	77.1	66.8	55.8	48.7	52.4	45.3	64 7	84.5	41.5	63.0	43.0	36.5	5.0
29	53.8	49.6	46.5	76.5	60.3	52.7	47.5	60.3	47.0	64.4	80.2	48.0	64.1	32 2	42.0	6.0
30	54.5	51.9	50.1	85.4	56.2	51.8	48.7	76.3	49.4	80.9	82.1	46.0	64.0	36.1	41.4	4.6
M	56.07	51.50	48.30	76.17	61.80	53.52	47.71	62.15	48.00	69.16	80.04	47.39	63.71	32.65	43.11	4.18

The highest or lowest readings of the month are underlined.

TABLE 1.—Continued.

FORT COLLINS, COLO., FOR MONTH OF SEPTEMBER, 1897.

Barometer, Corrected for Temperature and Instrumental Error.			PRECIPITATION				Direction of Wind		Total Movement 24 Hours following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	Totol Am't Rain and M'lt'd Snow	Av'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins.			Miles	C	C	C	Cal	
24.993	24 945	24.969	....	....	....	....	0	n	95.0	57.0	40.4	16.6	12 63	....
24.966	24.829	24.897	....	....	....	....	....	n w	100.3	49.5	36.6	12.9	9.40	....
24.976	24.973	24.975	....	....	....	....	0	0	115.5	....	....	....	....	D
25.129	25.055	25.092	....	....	....	....	0	w	154 9	....	....	....	....	D
25.143	25.048	25.095	....	....	....	....	n w	w	129.6	....	....	....	....	Lt D
25.044	24.981	25.013	....	....	....	....	e [o]	0	106.6	....	....	....	....	D
25.044	24 899	24.971	....	....	....	....	....	0	141.6	....	....	....	....	D
24.873	24 827	24.850	....	....	....	....	s e	s e	171 0	....	....	....	....	Lt D
25.135	25.128	25.132	....	....	....	....	....	s w	123.8	....	....	....	....	....
25.173	25.125	25.149	7:30 a m	8:30 a.m	.01	....	0	0	101.8	....	....	....	....	....
25.2?1	25.082	25.141	7:25p.m	....	....	....	s e	w	106.0	....	....	....	....	....
25.101	25.051	25.076	4:45p.m	6:00p.m	.08	....	n w	0	99.2	....	....	....	....	Lt D
25.038	24.972	25.005	6:15p.m	9:00p.m	.39	....	0	n e	121.2	56.3	36.8	19.5	14.59	....
25.051	25.001	25.026	7:30 a.m	....	.22	....	n e	w	109.5	....	....	....	....	....
25.090	25.159	25.125	5:30p.m	....	.03	....	0	e	189 0	52.5	34.5	18 0	13.17	D
25.489	25.403	25.446	....	....	.02	....	s w	e	133.8	....	....	....	....	....
25.417	25.265	25.341	....	....	....	....	0	w	250.7	41.5	26.1	15.4	10.45	Lt F
25.291	25.241	25.266	....	....	....	....	n w	w	*	....	....	....	....	D
25.321	25.235	25.278	....	....	....	....	0	....	88.8	....	....	....	....	D
25.284	25.210	25.247	....	....	....	....	0	0	99.5	....	....	....	....	D
25.258	25.1?9	25.228	....	....	....	....	0	0	194 8	....	....	....	....	....
25.?45	25.176	25.211	....	....	....	....	0	0	*	....	....	....	....	D
25.189	25.136	25.162	....	....	....	....	n w	n	117.2	....	....	....	....	D
25.174	25.179	25.177	....	....	....	....	n	s w	123.9	....	....	....	....	....
25.213	25.156	25.184	....	....	....	....	w	w	93.0	....	....	....	....	D
25.170	25.080	25.125	....	....	....	....	....	n	108.6	....	....	....	....	D
25.147	25.113	25.130	....	....	....	....	0	0	107.0	51.5	36.0	15.5	11.36	D
25.160	25.044	25.102	7:00p.m	....	....	....	0	w	93.7	52.4	36.7	15.7	11.57	D
25.147	25.146	25 147	....	....	T	....	....	n w	98.8	46.1	31.7	14.4	10.?6	D
25.205	25.120	25.162	3:10p.m	....	T	....	0	n w	105.6	51.5	36.2	15 3	11.22	D
25.156	25.093	25.124	....	....	0.75	....	....	....	116.1	50.92	35.00	15.92	11.62	....

* Two days record.

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE,

	TEMP., DEW POINT AND RELATIVE HUMIDITY.								Daily Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Terrestrial Radiation	
	7 A. M.				7 P. M.											
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity							Instrument Reading	Radiation
	F°	F°	F°	Per Cent	F°	F°	F°	Per Cent	F°	Per Cent	F°	F°	F°	F°	F°	F°
1	50.9	48.4	46.5	85.3	64.1	50.9	40.4	41.9	43.4	63.6	76.3	42.0	59.1	34.3	37.8	4.2
2	51.0	46.2	42.2	72.1	57.9	49.1	42.1	55.5	42.2	63.8	78.7	41.2	60.0	37.5	37.0	4.2
3	50.3	45.9	42.2	74.0	57.2	50.4	45.4	64.6	43.8	69.3	70.9	43.0	56.9	27.9	39.0	4 0
4	43.1	41.1	39.2	86.4	55.0	47.7	41.7	60.8	40.4	73.6	77.0	38.6	57.8	38.4	34.3	4.3
5	46.2	41.2	36.1	68.4	53.2	44.7	36.7	53.7	36.4	61.0	74.0	37.9	56 0	36.1	32.4	5.5
6	45.0	40.8	36.6	72.8	57.1	45.9	35.3	44.2	36.0	58.5	81.7	35.0	58.3	46.7	29 9	5.1
7	45.2	41.3	37.4	74.9	57.7	53.8	51.3	79.3	44.3	77.1	80.2	47.0	58.6	43.2	32.0	5.0
8	43.0	41.5	40.0	89.7	46.6	42.3	38.2	73.0	39.1	81.4	49.7	41.9	45.8	7.8	40.8	0.7
9	37.3	33.3	28.0	69.1	46.2	42.9	39.8	79.1	33.9	74.1	59.2	33.7	46.5	25.5	29.9	3.8
10	48.3	41.2	33.6	57.3	44.1	37.9	30.6	59.4	32.1	58.3	62.8	42.9	52.8	19.9	37.7	5.2
11	39.7	36.7	33.2	78.1	44.3	38.3	31.4	60.8	32.3	69.5	75.9	32.4	54.2	43.5	28.7	4.1
12	33.7	31.8	29.2	83.5	53.4	45.0	37.2	54.3	33.2	68.9	71.0	27.5	49.2	43.5	24.0	3.5
13	41.9	37.8	33.2	71.7	58.0	45.0	31.7	37.1	32.5	54.4	80.0	39.3	59.7	40.7	34.0	5.3
14	51.6	44.1	37.0	57.5	55.7	45.0	34.5	45.2	35.7	51.3	73.0	38.0	55.5	35.0	34.0	4.0
15	36.8	35.0	32.8	85.6	38.9	34.9	29.9	70.3	31.4	78.0	63.3	33.0	48.1	30.3	28 0	5.0
16	30.7	30.7	30.7	100.0	30.1	30.1	30.1	100.0	30.4	100.0	35.6	29.3	32.5	6 3	29.0	0.3
17	27.2	26.9	26.4	96.9	30.0	29 2	28.0	92.3	27.2	94.6	38.7	26.0	32.3	12.7	26.0	0.0
18	31.2	30.8	30.2	96.2	43.4	37.0	29.2	57.5	29.7	76.8	67.0	28.4	47.7	38.6	23.6	4.8
19	30.4	29.9	29.2	95.2	41.9	37.0	31.1	66.2	30.1	80.7	69.0	24.0	46.5	45.0	19.7	4.3
20	36.6	3 .0	25.5	63.8	48.0	38.1	25.5	41.3	25.5	52.6	71.7	28.7	50.2	43.0	24.3	4.4
21	32.7	31.7	30.4	91.1	45.1	38.2	30.0	55.7	30.2	73.4	72.4	26.0	49.2	46.4	21.1	4.9
22	32.8	31.1	28.7	84.9	48.2	39.0	27.9	45.3	28.3	65.1	69.0	30.5	49.8	38.5	27.0	3.5
23	32.1	30.1	27.2	81.8	40.1	35.2	29.0	64.8	28.1	73.3	* † 69.8	30.0	49.9	39.8	25.0	5.0
24	34.9	31.9	27.8	75 3	47.1	38 9	29.2	49.8	28.5	62.5	74.8	29.0	51.9	45.8	25.0	4.0
25	45.6	37.9	28.5	51.3	39.9	35.2	29.2	66.0	28.9	58.7	55.7	39.1	47.4	16.6	32.8	6.3
26	31.9	31.9	31.9	100 0	26.0	26.0	26.0	100.0	28.9	100.0	33.5	*26.0	29.7	7.5	‡30 6	0.5
27	26.7	23.9	18.6	71.0	34.6	28.2	16.9	47.5	17.8	59.2	42.7	24.3	33.5	18.4	21.1	3.2
28	33.9	29.7	23.3	64.5	31.7	29.9	27.3	83.5	25.3	74.0	51.0	25.7	38.4	25.3	19.2	6.5
29	30.8	29.2	26.9	85.0	39.2	36.9	34.3	82.9	30.6	84 0	68.8	22.3	45.5	46.5	17.9	4.4
30	37.8	31.8	22.9	54.6	37.0	35.4	33.5	87.3	28.2	70.9	*54.5	21.5	38.0	33.0	16.5	5.0
31	34.9	31.7	27.3	73.6	34.0	31.1	27.0	75.4	27.1	74.5	62.0	25.7	43.9	36.3	19 7	6.0
M	38.52	35.40	31.70	77.79	45.35	39.33	32.92	64.35	32.31	71.07	64.84	32.25	48.53	32.58	28 32	4.1

* Minimum temperatnre of day occurred between 7 a. m. and 7 p. m.
† Richard Self Register.
‡ Radiation from minimum reading at 7 a. m.

The highest or lowest readings of the month are underlined.

TABLE 1.—Continued.

FORT COLLINS, COLO., FOR MONTH OF OCTOBER, 1897.

Barometer, Corrected for Temperature and Instrumental Error			PRECIPITATION				Direction of Wind		Total Movement 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	Total Am't Rain and M'ltd Snow	Av'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins			Miles	C°	C°	C°	Cal.	
25.054	24.886	24.970	....	....	......	....	s e	s w	140.6	43.8	31.2	12.6	8.80	D
25.078	25.105	25.091	....	....	......	....	0	n w	153.2	46.4	32.8	13.6	9.65	D
25.150	25.172	25.161	....	....	......	....	s e	n	111.0	......	......	......	......	D
25.222	25.219	25.221	Nt.	Nt.	T	....	n w	s	113.8	49 6	33.4	16.2	11.67	D
25.409	25.327	25.368	....	....	......	....	w	0	113.0	47.6	31.3	16.3	11.56	D
25.302	25.174	25.238	....	....	......	...	s e	w	108.0	51.4	35.2	16.2	11.83	F
25.111	25.077	25.094	6:04p.m	....	.02	....	w	n	145.8	......	......	......	.....	D
25.273	25.182	25.227	a.m	Nt.	.18	....	n w	s w	141.0	17.5	11.6	5.9	3.46	R
25.018	24.838	24.928	....	....	.....	....	n w	s w	155.0	27.0	16.7	10.3	6.38	F
25.962	24.853	24.908	....	....	......	....	n	w	124.9	......	......	....	......	......
24.762	24.846	24.804	....	....	......	....	w	n e	181.5	41.2	29.9	11.3	7.77	F
24.855	24.719	24.787	....	....	......	....	n e	w	126.6	......	....	....	......	F
24.744	24.808	24.776	....	....	......	....	n e	0	233.6	......	......	......	....	......
24·837	24.862	24.849	....	....	.....	....	w	w	126.4	......	......	......	....	......
25.027	25.198	25.113	5:30p.m	....	T	....	0	n e	183.2	......	......	...	....	F
25.393	25.317	25.355	....	....	.28	2	n	n e	108.6	......	......	......	....	Lt Sn
25.186	25.027	25.106	Nt.	Nt.	.01	1	e	n w	66.1	....	....	......	......	......
25.041	25.077	25.059	....	....	......	....	w	n e	121.5	42.9	25.5	17.4	11.8.	Hv. F
25.094	24.994	25.044	....	....	......	..	0	0	114.1	......	......	......	......	F
24.978	25.040	25.009	....	....	......	....	n w	s	101.6	53.4	32.5	20.9	15.28	F
25.077	24.944	25.011	....	....	......	....	n w	s w	103 9	46.5	29.3	17 2	12.05	F
24.892	24.955	24.923	....	....	......	....	w	n w	96.8	31.4	23.5	7.9	5.11	......
25.039	24.896	24.968	....	....	......	...	......	w	102.3	......	....	......	......	F
24.800	24.619	24.709	....	....	......	....	n w	w	124.9	......	......	......	......	F
24.709	24.821	24.765	12:45pm	....	T	....	n e	n	401.8	16.9	13.0	3.9	2.2:	F
25.045	25.189	25.117	6:50a.m	....	.09	....	n	n e	395.0	.....	......	......	.....	Sn
25.175	25.203	25.189	6:30p.m	Nt.	.17	2	n w	n	163.7	......	......	......	......	Sn
25.284	25.176	25.230	......	....	......	....	s	w	140.8	38.4	20.2	18 2	11.94	......
25.101	25.001	25.053	... .	....	......	....	w	w	106.7	46.3	29.6	16.7	11.70	F
24.952	25.069	25.010	....	... ...	......	....	0	n w	229.6	......	......	......	......	F
25.192	25.220	25.206	....	....	......	....	n	s w	188.9	......	......	......	......	F
25.057	25.026	25.042	....	....	0.75	5	......	... .	152.4	40.02	26.38	13.64	9.42	......

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE.

	TEMP., DEW POINT AND RELATIVE HUMIDITY. 7 A. M. Dry Bulb	7 A. M. Wet Bulb	7 A. M. Dew Point	7 A. M. Relative Humidity	7 P. M. Dry Bulb	7 P. M. Wet Bulb	7 P. M. Dew Point.	7 P. M. Relative Humidity	Daily Mean Dew Point.	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Terrestrial Radiation: Instrument Reading	Terrestrial Radiation: Radiation
	F °	F °	F °	Per Cent	F °	F °	F °	Per Cent	F °	Per Cent	F °	F °	F °	F °	F °	F °
1	26.1	24.8	22 5	86.1	37.0	32.8	27.1	67.3	24.8	76.7	70.0	21.8	45.9	48.2	18.0	3.8
2	28.4	26.8	24.2	84.0	38.0	34.2	29.3	71.2	26.7	77.6	70.2	23.8	47.0	46.4	20.0	3.8
3	32.0	29.9	26.8	81.0	41.8	35.7	27.9	58.0	27.4	69.5	68.9	28.7	46.3	35.2	24.0	4.7
4	31.8	29.0	24.8	74.8	24.9	24.0	22.4	90.2	23.6	82.5	46.7	30.3	38.5	16.4	28.1	2.2
5	18.8	18.2	16.9	92.2	29.1	26.6	22.4	75.6	19.6	83.9	49.2	13.0	31.1	36.2	8.0	5.0
6	32.6	29.6	25.0	73.7	36.0	34.0	31.5	83.7	28.3	78.7	50.0	20.0	35.0	30.0	15.8	4.2
7	29.1	29.1	29.1	100.	36.8	29.8	18.0	45.9	23.5	72.9	43.4	28.0	35.7	15.4	28.2	-0.2
8	28.9	22.1	5.1	35.8	25.9	21.1	9.8	50.3	7.5	43.1	38.7	†27.0	32.8	11.7	*21.0	6.0
9	32.9	25.7	10.5	38.8	46.5	35.0	17.2	30.6	13.8	34.7	°57.2	18.0	37.6	39.2	11.0	7.0
10	54.0	40.8	24.4	31.9	34.4	31.7	28.0	77.3	26 2	54.6	64.8	38.0	51.4	26.8	34.3	3.7
11	24.8	24.2	23.2	93.4	53.1	42.9	32.1	45.2	27.7	69.3	72.3	21.7	47.0	50.6	17.8	3.9
12	38.8	35.3	31.0	73.9	61.3	46.8	32.8	34.2	31.9	54.0	75.0	32.7	53.9	42.3	27.2	5.5
13	38.8	35.0	30.3	71.8	45.5	36.5	24.5	43.4	27.4	57.6	70.2	36.8	53.5	33.4	31.8	5.0
14	27.4	25.5	22.2	80.5	41.8	36.1	29.0	60.7	25.6	70.6	62.4	26.0	44.2	36.4	20.4	5.6
15	25.0	24.6	23.9	95.6	9.6	9.4	8.8	96.6	16.3	96.1	30.2	8.2	19.2	22.0	-0.7	8.9
16	5.4	5.0	3.4	91.9	22.0	21.1	19.2	89.3	11.3	90.6	32.5	0.7	16.6	31.8	-5.2	5.9
17	21.2	20.0	17.5	85.5	31.2	28.9	25.5	78.7	21.5	82.1	53.3	16.8	35.0	36.5	12.9	3.9
18	26.8	24.9	21.6	80.2	36.3	33.3	29.3	76.2	25.5	78.2	64.0	24.0	44.0	40.0	20.2	3.8
19	38.2	32.6	24.7	57.9	40.0	36.2	31.7	72.6	28.2	65.3	75.6	31.0	53.3	44.6	25.8	5.2
20	31.6	27.8	21.5	65.7	58.5	42.8	23.9	26.4	22.7	46.0	66.0	29.5	47.8	36.5	22.0	7.5
21	26.0	25.1	23.6	90.4	29.4	27.8	25.3	84.4	24.4	87.4	29.3	25.4	27.3	3.9	22.0	2.4
22	25.8	25.0	23.7	91.4	40.0	36.5	32.4	74.7	28.1	83.1	41.8	24.5	33.2	17.3	20.0	4.5
23	28.5	27.3	25.4	88.0	34.0	32.5	30.5	87.0	27.9	87.5	52.0	25.2	38.6	26.8	20.6	4.6
24	24.0	23.2	21.7	90.9	51.6	41.0	24.1	30.8	22.9	60.8	65.2	20.0	42.6	45.2	18.0	2.0
25	23.4	22.5	20.7	89.7	19.6	19.3	18.7	96.2	19.7	93.0	27.0	†22.0	24.5	5.0	*22.0	0.0
26	-1.0	-1.0	-1.0	100.	8.0	8.0	8.0	100.	3.5	100.	29.0	-3.0	13.0	32.0	-8.3	5.3
27	12.5	12.5	12.5	100.	10.8	10.8	10.8	100.	11.7	100.	28.0	1.6	14.8	26.4	-3.6	5.2
28	12.8	12.8	12.8	100.	3.0	3.0	3.0	100.	7.9	100.	12.5	† 4.0	8.2	8.5	* 7.0	-3.0
29	6.7	6.7	6.7	100.	21.5	20.0	16.9	81.9	11.8	90.9	35.7	1.0	17.4	36.7	-5.0	4.0
30	34.4	27.8	15.8	45.7	31.0	29.0	26.0	81.3	20.9	63.5	54.0	11.2	32.6	42.8	11.6	-0.4
M	26.19	23.76	19.68	79.69	33.39	28.89	22.87	70.32	21.28	75.01	51.00	20.20	35.60	30.81	16.16	4.03

° Maximum temperature of day occurred between 7 p. m. and 7 a. m

† Minimum temperature of day occurred between 7 a. m. and 7 p. m.

* Reading at 7 a. m.

The highest or lowest readings of the month are underlined.

TABLE 1—Continued.

FORT COLLINS, COLO., FOR MONTH OF NOVEMBER, 1897.

Barometer, Corrected for Temperature and Instrumental Error.			PRECIPITATION				Direction of Wind		Total Movement 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	Total Am't Rain and M'ltd Snow	Av'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins	Ins.			Ins.	Ins.			Miles	C	C	C		
25.203	25.176	25.189	....	....	......	....	n w	w	132.7	45.1	28.0	17.1	11.86	F
25.126	24.966	25.046	....	....	....	....	n w	w	114.2	......	......	.....	......	F
24.858	24.761	24.810	....		......	....	n w	n	185.5	27.1	18.2	8.9	5.54	F
25.014	23.085	25.049	7:20a.m	8:45a.m	.01	....	n	n	164.4	35.4	16.5	18.9	12.08	F
24.969	24.882	24.926	....	....	......	...	n	n w	100.7	36.0	18.1	17.9	11.54	Hv. F
24.878	24.889	24.883	Nt.	....	......	..	s w	e	124.5	......	......	......	......	F
24.852	24.824	24.838	....	4:00p.m	.03	...	n e	n w	266.8	......	......	......	......	Lt sn
24.871	24.917	24.894	....	....	......	....	n w	n w	369.3	13.8	6.0	7.8	4.41	......
24.899	24.763	24.831	....	....	......	....	w nw	n e	356.9	31.0	16.0	15.0	9.41	......
24.653	24.999	24.826	....	....	......	....	w nw	s	494.0	43.4	25.2	18.2	12.40	......
25.048	25.074	25.061	....	....	.....	...	w	n w	153.5	......	......	......	......	F
25.080	25.014	25.047	....	....	......	...	0	s w	117.0	47.7	31.8	15.9	11.30	......
24.978	24.811	24.895	....	....	T	....	s w	w	131.9	......	......	......	......	F
24.798	24.787	24.792	Nt.	....	......	....	s w	w	198.5	......	......	......	......	......
25.103	25.320	25.212	....	10:20am	.34	3	n e	n w	104.8	13.7	4.1	9.6	5.38	Sn
25.339	25.230	25.284	....	....	......	...	n	s w	101.8	39.0	14.1	24.9	16.00	F
25.279	25.204	25.242	....	....	......	...	n w	w	119.2	39.4	20.0	19.4	12.77	......
25.207	25.153	25.180	....	....	......	..	w	w	120.5	......	......	......	......	F
25.057	24.867	24.962	....	....	......	...	s e	0	137.2	......	......	......	......	......
24.758	24.806	24.782	....	....	......	...	n w	s w	166.8	......	......	......	......	F
25.089	25.078	25.083	......	....	.....	....	s e	s e	106.8	......	......	......	......	......
25.164	25.281	25.223	....	....	......	..	w	s	91.6	......	......	......	......	F
25.152	24.920	25.036	....	....	......	....	e	w	68.0	......	......	......	......	......
24.764	24.602	24.683	Nt.	....	......	...	e	w	246.0	......	......	......	......	......
24.715	24.949	24.832	7:45a.m	2:30p.m	.29	3¼	e	w	75.7	.....	......	......	......	Sn
25.097	25.040	25.068	....	....	......	....	n w	e	81.4	......	......	......	......	......
24.909	24.966	24.938	....	....	......	....	s	e	98.1	......	......	......	......	......
24.971	25.207	25.089	....	....	T	....	s e	n	181.3	......	......	......	......	Sn
25.153	25.064	25.108	....	....	.....	...	n w	n	103.0	....	......	......	......	......
24.850	24.920	24.885	....	....	......	....	w	s	291.2	......	......	......	......	......
24.994	24.9-5	24.990	....	....	0.67	6	......	......	166.8	33.78	18.00	15.78	10.24	......

Use l to indicate approximate time.

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE,

	TEMP., DEW POINT AND RELATIVE HUMIDITY								Daily Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Terrestrial Radiation	
	7 A. M.				7 P. M.											
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity							Instrument Reading	Radiation
	F °	F °	F °	Per Cent.	F °	F °	F °	Per Cent.	F °	Per Cent.	F °	F °	F °	F °	F °	F °
1	21.7	21.7	21.7	100.0	10.5	10.5	10.5	100.	16.1	100.	22.6	11.0	16.8	11.6	21.0	0.
2	4.0	4.0	4.0	100.0	8.0	8.0	8.0	100.	6.0	100.	10.0	3.4	6.7	6.6	3.2	0.2
3	18.0	13.6	-1.4	42.2	-5.0	-5.0	-5.0	100.	-3.2	71.1	31.0	-1.5	14.7	32.5	7.2	0.3
4	5.4	4.7	1.9	85.9	21.5	18.8	12.4	67.6	7.1	76.7	40.0	-7.6	16.2	47.6	-13.8	6.2
5	18.8	17.8	15.4	87.0	37.5	29.8	16.5	41.8	16.0	64.4	*51.6	7.0	29.3	44.6	3.0	4.0
6	29.0	23.8	12.8	50.3	29.1	27.1	23.9	80.4	18.3	65.4	*47.7	26.8	37.3	20.9	19.0	7.8
7	40.2	31.3	16.3	37.4	33.4	30.6	26.5	75.8	21.4	56.6	53.4	19.3	36.3	34.1	15.2	4.1
8	28.1	26.2	23.0	80.8	39.1	35.8	31.8	75.6	27.4	78.2	55.2	26.7	41.0	28.5	23.2	3.5
9	35.0	31.3	26.0	69.6	28.4	25.1	22.2	77.1	24.1	73.3	43.0	†28.3	35.6	14.7	†21.8	6.5
10	19.8	19.1	17.7	91.1	35.4	27.9	13.7	40.2	15.7	65.7	44.4	17.0	30.7	27.4	11.3	5.7
11	19.2	18.8	18.2	94.8	27.0	25.2	22.1	81.3	20.2	88.0	*45.3	17.8	31.6	27.5	11.0	6.8
12	32.3	31.8	31.1	95.5	33.0	25.7	10.2	38.1	20.6	66.8	42.2	25.0	33.6	17.2	22.6	2.4
13	24.2	19.8	9.1	51.8	26.2	23.2	17.3	68.7	13.2	60.3	38.9	†22.4	30.6	16.5	15.0	7.4
14	18.7	18.4	17.8	96.1	47.7	34.9	13.8	25.5	15.8	60.8	52.1	†17.3	34.7	34.8	15.0	2.3
15	17.0	16.0	13.4	86.3	4.0	3.6	2.0	91.5	7.7	88.9	17.3	† 3.0	10.2	14.3	-3.5	6.5
16	-8.8	-8.8	-8.8	100.	-1.0	-1.5	-3.8	86.8	-6.3	93.4	10.5	-10.8	-0.2	21.3	-15.3	4.5
17	-6.0	-6.0	-6.0	100.	5.0	4.6	3.0	91.8	-1.5	95.9	20.8	-9.8	5.5	30.6	-13.9	4.1
18	-5.2	-5.2	-5.2	100	6.0	5.7	4.5	94.1	-0.3	97.0	25.2	†-6.0	9.6	31.2	-10.5	4.5
19	1.2	1.0	0.2	95.2	2.1	2.1	2.1	100.	1.1	97.6	21.2	-2.0	9.6	23.2	-7.0	5.0
20	-4.0	-4.0	-4.0	100.	8.0	7.6	6.2	92.6	1.1	96.3	29.1	†-5.8	11.7	34.9	-9.0	3.2
21	-4.8	-5.4	-8.7	81.4	11.6	10.8	8.2	87.0	-0.2	84.2	*33.3	-6.0	13.6	39.3	-10.8	4.8
22	26.8	22.5	13.3	56.5	34.2	28.2	17.8	50.1	15.5	53.3	46.8	6.0	26.4	40.8	1.9	4.1
23	15.9	15.2	13.4	90.1	25.7	24.3	21.8	84.9	17.6	87.5	48.3	15.7	32.0	32.6	10.0	5.7
24	13.8	13.2	11.5	90.9	28.0	25.7	21.7	76.8	16.6	83.9	51.5	12.7	32.1	38.8	8.4	4.3
25	15.3	15.3	15.3	100.	33.2	25.8	10.1	37.6	12.7	68.8	40.0	15.2	27.6	24.8	8.3	6.9
26	12.8	12.2	10.5	90.6	36.0	28.0	12.5	37.4	11.5	64.0	41.2	†12.2	26.7	29.0	† 6.3	5.9
27	21.3	20.2	17.9	86.7	34.4	29.2	20.7	56.8	19.3	71.7	47.0	†20.0	33.5	27.0	15.2	4.8
28	27.3	25.6	22.7	82.4	48.2	36.8	20.6	33.5	21.7	58.0	58.8	†25.1	42.0	33.7	20.0	5.1
29	46.9	36.1	20.6	35.0	44.7	32.7	11.0	25.2	15.8	30.1	63.0	40.2	51.6	22.8	29.9	10.3
30	45.0	32.0	6.1	20.2	29.1	25.9	20.2	69.2	13.1	44.7	47.3	†28.8	38.0	18.5	26.0	2.8
31	14.2	13.8	12.7	94.0	15.0	13.6	9.7	79.7	11.2	86.8	29.1	†14.0	21.6	15.1	5.8	8.2
M	17.52	15.35	10.92	80.38	23.74	20.05	13.30	69.91	12.11	75.14	38.96	11.79	25.37	27.17	7.63	4.77

† Minimum temperature of day occurred between 7 a. m. and 7 p. m.
* Maximum temperature occurred between 7 p. m. and 7 a. m.

The highest or lowest readings of the month are underlined.

TABLE 1—Continued.

FORT COLLINS, COLO., FOR MONTH OF DECEMBER, 1897.

Barometer, Corrected for Temperature and Instrumental Error.			PRECIPITATION				Direction of Wind		Total Movement 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	Total Am'l Rain and M'lt'd Snow	Av'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins.			Miles	C	C	C	Cal	
24.917	24.901	24.909	8 a. m.	....	.12	2	s e	s e	158.3	......	......	......	......	Sn
24.919	25.095	25.007	....	....	.12	1	s	e	148.9	......	......	......	......	Sn
25.188	25.164	25.176	....	.. ....	.12	1	n	......	158.9	.....	......	......	.... .	Sn
25.029	25.155	25.092	....	....	......	....	s w	......	135.9	......	......	......	.....	......
25.043	24.805	24.924	....	....	......	...	n w	s w	246.9	......	......	......	......	......
24.900	24.873	24.886	....	....	......	....	s w	w	168.9	37.5	16.8	20.7	13.36	......
24.759	24.905	24.832	....	....	......	....	w	w	171.3	38.3	19.3	19.0	12.42	......
24.718	24.721	24.720	7:15a.m	....	T	....	n	s w	175.7	28.7	16.1	12.6	7.84	F
24.916	25.018	24.967	....	Nt.	.21	Rn.	n w	s	171.9	22.4	10.4	12.0	7.13	R
24.982	25.073	25.027	....	....	.....	....	e	w	182.7	16.2	8.4	7.8	4.49	F
25.039	24.784	24.912	....	....	.....	....	n w	w	241.8	6.5	1.0	5.5	2.96	F
24.799	24.998	24.898	7 a. m.	....	T	...	n	n	375.0	......	......	......	......	Sn
25.060	24.919	24.990	....	... ...	......	. ..	n e	n w	141.4	30.9	12.2	18.7	11.56	......
24.635	24.439	24.537	Nt.	....	......	....	s w	w	223.4	......	......	......	......	......
24.496	24.820	24.658	....	‡ 9 a. m	.10	1½	e	s	243.7	Cl'dy	......	......	......	Sn
24.936	24.911	24.923	....	....	.....	....	n	n w	86.0	27.9	3.0	24.9	14.70	F
25.068	25.055	25.062	....	....	......	....	n w	w	97.7	18.1	1.3	16.8	9.48	F
24 997	25.023	25.010	....	....	......	....	n	n w	85.3	30.1	6.8	23.3	14.07	F
24.951	24 827	24.889	‡10 a.m	....	T	...	n w	0	74 2	......	......	......	......	F
24.859	24.982	24.920	....	....	.....	....	n e	n w	116.3	32.4	11.0	21.4	13.25	F
24.926	24.960	24.943	....	....	......	....	n	n w	100.5	21.0	0.8	20.2	11.51	F
25.035	25.146	25.090	....	....	......	....	w n w	w	197.2	33.1	17.1	16.0	10.16	......
25.152	25.066	25.109	....	....	......	....	0	n w	58.7	36.1	18.4	17.7	11.43	......
24.950	25.024	24.987	....	....	......	....	n	w	109.9	35.1	17.1	18.0	11.52	F
25.145	25.131	25.128	....	....	......	....	n w	n w	183.0	.....	......	......	......	F
25.149	25.116	25.131	....	....	......	....	n e	n w	242.1	......	......	......	......	......
25.146	25.130	25.138	....	....	......	....	s e	s w	127.2	14.0	5.5	8.5	4.80	......
25.149	25.139	25.144	....	....	......	....	n w	n w	155.6	38.1	21.5	16.6	10.93	......
25.172	25.092	25.132	....	....	......	....	n w	w	405.7	43.1	25.8	17.3	11.73	......
24.983	25.297	25.146	11 a. m	....	T	....	w	n e	381.9	......	......	......	......	......
25 548	25.435	25·492	7 p. m	....	......	....	n	s	168.7	27.5	8.2	19.3	11.60	......
24.986	25.000	24.993	....	....	0.67	5½	......	......	178.5	28.26	11.62	16.65	10.26	......

‡ Used to indicate approximate time.

The monthly values of the observations detailed in the preceding table are summarised in table 2, following. Figures 12, 13, 14 and 15 go in connection with this table. It may be found suggestive to compare these values with the corresponding ones at the other stations given.

TABLE 2.

SUMMARY FOR 1897, AT AGRICULTURAL COLLEGE, FORT COLLINS, COLO.

Latitude, 40° 34′; Longitude, 105° West from Greenwich; Elevation of Barometer, 4,994 ft: of grounds 4,980 ft.

1897. Month	Mean Pressure Corrected for Temperature Only.	TEMPERATURE (IN DEGREES FAHRENHEIT). Mean. ½ max+min	Average Maximum	Average Minimum	7 A. M.	7 P. M.	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	Wet Bulb 7 A. M.	Wet Bulb 7 P. M.	Average Temp'rat'e Below 32°	Minimum Below 32°	Precipitation. (Rain or Melted Snow.	Snowfall	No. of Stormy Days	Relative Humidity	Dew Point	No. dys. Frost or Dew Obsv'd Frost	Dew
	Ins.												No. of Days	No. of Dys	Ins.	Ins.	Ins.	per Ct.	F °		
Jan. . .	24.985	24.8	40.2	9.3	12.0	22.4	64.0	-26.0	30.9	51.8	10.5	17.7	22	31	0.18	2¼	2	68.4	6.6	13	..
Feb. . . .	24.853	27.6	40.9	14.2	16.9	28.1	59.5	-5.3	26.7	51.7	15.6	24.0	19	27	0.54	6¼	6	74.7	14.1	14	..
March .	24.806	32.3	44.8	19.9	25.3	32.7	65.3	-7.0	25.0	45.2	23.6	28.7	17	30	2.15	19½	9	72.6	19.8	13	..
April . .	25.006	45.8	59.5	32.0	41.9	46.8	77.2	20.0	27.5	42.8	37.1	38.3	2	13	1.39	3¾	7	61.0	29.5	8	..
May . . .	25.035	58.1	73.6	42.7	56.2	59.5	82.3	31.6	30.9	43.5	49.9	51.0	0	1	2.06	. . . .	13	63.0	44.6	2	8
June. . .	24.964	63.1	77.6	48.2	60.4	63.9	90.1	35.3	28.9	44.1	54.9	55.4	0	0	1.69	. . . .	12	69.0	50.5	1	15
July . . .	25.061	66.8	83.3	50.4	62.9	66.9	94.8	38.9	32.9	47.1	57.0	58.3	0	0	2.65	. . . .	9	68.0	53.3	..	21
August	25.123	66.9	82.3	51.4	60.9	65.3	93.5	42.7	30.9	48.5	56.6	57.8	0	0	1.74	. . . .	12	73.0	53.6	.	24
Sept. . .	25.124	63.7	80.0	47.4	56.1	61.8	89.8	33.8	32.6	43.0	51.5	53.5	0	0	0.75	. . . .	6	69.2	48.0	1	19
Oct. . . .	25.042	48.6	64.8	32.3	38.5	45.4	81.7	21.5	32.6	46.7	35.4	39.3	1	16	0.75	4	6	71.1	32.3	15	6
Nov. . . .	24.990	35.6	51.0	20.2	26.2	33.4	75.6	-3.0	30.8	50.6	23.8	28.9	9	27	0.67	6¼	4	75.0	21.3	12	..
Dec. . . .	24.993	25.4	39.0	11.8	17.5	23.7	63.0	-10.8	27.2	47.6	15.4	20.0	19	30	0.67	5½	5	75.1	12.1	10	..
Year. . .	24.999	46.6	61.4	31.6	39.6	45.8	*94.8	*-26.0	29.7	*51.8	35.9	39.4	89	175	15.24	47½	9.1	70.0	32.1	89	93
Norm'l	24.983	46.6	62.0	31.9	39.6	46.9	*99.2	*-28.4	30.1	*56.2	35.2	39.1	. . . . . .	. . . .	13.86	. . . .	69.7	64.5	30.3		

* Extreme values.

§41. Figure 12 represents the precipitation by months, and shows both the rainfall for 1897 and the normal as obtained from observations extending over a large number of years, varying from 15 to 19 years for different months. The figures show clearly the preponderance of precipitation during the growing season. Each of the five months from April to August averages more than one inch of rainfall, and none of the other months have as much. Two-thirds of the rainfall of the year is received in these five months, and as this period, especially with the addition of March, includes practically all the growing season for fair crops, the importance of the distribution is evident. With this distri-

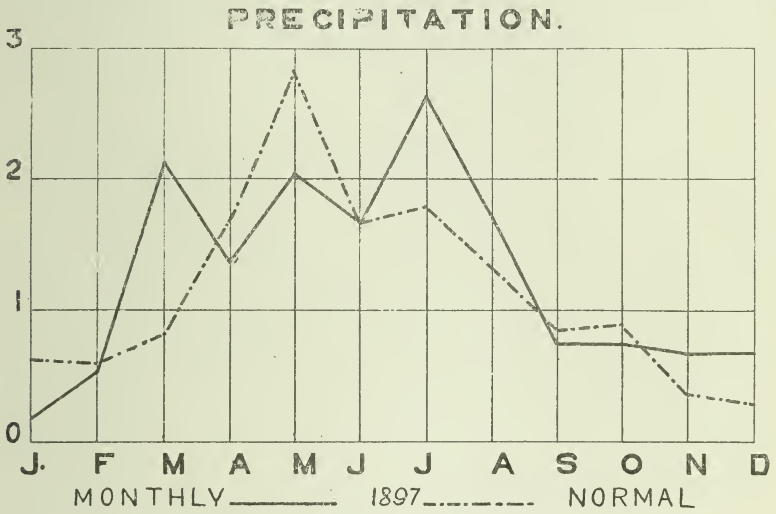


Fig. 12.

bution, the small amount of rainfall which we have is as effective as a much more abundant rainfall, but with a large proportion falling during the winter months.

§42. Every day on which enough rain falls to measure is included in the list of stormy days, and these are shown graphically in figure 13. The number of stormy days varies in nearly the same way as the amount of rainfall. While the precipitation in April exceeds that in March, the number of stormy days is less, which indicates that the amount received in each storm is greater in April. Likewise the storms in August average less than those in July.

§43. There is considerable range between the highest and lowest rainfalls recorded in any given month as is evident by inspection of table 5. The heavier, continued storms, lasting all day or extending through several days, occur principally in May, but the period when such storms are possible extend through April and forward into June. After this period the prevailing storms in the summer months are local thunder storms.

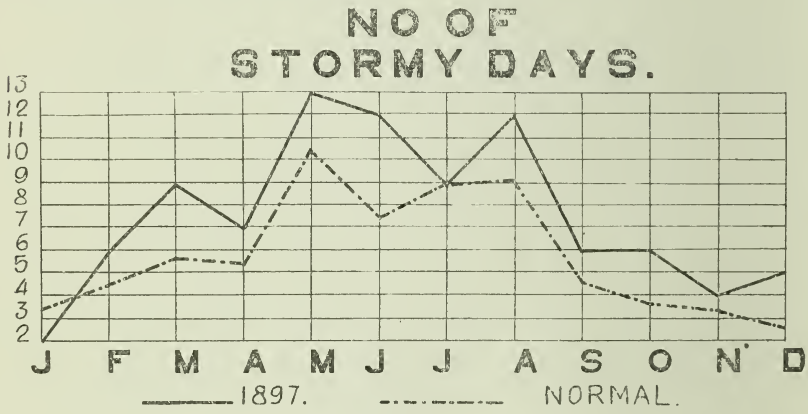


Fig. 13.

§44. Figure 14 shows the changes in temperature during the different months of the year as well as the average and the normal. The upper end of the line in any month indicates the highest temperature recorded during the month at any time, and the lower end indicates in a similar manner the lowest temperature during the month. The scale of temperatures is shown at the left side of the diagram. The length of the line thus shows the range during the month.

§45. The thicker portion of the line shows the limit of the temperatures on the average day. The upper ends of this portion, indicated by the cross line, show the average of the highest and lowest temperatures for each day through-

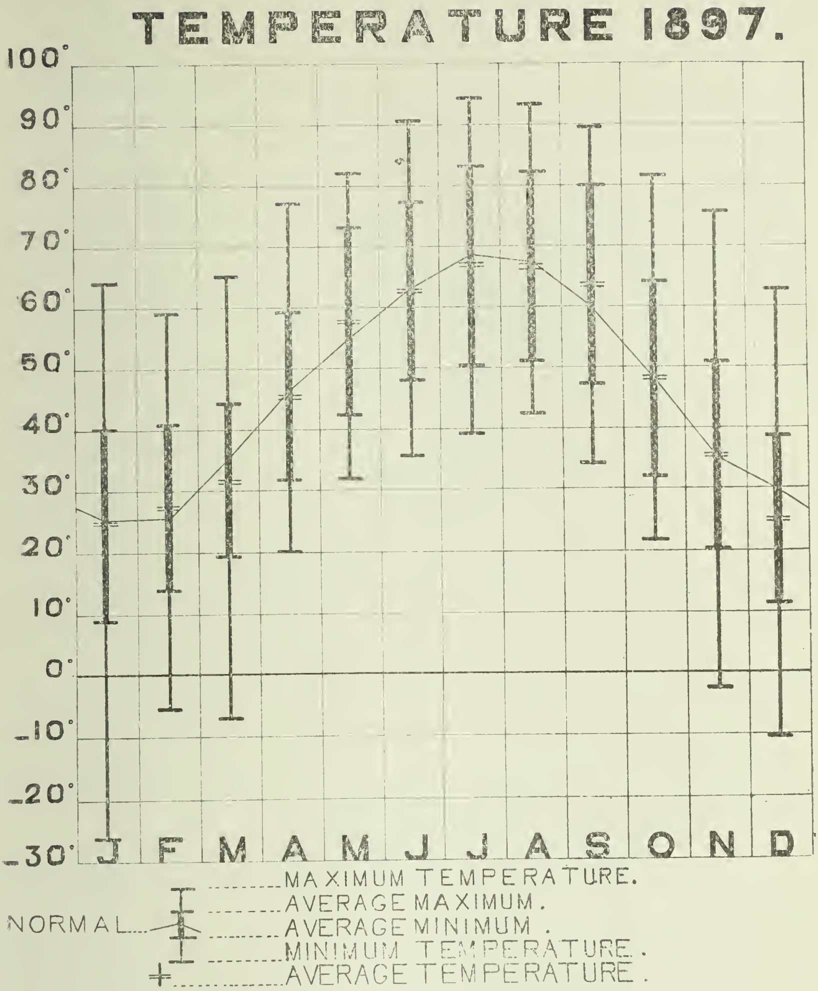

TEMPERATURE 1897.
100°
90°
80°
70°
60°
50°
40°
30°
20°
10°
0°
-10°
-20°
-30°
J F M A M J J A S O N D
MAXIMUM TEMPERATURE.
AVERAGE MAXIMUM.
NORMAL
AVERAGE MINIMUM.
MINIMUM TEMPERATURE.
AVERAGE TEMPERATURE.

Fig. 14.

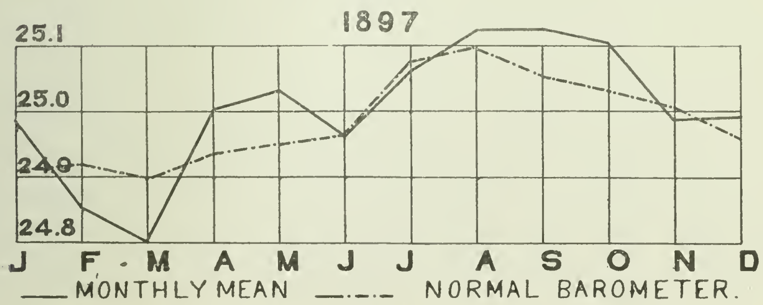

1897
25.1
25.0
24.9
24.8
J F M A M J J A S O N D
MONTHLY MEAN
NORMAL BAROMETER.

Fig. 15.

out the month, and the double cross-line indicates the average temperature for the month.

§46. From the diagram, which puts in graphic form a portion of the summary given in table 2, it will be observed that the lowest temperature recorded during the year was in January and was 26° below zero, and that the highest temperature in the same month was 64°. For the 31 days of the month the maximum temperatures of each day averaged 40° and throughout the month the minimum temperature descended on the average to 9°. The temperature fell below zero in five different months and rose above 90° in three months. The greatest range in any single month is in January when the range was from 26° below zero to 64° above, or an absolute range of 90°. The range during the year was 120°.

§46. The same diagram shows the average monthly temperatures for 1897 by two short cross-lines and the normal by the full line crossing the vertical lines. As shown by the diagram both January and February were warmer than the average, March was cold, May warm and September unusually warm. April is nearer the average temperature of the year than any other single month, October is slightly above the yearly average, and the mean of April and October is close to the average of the year.

§47. The monthly mean barometer, as shown in fig. 15, requires little comment. The variation during 1897 was greater than the normal, February and March being below, while the two succeeding months, as well as August, September and October are above the normal.

Though the barometer is one of the most important instruments for one observing the weather, and wishing to be forewarned of impending changes, it is one of the most useless to the agricultural meteorologist. Not that it is not of some value, for the rise of water in soils, the flow of water in drains, the increase of seepage water, and the numerous important fluctuations, all show a connection with the changes in the barometer, but as a whole the connection with the phenomena of most importance in plant growth is obscure and not likely to be of value to other than the scientific student or the professional meteorologist. Many who are interested in meteorological observations have the impression that a barometer is one of the most necessary instruments and that no observations of value can be made without it. So far is this from being true that to most people it is of little use, and a small part of the expense required for a barometer will purchase a good set of thermometers and a rain gage which, systematically observed, will yield useful climatic data.

SUB-STATIONS.

The observations at Cheyenne Wells and at Rocky Ford are not given in detail, but are summarised in tables 3 and 4. The conditions of exposure are not so good as at Fort Collins. The averages and the reduction to determine the dew point and relative humidity from the observations are computed at the home station at Fort Collins. For a portion of the year the wet and dry bulb thermometers observed at the Cheyenne Wells station were obtained from other sources than through the home station, and it was subsequently found that the thermometers were in error, and the corresponding relative humidities and dew points are incorrect.

TABLE 3.

SUMMARY FOR 1897, AT ROCKY FORD SUB-STATION.

P. K. BLINN, OBSERVER JANUARY TO JUNE, W. F. CROWLEY, FROM AUGUST.

Latitude 39° 3'. Longitude 103° 45'; Elevation 4,160 feet

Month.	TEMPERATURE (IN DEGREES FAHRENHEIT.) Mean	Av. Maximum	Av. Minimum	7 A. M.	7 P. M.	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	Wet Bulb 7 A. M.	Wet Bulb 7 P. M.	Av. Temp. Below 32°	Minimum Below 32°	Precipitation. (Rain or Melted Snow)	Total Snowfall	Number of Stormy Days	Relative Humidity Mean	Dew Point Mean	No. dys. Frost	No. dys. Dew Obsv'd	Prevailing Direction of Wind
	F°	F°	F°	F°	F°	F°	F°	F°	F°	F°	F°	No. dys	No. dys		Ins		Per Ct.	F°			
Jan....	25.9	38.4	13.3	19.1	28.9	54.0	-15.	25.1	36.0	18.1	27.0	19	31	0.75	5	1	84.7	20.0	.	..	n w
Feb....	34.8	48.1	21.4	28.1	35.6	65.0	0.0	26.7	46.0	25.8	31.6	9	28	0.37	2	2	73.8	23.6	..	..	w n w
March.	39.8	56.0	23.5	31.8	41.2	74.0	7.0	32.6	50.0	28.5	37.4	7	25	0.20	....	1	65.0	25.8	..	..	s
April..	50.1	67.1	33.2	45.6	52.8	85.0	20.0	33.9	51.0	40.7	43.7	0	12	0.44	....	2	60.3	34.4	..	..	n e
May...	....	....	....	....	....	...	....	....	....	....	....	....	...	....	....	....	....	....	..	..	......
June...	...	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	..	..	......
July...	....	....	....	....	....	....	....	....	....	....	....	....	...	....	....	....	....	....	..	..	......
Aug....	†70.2	†87.5	†52 8	*64.3	*71.3	99.0	46.5	31.9	47.5	59.7	61.7	0	0	0.73	....	5	*68.5	*55.9	.	10	e
Sept...	69.3	85.6	53.0	‡60.8	‡70.1	97.5	42.0	32.7	41.5	‡56.9	‡61.7	0	0	0.79	....	2	‡68.1	‡54.9	..	8	s e
Oct....	54.0	68.9	39.1	45 8	53.7	87.5	24.0	29.8	48.5	40.5	45.7	1	6	2.64	4	4	67.8	37.3	12	3	n w
Nov....	41.7	59.5	23.9	29.5	40.8	80.0	10.0	35.6	57.0	26.8	34.1	2	26	0.19	½	1	65.6	23.4	17	..	n n w
Dec....	26.7	41.3	12.1	19.3	25.3	74.0	-8.0	29.1	50.0	17.1	22.7	24	30	1.06	6.8	3	74.7	11.7	15	..	n n w
Sums	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	...	..	..	......
Av.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	..	..	......

* First 7 days missing
† First 12 days missing.
‡ First 10 days missing.

TABLE 4.

SUMMARY FOR CHEYENNE WELLS SUB-STATION.

J. E. PAYNE, OBSERVER.

Latitude 38° 50′; Longitude 102° 20′; Elevation 4,278 feet.

Month	TEMPERATURE													Precipitation. (Rain or Melted Snow	Total Snowfall	No. Stormy Days	Relative Humidity	Dew Point Mean	No. Dys Frost or Dew Obsv'd		Average Cloudiness	Prevailing Direction of Wind
	Mean ½ Maximum	Average Maximum	Average Minimum	7 A. M.	7 P. M.	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	Wet Bulb 7 A. M.	Wet Bulb 7 P. M.	Av. Temp. Below 32	Minimum Below 32						Frost	Dew		
	F°	F	F°	F°	F	F°	F°	F°	F°	F°	F°	No. Days	No. Days	Ins	Ins		Per Ct.	F°				
Jan....	25.9	38.2	13.7	20.0	21.7	60.6	-12.	24.5	41.0	18.2	19.5	17	31	0.26	....	2	78.5	14.6	13	..	3.4	n w
Feb....	31.7	45.8	17.6	24.8	28.7	63.4	9.0	28.2	49.5	23.6	24.8	13	28	0.10	1	1	75.5	19.0	7	..	4.3	n w
March..	35.2	48.5	22.0	‡ 29.4	‡ 35.8	69.6	6.6	26.5	39.6	‡ 28.3	‡ 31.8	10	26	1.58	9	4	‡ 79.3	‡ 26.2	7	..	4.2	s
April..	48.0	61.9	34.1	45.3	48.6	81.8	26.0	27.8	45.2	....	....	0	12	1.20	T	7	....	....	6	1	3.7	n n e
May ...	62.0	76.7	47.2	58.2	63.5	92.2	37.0	29.6	44.0	....	...	0	0	1.44	....	5	....	....	..	4	5.8	s e
June...	68.9	84.7	53.2	65.5	69.3	97.6	43.0	31.5	41.1	....	...	0	0	2 22	....	11	....	....	..	..	5.0	s e
July...	74.1	89.8	58.4	71.9	75.5	102.6	47.6	31.4	41.2	....	....	0	0	4.21	....	5	....	....	..	1	3.0	s
August	70.0	83.2	56 7	67.1	70.6	96.0	51.0	26.6	39.0	....	....	0	0	3.24	....	7	....	....	..	8	3.4	s e
Sept..	69.0	84.2	53.8	63.8	69.3	96.0	37.2	30.4	43.0	....	....	0	0	0.92	T	2	....	....	..	1	2.4	s
Oct....	53.6	67.4	39.8	46.8	50.9	88.0	21.0	27.6	44.2	...	....	1	7	2.73	3	6	....	....	5	2	....	w
Nov....	39.8	56.0	23.6	32.1	34.0	79.2	3.2	32.3	47.2	....	....	8	25	0.10	1	1	....	....	13	..	3.3	w n w
Dec....	26.6	38.9	14.3	21.8	22 9	64.0	-9.8	24.6	45.0	....	....	16	31	0.20	2	2	....	....	2	..	4.0	n w
Av.	50.4	64.6	36 2	45.6	49.2	......	....	28.4	....	....	....	5.4	13.	1 52	....	4	....	....	..	..	....	......

‡ Record lacking from the 14th to 22d.

§49 The corresponding summaries from three of the volunteer observers are given in the three following tables, these stations being Lambs, Estes Park P. O., at an elevation of 9,000 feet: Geo. A. Barnes, Pinkhampton, at an approximate elevation of 8,400 feet, and Mrs. Sherwood, Gleneyre P. O., at an elevation of 8,000 feet. Their location is further described in section 54.

The instruments have in most cases, been furnished by the Experiment Station or have been compared with our instruments.

§50 An interesting comparison may be made between the records at the different elevations, especially between those at the foot of Longs Peak and at Fort Collins. The distance in an air line, is 35 miles, and the difference in elevation is 4,000 ft. The higher station has an average temperature for the year over 9° colder than Fort Collins. In the summer, from May to September inclusive, the mountain station averages 13° colder, while during the winter months of January, February and March, it averaged but 6° colder. It was, therefore, relatively warmer during the winter than during the summer.

§51 If the records are compared day by day, it is noticeable that the temperature at the higher station is often higher than at Fort Collins during the winter months, and this notwithstanding 4,000 feet difference of elevation. When first noticed some years ago, some doubt was felt as to the reality of the phenomena. Continued observation has not only confirmed it, but shown that in the winter months from December to April, it is very common. In some years the average temperature at the higher station has actually been above that at Fort Collins during the winter months. Such inversions of temperature have been observed between Denver and the summit of Pikes Peak.

§52 Many of the differences are due to the fact that the cold waves which sometime reach us in the winter from the north, consist of a wave of cold air, relatively shallow, which underruns the layer of warmer air, displacing it, and the cold wave is not in itself deep enough to reach up to the mountain stations and submerge them in its wintry bath. When the cold is due to local radiation, as when the ground is covered by a thin layer of snow, then the temperature at the mountain stations descends lower than on the plains.

TABLE 5.

SUMMARY AT MR. CARLYLE LAMB'S AT THE BASE OF LONG'S PEAK, ESTES PARK POSTOFFICE. ELEVATION, 9,000 FEET,

MONTH	Mean Temperature	Average Maximum	Average Minimum	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	Average Below 32°	Minimum Below 32°	Precipitation	Snowfall	Stormy Days
January	23.8	35.4	12.3	54	− 14	23.1	....	....	....	.40	8	....
February	19.1	29.7	8.6	48	− 10	21.1	33	26	28	1.20	19	7
March	22.6	33.0	12.3	53	− 11	20.7	35	22	31	1.96	24	5
April	32.5	43.1	21.9	60	1	21.2	38	13	27	1 35	18	8
May	45.0	57.9	32.2	68	23	25.7	35	0	14	1.60	4	3
June	49.6	62.5	36.7	74	26	25.8	34	0	2	1.50	1	5
July	54.7	67.7	41.6	78	32	26.1	37	0	0	1.85	0	5
August	53.5	63.5	43.6	75	22	19.9	39	0	0	1.29	0	8
September	50.5	66.2	34.8	75	28	31.4	37	0	3	0.95	0	4
October	39.6	53.2	26.1	67	2	27.1	39	6	24	1.10	9	4
November	34.2	44.7	23.7	72	− 4	21.0	44	14	21	.55	12	4
December	22.6	33.1	12.0	48	− 9	21.1	41	25	30	.25	5	4
Year	37.3	49.2	25.5	..	....	23.7	....	....	....	14.00	100	...

TABLE 6.

SUMMARY AT MR. GEO. A. BARNES', PINKHAMPTON, COLO. ELEVATION 8,100 FEET.

MONTH	Mean Temp. ½ (7 a. + 7 p.)	Av. Temp. 7 a. m.	Av. Temp. 12 m.	Av. Temp. 7 p. m.	Highest Temp. 12 m.	Lowest Temp. 7 a. m.	Mean Range	Greatest Range 7 a. m. to 12 m.	No. of Days Averaging Below 32°	No. of Days Minimum Below 32°	Precipitation	Snowfall	No. of Stormy Days
	F °	F °	F °	F °	F °	F °	F °	F °			Ins.	Ins.	
January	11.6	6.8	29.7	16.5	50	−17	25 1	44	31	31	1.50	15	6
February	16.3	12.5	34.5	20.2	52	− 7	23.9	42	28	28	1.35	13½	8
March	19.8	15.3	39.3	24.2	65	− 9	24.9	42	28	30	2.20	22	7
April	33.3	26.5	53.8	40.0	81	2	27.5	51	12	22	1.95	19½	10
May	47.7	38.5	68.4	56.9	82	29	30.0	47	0	1	2.06	....	6
June	53.0	43.9	69.1	62.0	83	33	26.0	45	0	0	2.62	2	11
July	55.6	46.6	75.9	61.5	86	37	29.9	43	0	0	2.41	....	14
August	55.9	44.6	79.2	67.2	87	36	31.8	51	0	0	1.38	....	12
September	52.6	42.2	73.2	62.9	84	28	31.0	46	0	2	.35	....	7
October	36.5	30.3	57.0	42.7	78	5	26.8	52	9	14	.45	1	8
November	26.5	26.6	44.8	26.4	68	10	20.9	44	15	18	1.10	11	5
December	15.5	12 6	27.5	18.4	49	−24	19.4	38	29	29	2.00	20	9
Year	35.4	28.9	51.4	41.8	..	..	26.7	..	152	175	19.37	104	106

TABLE 7.

SUMMARY AT GLENEYRE P. O., MRS. F. W. SHERWOOD, OBSERVER, NEAR THE HEAD OF THE LARAMIE RIVER. ELEVATION, 8,000 FEET.

MONTH	Av. Temp. 7 a. m.	Av. Temp. 2 p. m.	Av. Temp. 9 p. m.	Mean Temp. ½ (Max+Min)	Av. Maximum	Av. Minimum	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	No. Days Av. Below 32°	Days Minimum Below 32°	Precipitation Inches	Snowfall	No. of Stormy Days
January	12.8	27.8	16.4	16.5	29.7	3.2	47	-18	26.5	38	29	31	1.00	10	4
February	15.0	25.4	16.8	17.8	26.4	9.2	43	- 8	17.2	33	28	28	.70	10½	6
March	18.9	27.6	20.5	22.0	31.4	12.7	52	-10	18.7	42	27	31	2.90	28	4
April	24.5	41.1	28.7	31.4	42.8	19.9	67	- 5	22.9	40	15	27	†2.00	† 24½	† 8
May	41.4	58.3	41.0	47.2	60.0	34.5	70	27	25.5	39	0	8	.30	......	2
June	47.6	63.8	46.2	51.1	67.2	35.0	83	23	32.2	50	0	5	.50	......	7
* July	53.5	67.2	52.4	56.0	69.5	42.6	82	33	26.9	44	0	0	......	......	2
August	52.0	68.1	51.1	56.6	71.3	41.8	78	33	29.5	40	0	0	......	......	8
September	......	......	......	......	......	....	......	.....	......	....	.. ..	....	......	......	....
October	32.9	48.1	34.7	37.8	49.5	26.0	64	1	23.5	38	8	22	1.20	12½	6
November	30.5	41.1	29.9	32.4	42.9	21.9	66	2	21.0	46	13	24	.50	11	10
December	16.3	23.6	16.2	15.8	25.1	6.6	48	-16	18.5	38	29	31	1.65	16½	11
Year	......	......	......	......	......	....	83	-18	......	....	....	....	......	......	....

* Records lacking for first twelve days.

† No record of precipitation after the 12th, owing to absence.

PRECIPITATION.

§ 53 From a number of places precipitation and other records have been furnished by volunteer observers who have been furnished with instruments from this station These stations have been selected in most cases for the purpose of obtaining a record of the precipitation in the mountains which form the water shed of the adjacent rivers. As the Cache a la Poudre river has been the subject of investigations for a number of years and records have been maintained of its flow, it has been desired to study the amount and distribution of the precipitation on its water shed. We have not received reports from as many observers this year as formerly.

§ 54 Of the stations noticed in the following table, the first five are situated in the mountains and the last five on the plains.

Pinkhampton is located on the eastern border of North

Park at an elevation of 8,400 feet. It is situated to the west of the range whose eastern slope forms the water shed of the Laramie and of the Cache a la Poudre rivers. Mr. G. A. Barnes has been the observer and has also kept a record of temperature.

The station in Estes Park has been kept by Mr. Carlyle Lamb, living at the foot of Longs Peak to the south of the park proper, but situated almost on the divide between the waters which flow into the St. Vrain on the south and the Big Thompson on the north. This station is in a mountain valley extending north and south. To the east the Twin mountains, within less than two miles, rise to a height of about 11,500 feet, while to the west, within four miles, Longs Peak reaches an elevation of 14,271 feet. Mr. Lamb is a close observer and has taken great interest in other observations as well as in these particular ones. He has kept a record of the rainfall as well as of temperature for a number of years.

Gleneyre is situated twenty miles east of Pinkhampton, on the opposite side of the high range of mountains which forms the northeast rim of North Park. It is situated on the Laramie river which runs nearly north and south, and is separated on the east side by a lesser range of mountains from the water shed of the North Poudre. It is, therefore, protected from winds from all directions except the north. The influence of the mountains is shown in the decreased rainfall noticed. The elevation is about 8,000 feet. Mrs. F. W. Sherwood has been the observer.

§ 55 At Westlake Mr. S. J. Peery has been the observer. This place is located about twenty miles southeast of Gleneyre and a few miles north of Manhattan near the Cache a la Poudre river. The elevation is about 8,500 feet.

Water Dale, Arkins P. O., is the home of Mr. P. H. Boothroyd. It is on the banks of the Big Thompson river at the junction of the foot hills with the mountains. It is situated about twelve miles south and as many west of Fort Collins. The elevation about 5,500 feet.

Loveland is 13 miles south of Fort Collins in the valley of the Big Thompson creek. Rev. W. H. McCreery has been the observer for some years. Elevation 5,000 feet.

LeRoy is located in the valley of the Platte a little over 100 miles east of Fort Collins, and nearly 50 miles west of the eastern border of the state. Mr. C. J. Green has carried on the observations at this place for a number of years with much interest.

TABLE 8.

PRECIPITATION, 1897.

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Year
Pinkhampton....	1.50	1.35	2.20	1.95	2.06	2.62	2.41	1.38	0.55	0.45	1.10	2.00	19.57
Estes Park	1.55	1.20	1.96	1.35	1.60	1.50	1.85	1.29	0.95	1.10	0.55	0.25	15.15
Gleneyre....	1.00	0.70	2.90	‡2.00	0.50	0.20	0.40	0.30	.....	1.20	1.60	1.65	......
Westlake.......	T	0.88	4.70	......	1.80	......	......	.....	......	......	......	....	......
Waterdale..... .	0.18	0.50	2.32	1.82	3.61	2.30	2.42	1.09	0.84	1.07	0.82	0.64	17.61
Fort Collins.....	0.18	0.54	2.15	1.39	2.06	1.69	2.65	1.74	0.75	0.75	0.67	0.67	15.24
Loveland........	0.15	0.54	1.98	0.94	1.21	......	......	......	0.39	......	0.59	0.63	......
Rocky Ford.....	0.75	0.37	0.20	0.44	......	.....	......	0.73	0.79	2.64	0.19	1.06	......
Cheyenne Wells..	0.26	0.10	1.58	1.20	1.44	2.22	4.21	3.24	0.92	2.73	0.10	0.20	18.20
Leroy............	0.60	0.72	1.66	1.77	3.98	2.24	1.39	2.79	0.41	2.61	0.40	0.81	18.48

‡ The record incomplete until the 12th, rest of month lacking.

SOIL TEMPERATURES.

§ 56. The weekly averages of soil temperatures down to depths of six feet are shown in tables 2 and 10 and are represented graphically in figure 16.

§ 57. Two sets of thermometers have been in use during the year. Set A in the instrument plat on the lawn west of the engineering building, where they were placed Jan. 15, 1897, and set C on a high knoll near the college barn. The exposure for set A was nearly the same as at the former location, a removal from which became necesby the construction of the new chemical laboratory. The surface of the ground was covered with grass, but was subject to inundation when the adjacent lawn was irrigated. This was considered a serious drawback to the location, but afterwards resulted in an unique illustration of the effect of irrigation on soil temperature, which is mentioned later.

§ 58. The temperature of the soil varies according to the character and color of the soil, the kind of covering and the exposure to the heat of the sun, as well as to a number of accidental influences. Those soils spoken of, especially in the East, as early, owe their character principally to their greater temperature, which accelerates the germination and growth of the plant.

§ 59. Figure 16 shows the averages of set A by weeks throughout the year. The shallow temperatures, even when smoothed by using the weekly averages, show much greater variations than the deeper ones. Some time is taken for the surface temperature to affect the lower thermometers. Practically the daily variation disappears before reaching a depth of six feet, and the daily change does not often exceed one or two-tenths of a degree. The heat wave moves slowly through the soil, so that while the highest temperature of the day is reached at a depth of three feet at nearly the same hour as at the surface, its temperatures correspond to those of the day before. This cannot be seen in the present diagram. The curves do, however, especially in the winter, show the lagging of the annual curve of temperature. Examining the curves of the three deeper thermometers, it will be seen that they reach the lowest temperatures at different periods, one at six feet about three weeks behind the one at three feet. It is about six weeks behind the surface temperature, though in this case the accidental and short period variations mask the annual curve at the surface. During the summer there is a corresponding lagging of the highest temperatures at the greatest depths, though the normal curve is altered by the irrigations to which the ground where the thermometers were placed was subjected.

TABLE 9.

WEEKLY MEANS OF SOIL TEMPERATURES SET A, 1897.

WEEK ENDING	DEPTH						WEEK ENDING	DEPTH					
	3 In.	6 In.	1 Ft.	2 Ft.	3 Ft.	6 Ft.		3 In.	6 In.	1 Ft.	2 Ft.	3 Ft.	6 Ft.
Jan. 2.....	28.20	30.08	32.07	34.74	38.24	44.69	July 10...	69.32	69.44	69.33	67.91	66.91	62.30
Jan. 9.....	24.40	27.04	30.09	33.61	37.45	43.95	July 17...	69.86	69.98	69.84	68.10	66.97	62.24
Jan. 16:....	27.50	29.16	30.99	33.43	36.86	43.33	July 24...	66.63	67.11	67.63	67.09	66.53	62.24
Jan. 23.....	29.06	29.81	31.03	33.84	37.14	44.16	July 31...	69.13	69.16	68.94	67.32	66.32	62.16
Jan. 30.....	23.56	25.36	27.99	33.17	36.61	43.64	Aug. 7..	69.25	69.54	69.46	67.79	66.71	62.19
Feb. 6.....	28.71	29.34	30.06	32.52	36.04	43.21	Aug. 14..	70.99	71.50	71.60	70.04	68.44	63.81
Feb. 13.....	32.04	30.80	31.11	32.60	35.83	42.68	Aug. 21..	68.37	69.87	71.54	72.41	72.26	68.43
Feb. 20.....	29.72	30.27	30.79	32.73	35.79	42.40	Aug. 28..	67.48	68.32	69.24	69.85	70.49	67.96
Feb. 27.....	27.91	28.93	30.11	32.74	35.69	42.07	Sept. 4..	70.16	70.74	70.57	69.51	69.44	67.16
March 6...	31.36	31.31	31.48	32.64	35.55	41.67	Sept. 11..	68.88	69.76	70.18	69.69	69.39	66.71
March 13...	31.73	31.84	31.84	32.79	35.53	41.47	Sept. 18..	64.09	65.56	66.80	67.69	68.16	66.36
March 20...	32.12	31.43	31.96	32.98	35.56	41.22	Sept. 25..	62.82	63.69	64.47	65.14	66.09	65.73
March 27...	33.39	32.87	32.02	33.27	35.74	41.09	Oct. 2...	62.60	63.49	64.28	64.63	65.39	65.00
April 3....	35.94	35.69	33.87	34.36	36.38	41.09	Oct. 9...	57.62	59.14	60.77	62.64	64.07	64.43
April 10....	39.26	39.74	38.82	37.33	38.14	41.32	Oct. 16...	52.75	54.23	56.38	59.28	61.62	62.64
April 17,...	46.77	46.89	45.12	41.71	41.04	41.96	Oct. 23...	47.12	48.65	51.14	55.37	58.58	62.44
April 24....	50.69	50.97	49.91	46.51	44.84	43.20	Oct. 30...	44.15	45.59	48.04	52.55	55.87	61.05
May 1.....	53.03	53.22	52.16	48.91	47.40	44.79	Nov. 6..	41.34	43.01	45.19	49.48	53.08	59.53
May 8.....	57.07	57.04	56.15	51.91	49.68	46.36	Nov. 13..	40.79	41.75	43.33	47.01	50.76	58.01
May 15.....	57.48	57.65	56.94	53.95	52.04	47.85	Nov, 20..	39.39	40.26	42.39	46.19	49.56	56.59
May 22.....	61.23	61.11	59.84	56.14	53.84	49.27	Nov. 27..	37.53	33.60	40.72	44.48	47.99	55.49
May 29.....	62.17	62.27	61.71	58.39	56.09	50.52	Dec. 4...	33.12	34.09	26.75	41.70	46.03	54.25
June 5....	58.70	59.20	59.63	58.21	56.84	51.94	Dec. 11...	32.53	32.28	35.[illegible]8	39.71	43.99	52.98
June 12....	60.3[illegible]	60.36	59.90	57.76	56.74	52.81	Dec. 18...	31.31	32.26	34.46	38.78	42.86	51.77
June 19....	65.33	66.17	66.30	65.25	64.64	60.74	Dec. 25...	27.57	28.17	30.87	36.16	40.78	50.56
June 26...	70.20	70.44	70.31	68.59	66.87	62.60	1898— Jan. 1....	29.66	30.19	31.33	35.08	39.49	49.40
July 3.....	70.27	70.24	70.06	68.20	67.06	62.44	Average..	48.35	48.99	49.68	50.45	51.72	53.49

TABLE 10.

WEEKLY READINGS (NOT AVERAGES) OF SOIL THERMOMETERS, SET C, 1897, (ON UNIRRIGATED GROUND.)

WEEK ENDING	DEPTH				WEEK ENDING	DEPTH			
	6 In.	1 Ft.	2 Ft.	3 Ft.		6 In.	1 Ft.	2 Ft.	3 Ft.
January 7	28.1	29.0	33.5	35.9	July 1	68.5	66.2	62.6	59.5
January 14	29.7	29.9	33.3	35.2	July 8	66.9	66.1	63.7	60.3
January 21	28.8	29.1	32.8	34.8	July 15	68.5	66.1	64.2	61.3
January 28	22.9	25.1	31.3	34.0	July 22	67.1	65.1	63.5	61.1
February 4	27.8	28.1	30.8	32.6	July 29	69.0	66.7	64.3	61.7
February 11	29.6	29.8	32.2	33.3	August 5	68.0	67.0	65.2	62.8
February 18	30.2	30.2	32.3	33.5	August 12	69.1	67.1	65.4	62.9
February 25	28.2	29.0	32.3	33.8	August 19	66.2	65.1	65.2	63.3
March 4	31.2	31.1	32.8	33.7	August 26	68.0	66.1	64.5	62.6
March 11	32.2	32.6	33.9	34.4	September 2	68.0	66.1	64.8	62.8
March 18	32.7	32.5	33.8	34.5	September 9	68.1	67.1	65.6	63.6
March 25	33.2	33.2	34.8	35.3	Septemqer 17	60.2	61.0	63.3	62.9
April 1	35.1	35.5	37.3	36.8	September 23	61.9	61.2	61.8	61.1
April 8	38.7	37.8	38.3	37.6	September 30	62.8	61.6	61.8	60.8
April 15	41.6	43.1	40.8	39.2	October 8	58.2	58.7	60.0	59.8
April 22	48.2	46.5	44.8	42.5	October 16	51.7	53.6	56.8	57.2
April 29	51.0	49.7	47.8	45.0	October 21	48.2	49.1	53.4	55.1
May 6	56.5	53.6	50.7	47.4	October 28	41.2	45.7	51.0	52.8
May 13	56.4	54.5	52.4	49.7	November 4	43.3	44.5	48.3	50.3
May 20	59.2	57.4	53.9	51.5	November 12	43.2	42.6	45.8	47.7
May 27	60.0	59.4	57.2	53.6	November 18	38.7	40.3	45.0	47.1
June 3	57.4	57.1	56.8	54.4	December 9	34.6	35.6	39.8	42.3
June 10	60.8	58.8	56.7	54.3	December 16	32.7	34.1	37.8	41.1
June 17	64.0	62.1	59.6	56.3	December 23	26.1	27.7	31.2	38.3
June 24	67.2	65.1	61.6	58.0	December 30	31.2	31.3	34.2	36.6
					Average	48.76	48.32	49.08	48.65

§60. The dates of the highest and lowest temperatures for the different years, and the observed temperatures are shown in table 11. Considerable variation is shown in the dates of the highest temperature, partly in the case of the deeper depths especially from the effect of flooding from irrigation waters. The date of minimum is less subject to extraneous influences. As the temperatures are observed at 7 a. m. and 7 p. m. only, the highest and lowest temperatures of the day of the shallow thermometers are not not observed and the diurnal variation would slightly affect these readings. For the deeper thermometers the diurnal fluctuation is very small.

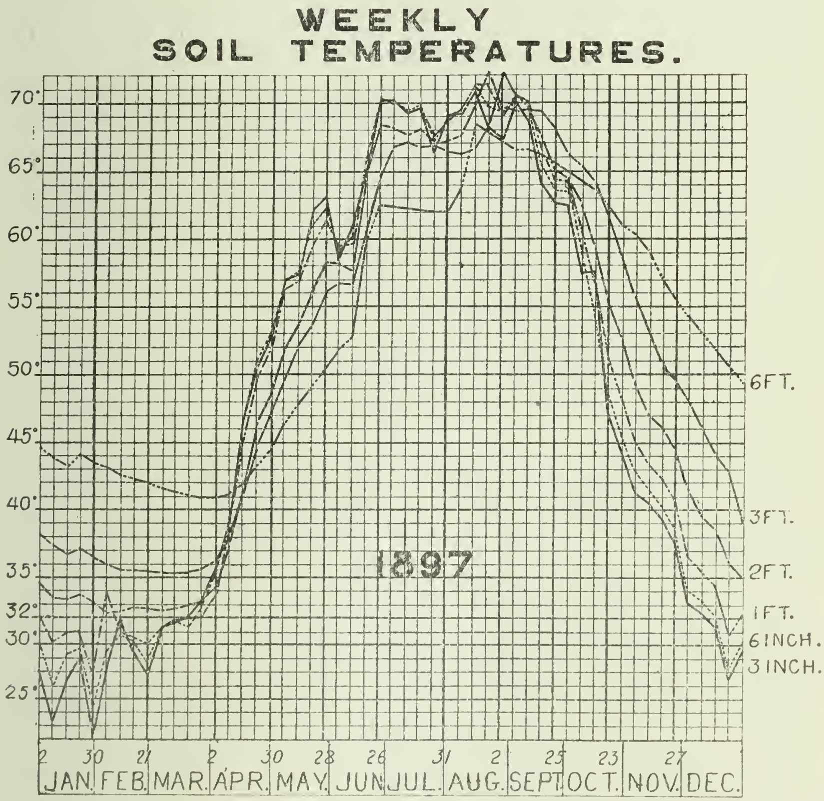


Fig. 16.

TABLE 11.

DATES OF EXTREME TEMPERATURES AT DIFFERENT DEPTHS FROM READINGS AT 7 A. M. AND 7 P. M.

Year	DEPTH											
	3 INCHES				6 INCHES				12 INCHES			
	Date	Max	Date	Min	Date	Max	Date	Min	Date	Max	Date	Min
1889	June 30..	87.7	Jan 9....	16.0	July 1...	81.2	Jan 9....	21.0	June 30....	76.8	Jan 21-22..	26.0
1890	July 1....	86.2	Jan 2....	14.5	July 1...	81.2	Jan 2....	20.0	July 16....	72.5	Jan 24.....	25.5
1891	July 24 ..	84.0	Feb 9....	17.8	July 11..	80.6	Feb 10...	21.9	....	....	....	....
1892	Aug 14...	84.2	Jan 13...	16.3	Aug 14...	80.8	Jan 11...	20.7	Aug 15	72.5	....	....
1893	June 28 to July 4	87.5	Jan 18...	21.3	July 5...	83.9	Jan 18...	26.0	July 5.....	76.1	Jan 21.....	30.3
1894	June 12..	78.6	Dec 28...	14.7	July 27..	76.1	Dec 28...	21.4	July 27....	71.5	Dec 28.....	24.3
1895	July 6 ...	83.2	Jan 15...	8.5	July 6...	78.8	Jan 15...	13.0	July 29....	71.6	Jan 15.....	19.2
1896	July 13 ..	90.8	Jan 4....	18.8	July 13..	86.1	Jan 4....	22.7	July 13....	77.1	Jan 4......	27.9
1897	July 7 ...	78.2	Jan 5....	18.9	Aug 12...	77.3	Jan 5....	23.9	Aug 12.....	77.0	Jan 5......	29.5

Year	DEPTH											
	2 FEET				3 FEET				6 FEET			
	Date	Max	Date	Min	Date	Max	Date	Min	Date	Max	Date	Min
1889	July 18..	67.3	Jan 28...	30.9	Aug 19...	64.6	Jan 29-31	33.3	Sept 5-10..	60.0	Mar 3......	39.2
1890	July 17 27 28-Aug 7.	66.9	Feb 11...	30.6	Aug 21..	64.6	Jan 29...	33.3	Sept 1-12..	60.0	Feb 18.....	39.4
1891	July 26..	68.7	Feb 14 16-17......	32.1	Aug 16 17 19-20...	65.6	Feb 19, 22 23, 26...	34.0	Sept 17..	63.8	Mar 12-23..	39.0
1892	Aug 17..	68.7	Jan 24-25	31.4	Aug 18...	65.5	Feb 28...	33.6	Sept 1.....	60.2	Feb 24-26..	39.6
1893	* July 6..	75.3	Jan 22...	32.6	July 24..	67.6	Jan 23-27 Feb 11..	34.8	† July 6.....	67.4	Feb 21,22-25	40.2
1894	‡ June 28..	69.8	Feb 25...	31.5	° June 28..	69.7	Feb 27-28	33.5	‖ June 28....	64.4	Mar 15.....	38.5
1895	Aug 2....	68.0	Jan 16...	27.5	Aug 7-8..	65.9	Jan 18...	32.8	Aug 30 to Sept 19....	61.0	Feb 28 to March 1 .	39.3
1896	Aug 15-17	71.9	Jan 6....	31.6	Aug 16-17	69.5	Jan 8, 17, 18	35.5	Aug 24-25..	62.8	Feb 17-22..	41.0
1897	Aug 12...	§ 76.1	Feb 2....	32.4	§ Aug 17 ..	§ 73.6	Feb 2-10.	35.5	§ Aug 16....	§ 75.5	Mar 24 to Apr 2.....	41.0

* Water applied to lawn 69 2 July 31 was probably the highest otherwise.
† " " " " 62.6, Sept 11-13 " " " "
‡ July 31 68.5, unaffected by water.
° Aug 22 66.7, " " "
‖ Sept 2 62.5, " " "
§ Affected by irrigation.
Observations made at 2 and 9 before July 1, 1889.

AN ILLUSTRATION OF THE INFLUENCE OF IRRIGATION ON SOIL TEMPERATURE.

§61. The control which irrigation gives of soil conditions is well known by students of irrigation and is more or less realized by farmers in the arid regions. The extent of this influence is, however, not often recognized, and it is rarely that an illustration as clear as was shown by the soil temperature observations during August, 1897, is to be obtained. In this case our soil thermometers being placed in the grass plat were so situated, that the irrigation of the lawn flooded, to a depth of some inches, the ground where the instruments were placed, and the irrigation was continued long enough to saturate the ground underneath. The temperature at a depth of six feet had been nearly uniform at 62° for a number of weeks before the date of irrigation on August 12th.

§62. With the application of the water it is noticed that the temperature immediately rises, reaching a temperature of 71° almost immediately after. The temperature fell almost immediately after the irrigation, so that during the next three days it had fallen to 64½°. On August 16th the irrigation was repeated, and this time the effect of this added to the effect of the first was to increase the temperature to 75½°. The temperature dropped rapidly to 69°, and then dropped gradually, not again reaching 62° until October. The effect of irrigation on the plat of ground and its vicinity, was felt for more than a month.

§63. The effect on the temperature at two feet and at at three feet in depth was much the same. At the first irrigation the temperature at two feet was increased over that at the lower depths. At the second irrigation the effect on the deep thermometer was almost as great as upon the two foot thermometer.

For the depths less than two feet, the diurnal fluctuation is marked, and as the corresponding curves confuse the diagram, they are omitted. The shallower thermometers also show the cooling effect from evaporation so much that their temperatures fell below the deeper ones.

§64. In view of the influence which temperature has upon the growth of plants, the importance of the fact shown in the diagram is apparent. Evidently the irrigator can increase the temperature of the soil by application of water of proper temperature. It is also evident from corresponding observations at the shallower depths, that the cooling efect on the soil from evaporation may be considerable.

§65. But as the application of water warmer than the soil will carry heat down into the soil and raise the temperature in spite of the cooling effect of evaporation, so an application of colder water has the opposite effect and chills the soil, both by the direct abstraction of heat and from evaporation.

§ 66. The diagram is here given because of its suggestiveness, and to call attention to the influence of the temperature of the water used. It also suggests a reason why most farmers find it undesirable to irrigate early in the spring and why fall irrigation is sometimes so advantageous irrespective of the need of moisture.

The importance of considerations of this kind, illustrated by the diagram, will be considered more extensively when the observations on irrigation and on soil temperature are published.

OBSERVATIONS SHOWING THE EFFECT OF IRRIGATION ON SOIL-TEMPERATURE

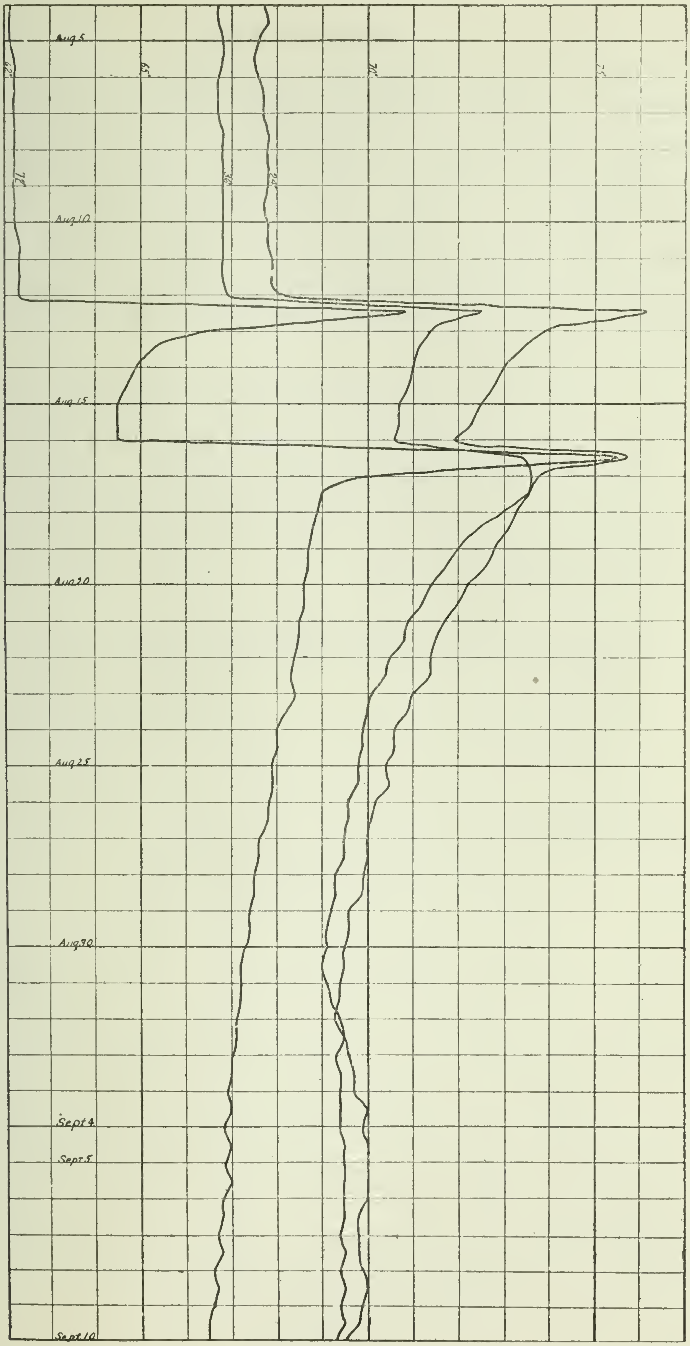


Fig. 17.

EVAPORATION.

§67. Table 10 gives the evaporation from our standard evaporation tank. This is sunk in the soil level with the surface. Observations with the hook gage are made twice per day from April to September, gage reading to one thousandths of a foot. At the same time the temperature of the water surface is observed twice per day at the maximum and minimum temperatures. During September and October the reading is made once daily. During the winter months ice forms and the observation is made at the beginning of each month.

It is found that the evaporation runs from one to two inches per month during the winter. The evaporation during the night is practically as rapid as during the day.

§68. An attempt was made to obtain a formula from the observations of 1889, and with enough success to compute the evaporation in 1890 from May to October with a difference of less than half inch. The formula was as follows: $E = .39\ (T - t)\ (1 + .02W)$.

E represents the evaporation in inches in 24 hours.

T is the vapor tension corresponding to the temperature of the surface of the water.

t is the vapor tension corresponding to the temperature of the dew point at that time.

W represents the number of miles of wind in the 24 hours.

Observations have since been made to obtain a more perfect formula, but are not yet reduced.

TABLE 12.

EVAPORATION FROM WATER SURFACE, TANK 3x3x3 FEET, FLUSH WITH GROUND AT FORT COLLINS, COLO.

Latitude 40° 34′; Longitude 105°+; Elevation 4,990 feet.

YEAR	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1887	2.46	3.23	4.60	5.55	5.19	5.75	5.23	4.24	4.12	3.26	1.48	1.60	46.71
1888	... ..	. ...	......	......	4.45	†7.70	†7.00	4.06	3.94	2.17	1.35	0.99	......
1889	1.08	1.03	2.75	4.06	3.72	4.34	5.20	5.15	5.19	3.28	0.62	1.42	37.84
1890	0.86	2.36	3.58	3.50	4.32	5.71	5.44	5.76	3.69	2.71	1.32	1.10	40.25
1891	*1.89	1.90	2.23	2.24	5.03	4.97	5.72	4.91	4.12	3.62	1.74	0.75	39.12
1892	2.51	‡2.15	2.78	3.58	3.49	4.20	4.69	5.64	5.11	3.33	1.93	1.13	40.54
1893	P	*1.52	3.79	5.40	5.12	6.12	6.41	4.73	5.04	3.79	1.05	1.38	......
1894	†1.14	†1·15	1.95	4.61	4.66	5.01	5.74	4.88	3.77	3.75	1.64	1.22	39.52
1895	†1.19	†1.19	P	4.91	4.27	4.13	4.57	4.52	4.06	2.24	1.53	1.68	......
1896	2.64	2.25	2.39	4.71	5.91	5.09	5.23	5.80	3.34	2.94	1.62	1.25	43.17
1897	1.80	2.20	P	3.33	4.13	4.26	4.64	4.76	3.97	2.88	1.47	0.94	......
Average	1.73	1.90	3.00	4.19	4.57	5.21	5·44	4.95	4.21	3.09	1.43	1.22	40.94

* Record from part of month.
† From record of two months.
‡ From record from February 17.
P Tank punctured, record lacking.

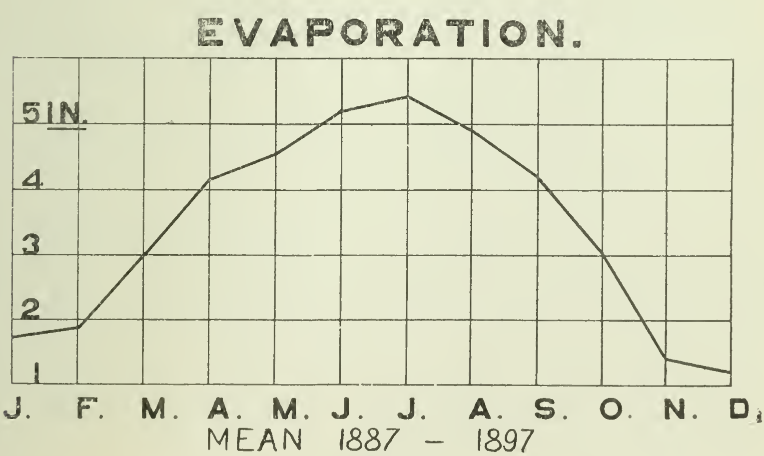


Fig. 18.

TABLE 13.

§69. The wind movement for the year has amounted to nearly 60,000 miles. March and April have been the windiest. By months the record is as follows:

	Direction.	Number of Miles.
Jan.,	N. W.	5058.3
Feb.,	W.	5622.6
March,	W.	7038.7
April,	N. W.	6614.3
May,	N. W.	4968.4
June,	E. W.	4302.5
July,	S. W.	4274.2
Aug.,	N. N. W	3532.4
Sept.,	N. W.	3483.4
Oct.,	N. W.	4723.9
Nov.,	N. W.	5003.3
Dec.,	N. W.	5534.7
Total for year		59356.7
Average	N. W	4946

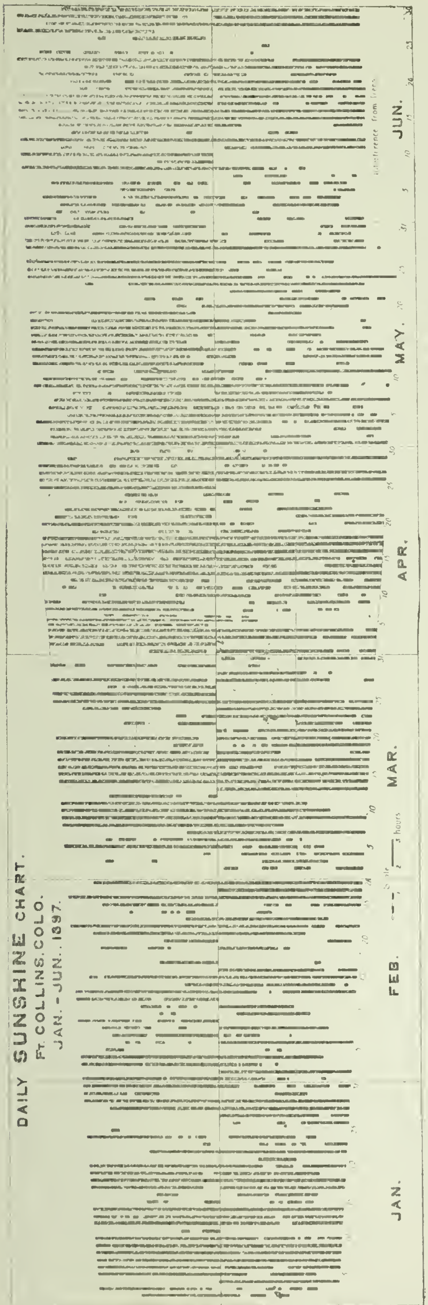
SUNSHINE.

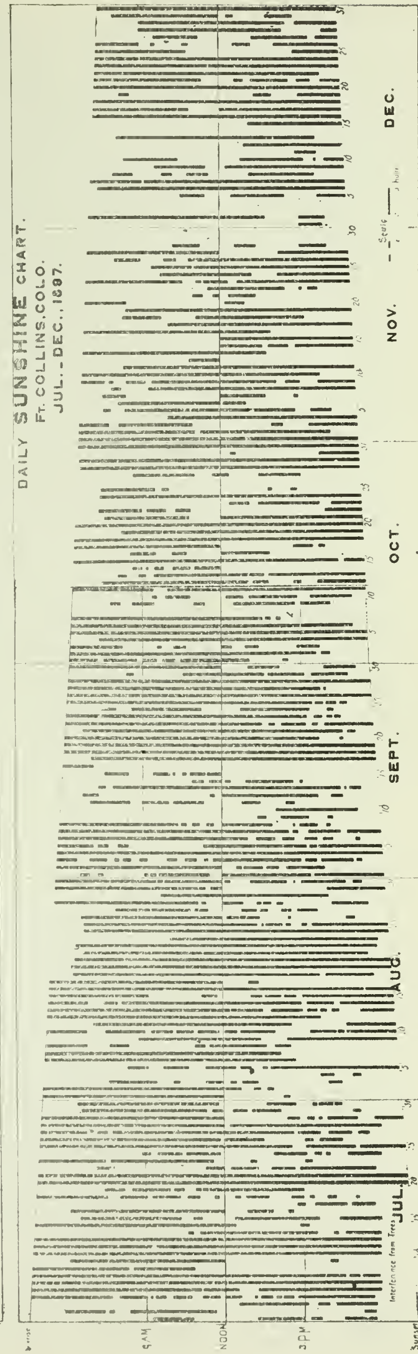
§70. Instead of giving the sunshine throughout the year by tables, an attempt is made in figure 19 to show graphically the amount through the year, showing not only the amount received each day, but the time when it occurs, which would be impossible to show clearly in a table.

A space is given for each day. The occurrence of sunshine is shown by the heavy line and the length of the line shows the duration of the sunshine, which can be determined by comparing with the scale. Cloudiness or the absence of sunshine is shown by the line being blank.

The upper line in the diagram represents the time of sunrise,—when, on a clear day, sunshine should begin,—the lower line, sunset. The distance of these lines from the middle line, representing noon, is proportional to the length of the forenoon and of the afternoon respectively. Allowance has been made for the shortening of the afternoon due to the presence of mountains on the western horizon. The two other lines represent 9 a. m. and 3 p. m., and are placed three hours distant from the middle or noon line. The time is, therefore, counted in apparent or sun time, without allowance for the equation of time.

If, therefore, the sun shines from its rising to its setting,


DAILY SUNSHINE CHART.
FT. COLLINS, COLO.
JAN.-JUN. 1897.
JAN.
FEB.
MAR.
APR.
MAY.
JUN.
Interference from Trees


DAILY SUNSHINE CHART.
FT. COLLINS, COLO.
JUL.-DEC., 1897.
JUL.
AUG.
SEPT.
OCT.
NOV.
DEC.
Interference from Trees
9AM
NOON
3PM
Sunset

the full line extends from the sunrise to the sunset line. If a cloud obscures the sun for a time, this is indicated by a break in the line, and the duration of the obscuration is shown by the length of the break. Hence the broken lines represent intermittent sunshine, or days of floating clouds. The spotted character of the diagram in the same months shows a feature noticeable in our mountain meteorology; fair weather in the forenoons, and of floating cumulus clouds or local thunder storms in the afternoons.

§ 71. The chart has been made from the photographic record made by means of the Pickering sunshine recorder, already described. As the intensity of the sunlight is not enough to record near sunrise or sunset, some element of judgment is involved both in the table and in the diagram in estimating the period of about half an hour near those times. As the diagram and the measurement were made by different persons, there may be a slight discrepancy in estimating this period in the two cases.

The distribution of the sunshine through the year is noteworthy, and to those interested in Colorado climate, whether as agriculturists or as health seekers, the chart will prove worthy of careful examination.

It will be noticed that there are many days on which the sun shines throughout the whole day; there are very few when it does not shine for a greater or longer time, but there were several days in 1897 when no sunshine is recorded by the sunshine recorder. The groups of sunshiny days are also noticeable in the diagram, their occurrence usually being at the same time as a wave of high barometric pressure.

§ 72. The important effect of sunshine on the maturation and quality of grains, the coloration of fruits and flowers, and its important influence from a sanitary standpoint, are too well recognized, to need more than a reference here. From the standpoint of Agricultural Meteorology both the amount and the intensity of sunlight are among the most important of the elements to be observed and studied, and while the connection between the sunlight and the growth and development of plants is complicated and surrounded with many difficulties, some of the definite relations are not beyond the possibility of determination. Records of the amount of sunshine since 1888 have been kept by similar methods at a number of stations and later it is hoped to give a more complete discussion of the questions relating to sunshine and its agricultural importance.

TABLE 14.

SUNSHINE 1897, SHOWING NO. OF HOURS AND MINUTES OF SUNSHINE OBSERVED AND THE PER CENT OF THE POSSIBLE.

MONTH	Sunshine to 9 a. m.		9 a. m. to Noon		Noon to 3 p.m		3 p. m. to Sunset		For Month	
	hrs min	Per Cent	hrs min	Per Cent	hrs min	Per Cent	hrs min	Per Cent	Total Hours	Per Cent.
January	26—43	45.8	60—41	65.2	63—03	67.8	23—08	50.0	173—35	60.4
February	26—20	41.4	47—40	56.8	53—49	64.1	22—30	41.1	150—19	52.6
March	41—37	46.0	55—53	60.1	62—48	67.5	43—59	54.1	204—17	57.1
April	61—38	68.5	66—01	61.4	51—09	56.8	50—12	50.7	229—00	59.2
May	81—06	63.1	77—32	83.2	55—25	59.6	49—19	40.7	263—22	60.5
June	76—38	57.7	60—02	66.7	48—17	53.6	51—11	40.5	236—08	53.8
July	83—18	62.8	73—00	78.5	55—57	60.2	66—42	53.2	278—57	62.8
August	69—01	54.2	78—26	84.3	63—35	68.4	52—37	48.4	263—39	64.0
September	51—31	65.8	65—31	72.8	71—49	80.0	44—24	52.0	233—15	64.9
October	42—33	53.3	65—15	70.2	63—09	70.2	36—53	53.0	207—50	63.1
November	19—55	35.3	55—00	61.1	60—11	66.9	24—04	48.5	159—10	56.0
December	19—15	42.3	54—37	57.7	59—18	62 6	25—18	60.8	158—28	57.3
Total Hours	599—35	......	759—38	......	708—30	......	490—17	......	2559—27	......
Average Per Cent	52.0	......	69.4	......	64.7	......	48.9	......	59.6	......

ACKNOWLEDGMENTS.

The planning of the observations, their character, and all questions of the forms of instruments, methods of observation and of reduction, corrections, etc., the head of the section is responsible for. The observations themselves in 1897 have largely been taken by Mr. Trimble and their reduction has been made or verified by him. During June, July and August, during the absence of Mr. Trimble assisting in other investigations, the observations were made principally by Mr. H. F. Alps, now connected with the U. S. Weather Bureau, but the reductions have been made or verified by Mr. Trimble. In September most of the observations were made by Mr. J. D. Stannard. The sunshine records were measured and the monthly sums found by Mr. W. R. Headden, now of the senior class in the Agricultural College. The diagrams representing thevarious observations, in figures 12 to 19 have been made by Mr. J.

C. Mulder, now of the senior class in the Agricultural College, who was employed as draughtsman during the summer.

The figures illustrating the instruments referred to have been obtained from the manufacturers, the names attached showing the source. Those of the French firm of Richard Freres, were copied from their catalogue. Figure 8 is from the firm of W. and L. E. Gurley, of Troy, N. Y. The figure of the statoscope record is due to the courtesy of the Engineering News Pub. Co., N. Y., the figure being made from records taken here.

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THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO 50.

Notes on Plum Culture.

Approved by the Station Council,
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

DECEMBER, 1898.

Bulletins will be sent to all residents of Colorado, interested in any branch of Agriculture, free of charge. Non-residents, upon application, can secure copies not needed for distribution within the State. The editors of newspapers to whom the Station pubications are sent are respectfully requested to make mention of the same in their columns. Address all communications to the

DIRECTOR OF THE EXPERIMENT STATION,
Fort Collins, Colorado.

EXPRESS, FORT COLLINS

THE AGRICULTURAL EXPERIMENT STATION,

FORT COLLINS, COLORADO.

NOTES ON PLUM CULTURE.

BY CHARLES S. CRANDALL.

Prefatory note on the application of horticultural rules.

There are certain general rules in the practice of horticulture that are capable of wide application. If we say that cherry trees should never be planted on wet or mucky soil, we state a general rule, equally applicable to any section of the country.

There are certain other rules, such as those governing the choice of varieties, selection of stocks, season for and manner of budding or grafting, time of planting and frequency of irrigation, that may be called specific rules. These are of necessity local in character and may be quite restricted in application.

Possibly no state presents greater diversity in local conditions that govern horticultural practice than does Colorado. Not only do wide differences exist between eastern and western sides of the Continental Divide, but either slope may be divided into sections that would warrant considerable differences in practice on many points, and then, each section may have peculiarities that would subdivide it. Even the differences between the two banks of a stream, or the varying soil conditions of two adjoining farms, may present factors that modify successful practice.

If a man moves from one section to another he will naturally attempt to grow the varieties and follow the methods with which he is familiar. He meets failure in many particulars and after a time learns by experience that his new surroundings call for different methods and likely different varieties. It has always been the experience in new countries that the pioneers in horticultural work made mistakes which they found expensive and discouraging, but by persistence they learned to avoid the early errors and finally achieved success. Later comers can, and should, profit by the experience of these pioneers. The methods they have found successful can be safely followed, no matter how they differ from those successfully practiced elsewhere.

The specific rules to which I here refer are often discussed in public, and frequently the views expressed are very diverse. Two men may discuss a particular practice, each persistent in holding his honestly expressed conviction, derived from personal experience, to be the only correct one. Each knows he is right and no amount of discussion will bring them to the same view. The newcomer seeking information is confused by the opposite views so strenuously contended for. Transactions of societies and the horticultural press bear evidence that such discussions are not infrequent. The writer is of the opinion that in many cases these discussions do more harm than good, or are at least profitless, because they are dropped with the differences unexplained. Inquiry will often bring out differences in the local conditions under which the experiences have been acquired that will fully account for the diverse views expressed.

The idea that I would emphasize and urge upon those who contemplate entering upon horticulture as a business is, that a careful study should be made of all the conditions surrounding the particular place chosen. Sum up the experience of the pioneers, consider the liability to late spring frosts, and early fall frosts, to storms and winds. Examine into the water supply, soil, subsoil, slope, exposure, direction of prevailing winds, and every other feature that may have bearing upon future success. Attention to these factors will enable intelligent action, saving expense and avoiding disappointment.

I am lead to dwell in some detail upon this matter of the application of specific rules because so many requests for advice on the points enumerated are constantly being received. Usually inquiries are unaccompanied by any statement of local conditions or aims in view, and it is difficult, often impossible, to give the desired information except in the most general terms, and this is unsatisfactory both to the writer and to the seeker after information.

DERIVATION AND DISTRIBUTION OF OUR PLUMS.

The genus Prunus as now constituted embraces those species from which have been developed all our stone fruits, Almonds, Peaches, Nectarines, Apricots, Plums and Cherries. Its representatives are widely distributed over the earth and the number of species as given by different authors varies greatly. Bentham and Hooker in their Genera Plantarum place the number at about eighty. A later work, the Index Kewensis, recognizes 121 species, and records 290 names as synonyms. The 121 species here considered valid are distributed as follows:

Eastern hemisphere 87 species, 15 of which are credited to Japan and 12 to China. Western hemisphere 32 species, 21 of which belong to the United States and the region north. Seven are credited to Mexico and four to South America and the West Indies. Two species are recorded as of unknown origin.

Our American manuals record species of the genus as follows:

Botany of California (1876), 6 species.

Chapman's Flora of the Southern States (1883), 7 species.

Coulter's Manual of the Rocky Mountain Region (1885), 5 species, 1 variety.

Gray's Manual, 6th Ed. (1890), 10 species, 1 introduced variety.

Coulter's Flora of Texas (1891), 8 species.

The Britton and Brown Flora (1897), 16 native, 4 introduced species, 2 native and 1 introduced varieties.

Taken together these floras recognize 27 native and 4 introduced species, and 3 native and one introduced varieties.

Of the native representatives of the genus, 16 species and 1 variety are true plums, or of such close affinity as to readily class with them, while 11 species and two varieties are cherries or belong with the cherry group. Nearly all the species enumerated in the manuals are, or have been at some time, introduced into gardens and cultivated, either for their fruits or as ornamentals, but the varieties now catalogued by nurserymen and grown in orchard, represent but few species. Of the native cherries only the shrubby sand-cherries (*Prunus pumila*, *P. Besseyi*, and *P. cuneata*) are grown for fruit. The Wild Red Cherry (*P. Pennsylvanica*) is occasionally used as a stock upon which the common sour cherries, of European origin, are grafted; it has also been used to a limited extent as a stock for some of the plums.

Of the native plum group, three species (*P. Americana*, *P. hortulana* with its variety *Mineri*, and *P. angustifolia*) have furnished nearly all of the cultivated varieties. The Beach plum (*P. maritima*) is the parent of but one variety of doubtful value. The Mariana so largely used for stocks, and the De Caradeuc are closely related, but of uncertain origin. A few varieties are probably hybrids, although the manner in which most of them originated is more a matter of speculation than of definite knowledge. There are still other varieties that cannot even be classed as hybrids and whose ancestry is likely to remain undetermined. Professor Bailey of Cornell, who has given the whole plum group careful study, arranges the native varieties into groups as follows:*

The American Group—*Prunus Americana.*

The Wild Goose Group—*Prunus hortulana.*

The Miner Group—*Prunus hortulana* var. *Mineri.*

The Chicasaw Group—*Prunus angustifolia.*

The Mariana Group—Of uncertain origin. De Caradeuc assigned to *Prunus cerasifera*, and Mariana thought to be a hybrid.

The Beach Plum—*Prunus maritima.*

The Wild Plum of the Pacific Coast—*Prunus subcordata.*

Hybrids, unclassified varieties—Of uncertain origin.

Our foreign introductions belong to two groups:

The European Plums, such as Lombard, Green Gage, and the numerous prunes—*Prunus domestica.*

The Japanese Plums—*Prunus triflora.*

While the European plums can be grown in some sections, the tender nature of the fruit buds makes them uncertain on the eastern slope, except in favored localities, and dependence must be placed mainly upon the Americana varieties. In the fruit districts of the western slope the Wild Goose is eminently successful and stands at the head of the list of profitable varieties, but it is probably too tender for the eastern slope, certainly for the northern and central districts.

In general throughout the West the native plums are proving profitable. Even in districts where the domestica varieties are successfully grown, the native red plums sell in competition with them, and at remunerative prices. While it may be admitted that most native varieties are inferior in size and flavor to those of the domestica class it, should be remembered that the extended introduction of the natives is comparatively recent, that the improvement in them has been rapid, and that they offer wonderful possibilities in the direction of future development. All the

* See bulletin No. 38, Cornell Experiment Station.

better varieties are very productive. Some show a strong tendency to excessive production, a habit which if allowed to go unchecked, not only gives inferior fruit, but tends to shorten the life of the tree. With such varieties systematic thinning must be practiced in order to insure regular crops, and fruit of the largest size and best flavor. Then, having produced good fruit, if the grower will exercise the same care in handling that is given other fruits, and will place them on the market in the same attractive packages, the demand which already exists will be greatly stimulated.

PROPAGATION OF THE PLUM.

Most varieties of plums have come to us as seedlings selected and retained because of their good qualities; they show development or variation from wild types in varying degree, but with all, the departure is such that we can not reproduce them through the seed, and in order to maintain them we are forced to adopt other means.

All varieties are perpetuated by either budding or grafting, usually on plum stocks. The kinds available as stocks are various and exhibit as great differences as appear between the varieties to be propagated. No one stock can be regarded as perfectly satisfactory for general use with all varieties, and it follows that care and thought must be exercised in making choice of what shall be used.

The character of the soil, whether light or sandy, or verging on the other extreme of heavy clay, and the general features of the climate will largely govern this choice, but consideration must also be given to the characteristics of the varieties to be propagated.

The desirable varieties have parentage in widely different species, each of which has characteristics peculiarly its own. The derivative varieties follow more or less closely after the parent species, inheriting habits, likes and dislikes, which must be regarded if we achieve success in their management. Even among derivatives of the same species we may find varieties sufficiently different to call for the use of different stocks and different methods of treatment. This would be looked for among the varieties that have been under cultivation for the longest periods, and is due to the fact that the variation and development from the original type has not been along parallel lines. Differences in climate, in food supply, and in general environment have led to divergence resulting in races which possess distinctive and well-marked characters.

Some knowledge, therefore, of the history and derivation of varieties is essential to the propagator in order that he may make intelligent selection of the stocks upon which to work his profitable varieties. Successful propagators, well versed in the history of varieties, and in the principles of culture will, however, often differ in their estimate of available stocks, just as they will differ on methods of practice. Strong growing varieties are not suited to very slow growing stocks because they over-top them and the trees are short lived. On the other hand success does not follow the attempt to force a slow-growing variety by working it upon a rank-growing stock. The nearer the variety to be grafted corresponds with the stock to be used in general habit and vigor of growth, the better will be the prospects for health and longevity in the tree.

Figures 1 and 2, Plate I, illustrate an overgrowing of the stock that is not uncommon. Figure 1 is a Yellow Sweet, (*Prunus Americana*,) planted in 1894. The enlargement just above the union is marked, and it is increasing each year. Figure 2 is a Wolf (*Prunus Americana*) tree of uncertain age, probably 14 or 15 years old, in which the enlargement is still more marked. We have no information as to the stocks used in either of these cases, but the fact that there is not perfect affinity between the varieties and their stocks is apparent.

For the European plums such as Lombard, Green Gage, and Bradshaw probably no stock is better than seedlings of some variety of the species from which these varieties came —*Prunus domestica*. These have been in common use for many years, but in recent years have been in some degree superseded by Myrobalan stocks (seedlings of *Prunus cerasifera*, a species of European origin). Myrobalan stocks are in common use in European countries and have rapidly grown in favor with our nurserymen, not because better trees can be grown upon them, but because it is easier to secure good Myrobalan than good domestica stocks. Seeds of domestica varieties that will produce an even stand of stocks is difficult to obtain, and the Myrobalan, which is easier to grow and less liable to injury from parasitic fungi, offers an acceptable substitute. Some nurserymen import the seeds and grow their own stocks, others find it more profitable to import the seedlings. They are usually received during the winter, planted in nursery rows in spring, and budded in July and August. In the south the stocks in common use are the Marianna plum and the peach, and very diverse opinions as to their relative merits have been expressed. Probably the differences arise from varying local conditions, for the testimony at hand indicates that on the light and dry soils the peach stock does best, while the Myrobalan is better suited to the heavier and more moist soils. Even at the north the peach meets with some favor as a stock for plums on light soils, but it is too tender for districts where severe winters are common. For the native varieties, Wolf, Weaver, De Soto and other derivatives of *Prunus Americana*, the natural inference that Americana stocks would be best seems to be borne out by experience, but the degree of success may depend in a measure upon the seed used. The species is extremely variable in general habit and rapidity of growth as well as in the fruit produced. Seeds from which to grow stocks should be chosen from vigorous free-growing trees only. The progeny of such trees will most nearly accord with the varieties to be propagated and better insure the future of the tree. Seeds are obtained in the fall, separated from the pulp, mixed with sand and kept in a cool, moist place, during the winter. If they can be frozen and thawed several times, so much the better, for they will then more readily crack under the pressure of the swelling embryo.

In spring they are sown in seed beds of deeply stirred rich soil. In the fall the seedlings are lifted, sorted and packed away in sand in a cool pit or cellar. The following spring they may be planted in nursery rows to be budded in July and August. The commencement of the budding season is determined by the maturity of the scion buds to be used; they are buds of the current year's production and must be well matured. Budding may be continued as long as the bark will "slip," and this as well as the maturation of the scion buds will be largely influenced by weather conditions. The length of the budding season may, therefore, vary greatly in different years. Usually the season with plums is shorter than with peaches or apples. About ten days after insertion the buds should be examined and the bands loosened if necessary. Where buds have failed to unite, the stocks may be rebudded and this may be repeated as often as the length of the season will allow. Late in the fall stocks on which buds have failed should be taken up and stored for grafting in late winter or early spring. When growth starts in the spring the budded stocks must receive prompt attention. The stock must be "headed down," that is, cut off above the bud, and here practice varies somewhat.

Some growers prefer to cut from four to six inches above the bud, while others would at once cut as close to the bud as it is safe. The idea in cutting high is to leave a stub which may serve as a support to which the shoot from the bud may be tied, the stub being removed at the close of the first season's growth. All shoots below as well as above the scion bud must be removed, otherwise they will starve the bud by diverting the sap to their own development. Further production of these shoots from the stock will occur, and they must be frequently checked in order to secure the best growth of the scion.

By far the greater number of plum trees grown commercially are produced by this process of budding. It is the easiest and best way when trees are grown in quantity, but as good trees can be produced by grafting, and often it is more convenient to graft than to bud. Here at the station we have used both methods and have found grafting rather more uniformly successful than budding. During the budding season the weather is hot and dry, and frequently no water is availabie for irrigating; many buds dry out and fail to take, so that under conditions similar to ours the writer believes the method of propagating by grafting will give the best satisfaction, and particularly to the fruit grower who propagates in a small way for his own use. I am aware that the idea is current that stone fruits, and particularly plums, are difficult to graft. It is true that certain precautions must be observed that need receive little attention when grafting the apple, but these simple precautions taken, the work is no more difficult and success is as certain as with the apple. Of course the mechanical work of putting scion and stock together must be well done, but outside of this there are three points upon which success mainly depends:

1st—The perfectly dormant condition of both stock and scion at the time the operation is performed.

2nd—The protection of the union by coating with wax.

3rd—Proper care of the plants between grafting and setting in nursery.

The work is usually performed during March or April, and may be continued so long as the dormant condition can be maintained. Plums, however, start growth under slight stimulus, and a few warm days will end the work, even when all ordinary precautions have been taken. We have frequently filled the passage-way in our outside storage-pit with snow and ice as a means of keeping the temperature down, and have thus gained a few days. It is best to commence early enough so that the finish need not be hurried by the weather conditions.

Scions must not only be dormant, but must be otherwise in good condition, neither wilted from drying, nor water soaked from being kept too wet. Sometimes it is convenient to take them from the trees as wanted; more frequently they will be cut late in the fall, or come from a distance, and the question of how to keep them will present itself.

They may be kept in an outside cellar or pit, packed in dry leaves, or in moss that is but slightlv damp. The aim should be simply to provide conditions that will prevent the loss of moisture, without affording opportunity for the absorption of an excess.

The particular method of grafting to be used is much a matter of taste. Several are available, among which the four following are named in the order of the writers preference: Veneer, Side, Whip and Cleft.

The side graft is probably in more general use than any of the others, but after several years experience with all of them we are inclined to favor the veneer method as giving the most perfect union.

It is not our purpose to here discuss the principles of grafting, but may remark that in all grafting no union takes place between cut surfaces of the wood. It is only through the adjustment of the cambium of the scion to that of the stock that union is secured, and here, it is not a union between cells existing at the time the grafting is done, but through new cells formed in extension of the cambium, which is the only channel of communication between leaves and roots. This being true it seems reasonable that the less the area of cut wood surfaces the better. The minimum of cut wood is secured by the veneer graft, which only exposes the wood in the oblique transverse cuts at the apex of the stock and the base of the scion. The one valid objection that may be urged against the veneer graft is that the scion is easily displaced. It is easily displaced if carelessly tied, but with reasonable care no trouble need be feared.

Whatever the method used the union should be thoroughly covered with some protective wax. A liquid wax to be applied with a brush is most convenient, and of several preparations one known as "Alcoholic Plastic" answers the purpose admirably. It is made as follows: One pound of Resin, and one ounce of tallow melted together; remove from the fire, and after cooling slightly, but while still liquid, add eight fluid ounces of alcohol and stir thoroughly. This preparation must be kept in a corked bottle or other closed vessel to prevent the evaporation of the alcohol.

After waxing, the grafted stocks should be returned to the cellar and kept at as low a temperature as possible without freezing until the time arrives for setting in nursery. The roots may be placed in damp sand, but the scions should be subjected to such a degree of moisture only, as will prevent drying out. The practice as here outlined is successfully followed in our station work. In all grafting of plums the scion should be set low on the crown so that when planted in the nursery the union may be placed well below the surface.

The plum is seldom worked above the ground, and there seems to be nothing in the practice to commend it for practical purposes. If it is attempted it should only be with varieties of close affinity, and trees of equal vigor. Scions from a slow-growing tree can not keep pace with the branches of a strong-grower, and if the strong scion is worked on the slower stock it soon out-grows it and the wind breaks it off. A scion of Indiana Red worked on a wild Americana stock three feet above the ground produced a straight whip five feet and four inches long; three feet above the union the new growth had the same diameter as the stock at the ground. It yielded to a moderate wind.

Sometimes when new varieties are procured for trial, a few scions are worked on old trees of some Americana variety with a view to obtaining fruit quickly. Thus trees of Ogon planted in 1894, have not yet fruited because the tops have killed back every year, but scions from the same trees, taken at the time of planting and worked on Prunus Americana have given us fruit for four seasons. Several other varieties treated in the same manner at the same time, have fruited, but all, or nearly all are now dead.

PRUNING.

Plums are pruned for the purpose of forming and maintaining a symmetrical, well-balanced top. Five or six branches, equally distributed about the stem, and having some vertical separation are selected to serve as a framework of the top. All others are removed and the leader is shortened. The branches retained should be cut back to some extent, but this, as well as the shortening of the leader must be determined for each tree, being dependent upon the root system and the apparent vigor. In shortening the branches and leader, the cuts should be made with reference to selected buds so placed that the future extension may be in the right direction. During the summer, rub off shoots that start where they are not wanted, and pinch the tips of rampant branches. The second spring, before growth starts, the shoots produced the previous year should be shortened to encourage the production of secondary, interior branches, and the third year this is repeated. From now on no pruning is needed except to remove branches starting from wrong places, and to control the too vigorous branches. This is best done by summer pinching, and in general it may be said that the less the knife is used on plum trees, the better it is for the trees. Most varieties require very little pruning after the head is once formed.

SOILS.

Plums will adapt themselves to almost any soil that would be chosen for apples or pears. Domestica varieties are perhaps best on heavy clay, and choice may be more restricted with them than with most other sorts. The native varieties are suited to a wide range of soils, but no tree will do well on wet mucky soils, and as the plum is a rank feeder and a heavy bearer, the soil must be of good fertility.

Colorado soils are in general well adapted for the plum, but even on the best, good cultivation and the systematic application of fertilizers is to be recommended.

IRRIGATION,

Frequency in the application of water is so entirely dependent upon the character of the soil that no rule can be made to govern it. How best to irrigate must be learned by experience for each orchard. In a general way it may be said that young trees require more water the first season than is necessary in succeeding years. Trees that are bearing, however, should receive almost, if not quite as much, as young trees; it is necessary for the best development of the fruit,

The soil of our station orchard is quite compact; water does not spread quickly, and each irrigation is prolonged for a greater time than would be necessary on more porous soils. When water is available we aim to apply it once in ten days for young trees; somewhat less frequently for those older.

The effects of drouth during July and August are frequently seen in small inferior fruit. Reasonable care in the application of water during this period will well repay the trouble in the increased quantity and better quality of fruit. It is, however, possible to apply an excess that may work as great injury as the most severe drouth. It is only by studying the appearance of the trees, and the condition of the soil that we can arrive at a correct adjustment of the quantity to be applied, and the time to apply it.

It is our practice here to withhold water after the first of September in order to check growth and allow the wood to ripen. If growing conditions are maintained through the fall the young and succulent wood, of even the hardiest varieties, is in danger of being killed by low winter temperatures, but if well ripened it survives the extremes without injury. Twice within the last six years we have had open winters that proved more productive of injury to trees than those of continuous cold. There were long periods of warm weather, with no frost in the ground, and no precipitation to supply the continuous evaporation. The soil became very dry and the trees suffered in consequence. To guard as much as possible against such injury it is the practice to give a late irrigation, usually in November. If the ground can be well saturated at this time it is of advantage to the orchard whether the months following be cold or warm; if warm, the soil will not so soon become dry, and danger from this source is lessened; if cold and the soil be continuously frozen, the moisture is retained and the conditions for spring growth improved.

The system practiced is to furrow for each irrigation, using a one-horse plow and turning from the trees on both sides of the row. Water is run in the furrows for from 12 to 36 hours according to the supply available and the condition of the soil. As soon as practicable after irrigating, a harrow is used to close the furrow and smooth the surface. The aim is to keep a constant mulch of loose soil on the surface so as to check evaporation as far as possible. The method of applying water is illustrated by plate 2.

PLANTING DISTANCE.

Practice and opinion on the matter of distance between trees in orchard planting is very diverse. The general tendency is toward too close planting and sometimes this is carried to extremes. I have seen several plum orchards planted 10x10 feet that even now when only five years old have much the appearance of thickets. Cultivation is impossible, the fruit is small and difficult to get at, insects find a safe harbor, and the whole arrangement is unsatisfactory and unprofitable. The condition grows worse with each year. In most cases the suggested remedy, removing alternate trees will not be followed until too late, if at all, and within a very few years the whole must of necessity be destroyed and the labor of planting lost.

The most common practice is to plant 15x15 feet, but this is too close for fully developed trees of spreading habit. A better plan is to plant 15x20 feet, or to adopt the accepted California practice and allow 20x20 feet. There seems to be a d cided preference for low-headed trees on the ground that they are less liable to injury from winds, and that less trunk is exposed to the action of the sun. With low-headed trees the disadvantages of close planting are more quickly apparent. The best formed trees in the station orchard are those headed at from 30 to 36 inches from the ground, and this is the distance we prefer.

Young trees are frequently injured by what are known as "frost cracks," a longitudinal splitting of bark and wood on the south side of the trunk, occurring in late winter or early spring and attributable to the extreme daily range of temperature which often occurs at this season. To guard against this injury the trunks should be protected in some way. Various devices have been used, but we have found wrapping with burlap the most effective and least expensive. Burlap that had been used for baling was purchased at dry goods stores for two cents per pound and cut into four inch strips, three and four feet long; one pound giving as an average 9 strips. These are wound spirally on the trunks, being held at the top by a lap, and by tying with cord at the bottom. One man can cover from 50 to 60 trees per hour with the material prepared and ready at hand. The covering is applied in November and removed in April or May. The same bands will serve for two or three seasons. The whole cost is less than one cent per tree and well repays the trouble.

ARRANGEMENT OF VARIETIES.

The Wild Goose plum has long been regarded as infertile when isolated and the same complaint has occasionally been made regarding other varieties, but the experiments carried on by Professor Waugh of Vermont, in 1896 and 1897, indicate that the actual extent of self-sterility among varieties of plums, has by no means been appreciated or even suspected. His tabulation shows that of 6,428 blossoms covered, on 56 varieties, representing all classes of plums, only five produced fruits, and from the experiments he draws the conclusion that "For all practical purposes, all classes and varieties of native plums may be regarded as absolutely self-sterile." It is possible that these results might vary with different seasons and in different localities, but making due allowance for possible variations, the results are startling enough to warrant the attention of plum growers everywhere. The cause of this sterility appears to lie largely in the inefficiency of the pollen of the flowers of a plant upon the stigmas of the flowers of the same plant. It lies in a condition known to exist among many wild as well as cultivated plants. One of nature's provisions for securing cross-fertilization, and the plants come under the recognized Knight's Law that "Nature intended that a sexual intercourse should take place between neighboring plants of the same species."

Self-sterility may also be due in some degree to imperfect pistils, the cause for which must be sought in some physiological weakness of the tree, such as might be brought about by the work of insects or disease, or from a feeble condition following the production of a phenomenally heavy crop of fruit. Or it may be due to unfavorable weather conditions prevailing at blooming time.

Recognizing, then, the existence of self-sterility among plums, the aim should be to so associate the varieties that one may supply pollen for the other. No data is at hand to warrant any definite statement as to what varieties are especially adapted to the fertilization of certain other varieties, but it is perfectly plain that to be of use to each other the varieties must bloom at the same time.

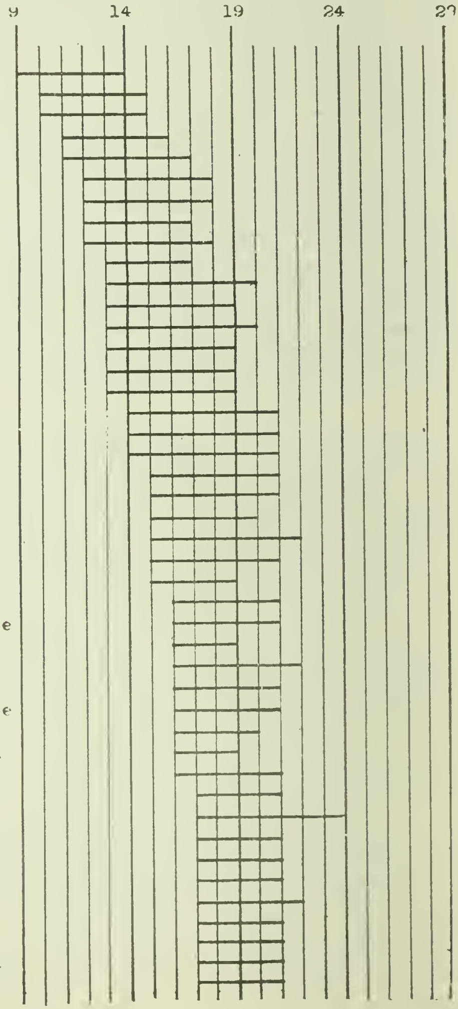
The varieties now available from which to choose show a rather wide range in blooming period; some bloom together, some finish before others begin and some overlap. All are much influenced by the weather at the time, and this may vary greatly in different years, not only in the appearance of the first flowers, but in the length of the blooming period. While irregularities may occur from one season to another, it is probable that the relative periods of the different varieties will remain much the same. For the convenience of those who may be interested, and also as a stimulus to further observations, we here reproduce a graphic tabulation of blossoming periods as given by Mr. J. W. Kerr of Denton, Maryland, in his trade catalogue. The same table is also given by Professor Waugh in the tenth report of the Vermont station. The latitude of Denton is very nearly that of Colorado Springs, but differences in altitude and climate make a considerable difference in the season of growth. The varieties are arranged in the table in the order of blossoming and it serves to show those blooming together as well as the earliest and latest bloomers. It will be observed that the classes to which the varieties are referred embrace three not given in our list; Nigra, Wayland, and Watsoni. The first is separated from *Prunus Americana* and recognizes in the northeastern plums the variety nigra of that species. The Wayland group is separated from the Miner group, with which it has close affinities. The Watsoni group are varieties of *Prunus Watsoni*, a sand plum ranging from Nebraska to Arkansas, and in the cultivated forms closely resembling the Chicasaw varieties with which they are usually classed.

PLUM BLOSSOM CHART.

Showing average plum blossoming seasons in the latitude of Denton, Md.

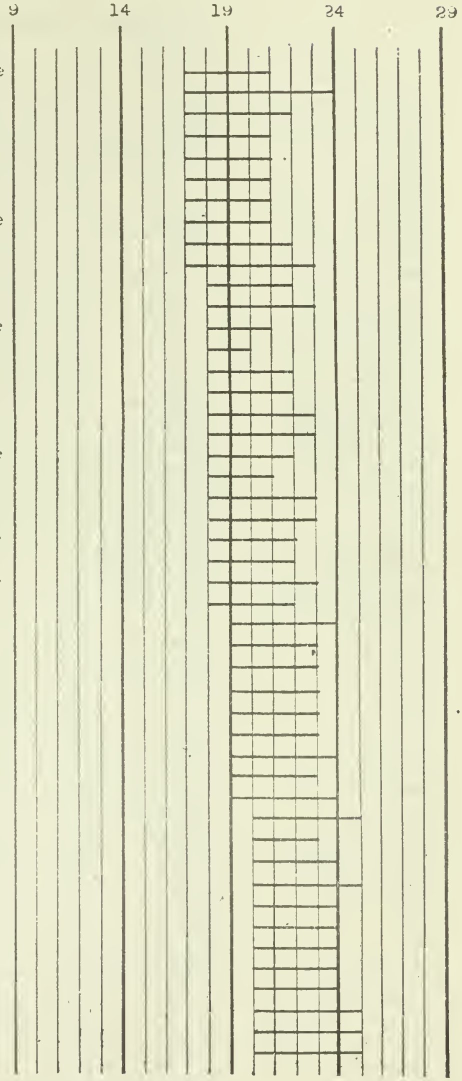
From J.W.Kerr's catalogue. Fall of 1897.

Variety	Class
Burbank	Japanese
Abundance	do
Satsuma	do
DeCaradeuc	Hybrid
Georgeson	Japanese
Engre	do
Marianna	Hybrid
Ogon	Japanese
Chase	do
Brill	Hybrid?
Chabot	Japanese
Kelsey	do
Ogeechee	Chicasaw
Shiro Sumomo	Japanese
Strawberry	Watsoni
Uchi Beni	Japanese
Maru	do
Wazata	Nigra
Yosebe	Japanese
Caddo Chief	Chicasaw
Early Red	do
Emerson	do
Itaska	Nigra
Kerr	Japanese
Munson	Chicasaw
Beaty	do
Clark	Wild Goose
Clifford	do
Colletta	Chicasaw
Deep Creek	Americana
Drouth King	Wild Goose
El Paso	Chicasaw
Hattie	Myrobalan
Yellow Sweet	Americana
Arkansas Lombard	Chicasaw
Cheney	Nigra
De Soto	Americana
Harrison	do
Heaton	do
Hiawatha	do
Hogg's No.2	Hybrid
Hughes	Chicasaw
Jefferson	Domestica
Lombard	do



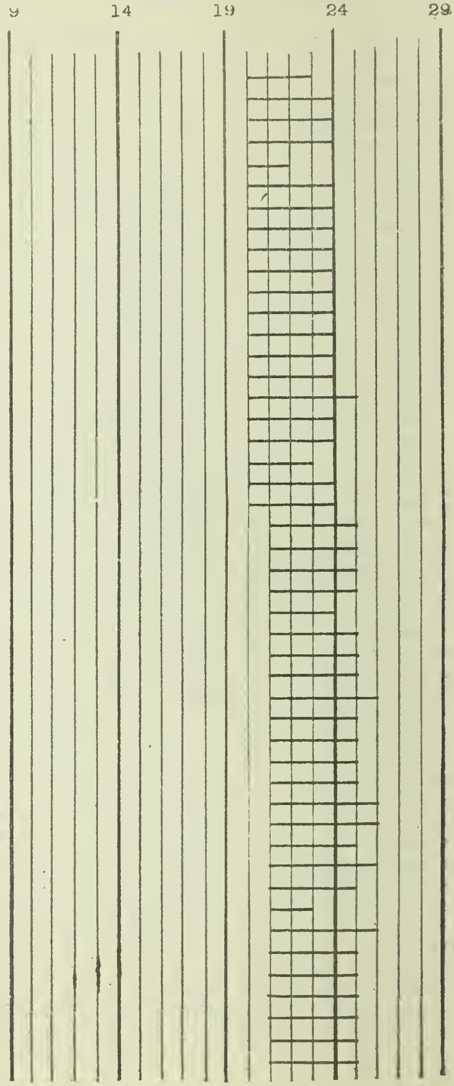
Plum Blossom Chart. continued.

Variety	Class
Milton	Wild Goose
Newman	Chicasaw
Ocheeda	Americana
Richland	Domestica
Rollingstone	Americana
Spaulding	Domestica
Wilder	Miner
Wild Goose	Wild Goose
Willard	Japanese
Yellow Panhandle	Watsoni
African	Chicasaw
Cherokee	Americana
Freeman's Favorite	Wild Goose
Gaylord	Americana
Hilltop	do
Louisa	do
Miner	Miner
Minnetonka	Americana
Ohio Prolific	Wild Goose
Osage	do
Smiley	do
Speer	Americana
Texas Belle	Wild Goose
Van Buren	Americana
Whitaker	Wild Goose
Yellow Transparent	Chicasaw
Comfort	Americana
Cottrell	do
Cumberland	Wayland
Kickapoo	Americana
Lone Star	Chicasaw
Lord's Seedling	Americana
Rockford	do
Roulette	Wild Goose
Schley	do
Champion	Americana
Chas. Downing	Wild Goose
Clara	Americana?
Cluck	Chicasaw
Crescent City	Miner
Columbia	Wayland
Dr. Tyler's Sugar Drop	Domestica
Gordon	Americana
Hammer	do
Hawkeye	do
Idall	Miner
Indian Chief	Wild Goose



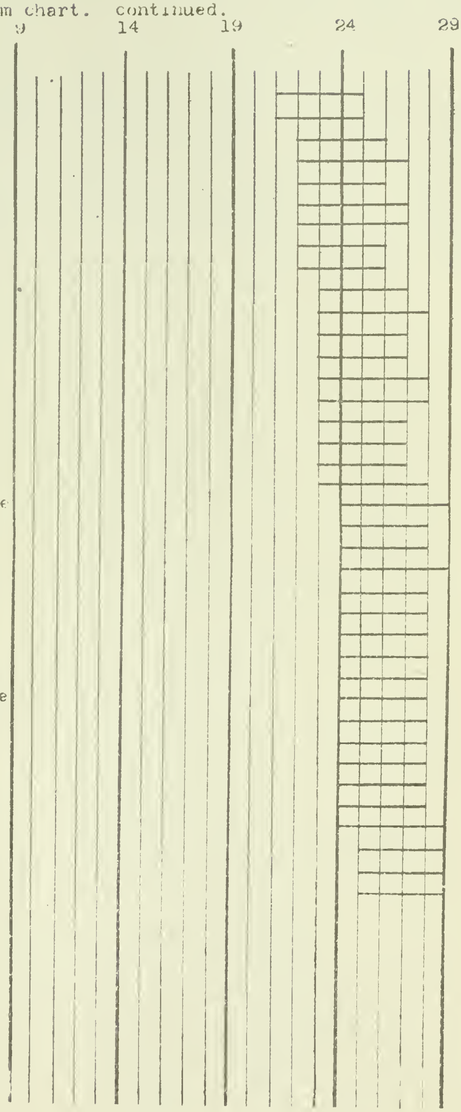
Plum blossom chart. continued.

Variety	April Class
Indiana Red	Miner
Jewell	Wild Goose
Kampeska	Americana
Kopp	do
LeDuc	do
Maquoketa	Miner
Muncy	Americana
Nelly	do
North Carolina	do
No.0.(Kerr)	do
No.6.(Kerr)	do
No.20.(Kerr)	do
Old Gold	do
Parsons	Miner
Pottawattomie	Chicasaw
Prairie Flower	Miner
Purple Yosemite	Americana
Sophie	Wild Goose
Sucker State	Wayland
Weaver	Americana
Wooten	Wild Goose
California	Americana
Coe's Golden Drop	Domestica
Colorado Queen	Americana
Dakota	do
Forest Rose	Miner
German Prune	Domestica
Hanson	Americana
Honey	do
Iris	Miner
Jones'Late	Americana
Knudson's Peach	do
Macedonia	Wild Goose
Mankato	Americana
Maryland	Hybrid
Missouri Apricot	Wayland
Moore's Arctic	Domestica
Moreman	Wayland
Noyes	Miner
Piram	Chicasaw
Poole's Pride	Wild Goose
Reine Claude	Domestica
Gen.Hand	do
Shropshire Damson	do
Stoddard	Americana
Surprise	Wild Goose
Williams	Nigra



Plum blossom chart. continued.

Variety	April Class
Williams' No.17	Americana
Wolf	do
Forest Garden	do
Red Panhandle	Watsoni
Smith	Americana
Utah Hybrid	Hybrid
Wayland	Wayland
World-beater	do
Wyant	Americana
American Eagle	do
Garfield	Wayland
Illinois Ironclad	Americana
Irene	do
Kanawha	Wayland
Leptune	do
Marion	Americana
Blackhawk	do
Rachel	Miner
Reed	Wayland
Choptank	Wild Goose
Esther	Miner
Galena	Americana
Golden Beauty	Wayland
Heideman's 38	Americana
Heideman's Black	Besseyi
Heideman's Red	do
Heideman's Yell	do
Newton Egg	Americana
Pendent	Wild Goose
Reche	Americana
William's No.0	do
Winnebago	do
Wood	do
Prunus maritima	Maritima
Holt	Americana
Joe Hooker	do
Peffer's Premium	do
Smith's Red	do

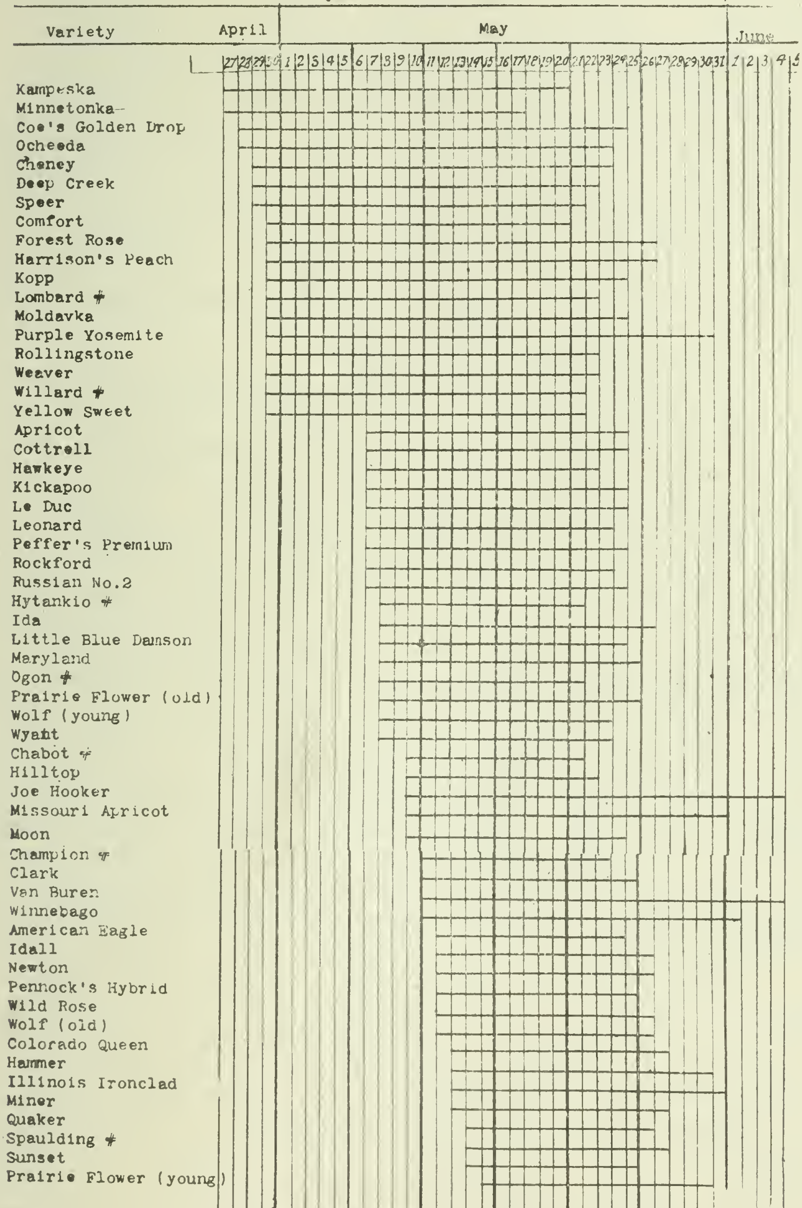


The following table arranged on the same plan as the preceeding shows the blossoming period of 56 varieties as compiled from observations in the station orchard last spring. Five of the varieties are represented by old trees of uncertain age, and of whose early history we have no record. They are probably from 12 to 15 years old.

The representatives of five others are young trees planted in 1897 and blooming for the first time. The remainder were planted in 1894. The flowering period of Joe Hooker was probably delayed, and later prolonged by the trees having been killed back somewhat during the preceeding winter. The flowering period is here computed from the time the first flowers opened until the petals had in great part fallen.

Flowering Period of Plums as Recorded in the Station Orchard

For the year 1898.



The two striking differences between the Maryland and Colorado tables are in the commencement of blooming, and in the length of the periods. Variations in climate would lead us to expect differences in the commencement of blooming. This difference here appears as 17 days, and it is probable that variations in seasons might either increase or diminish this. The variation in length of period is extreme. The shortest period recorded in the Maryland table is two days. Our shortest is 12 days. While the longest periods are 7 days in Maryland, and 31 days in Colorado. The great length of the periods observed here may in part be accounted for by the weather conditions prevailing at the time. It will be observed that 11 varieties began blooming on April 30, and that 9 varieties began on May 7, none opening in the interval. This is directly attributable to a storm which prevailed between these dates.

Rain began falling on April 30. On the night of May 2 wet snow accumulated to the depth of 3 inches. This covered the trees and clung to the branches for several days. It was continuously cloudy to the evening of May 5, and while it did not freeze during this period the temperature was sufficiently low to effectually check all vegetation. On examination after the storm it was found that considerable injury had been done. The *Americana* varieties that began opening the flowers before the storm, had most of the pistils in the open, and nearly open flowers killed. Kampeska showed less injury than any other variety of the class. On Minnetonka, Speer, Ocheeda and some others, it was difficult to find an uninjured pistil in open flowers or much advanced buds; most of them were black and shriveled. Coe's Golden Drop among *domestica* varieties had the pistils killed in all open flowers, and also in all advanced buds. Russian No. 2, although having no open flowers, had started the buds to some extent and nearly all were killed. Varieties that were at the time quite dormant suffered no apparent injury.

The storm had the direct effect of delaying the appearance of bloom on most varieties for at least seven days. Whether it effected the blooming period or not is matter of conjecture, but it seems probable that the long period of low temperature may have influenced the vitality of the buds in such way as to prolong the blooming season. The tables are suggestive, and the questions which arise from studying them can only be answered from the data of a number of seasons. Similar tables representing the different districts of the state, and covering other orchard fruits would be helpful to the planter, and would become more valuable as the number of years over which observations extend, increased.

TO WHAT DEGREE ARE PLUMS SELF-FERTILE.

The following tests to determine self-fertility were undertaken last spring, the work being in charge of my assistant, Mr. J. H. Cowan, who was assisted by one of our students. The preliminary work of covering the flowers was performed on April 30th, with the exception that the flower clusters on one variety, Missouri Apricot, were covered May 7. Grocer's paper bags were used and securely tied. Such flowers as were open, or partially open, were removed before covering, and are not counted. Approximately one half of the clusters were hand-pollinated, the other half being left to themselves. The hand-pollinated set embraced 43 clusters, containing 629 flowers and represented 40 varieties. The stigmas of all flowers were dusted with pollen, either from the same flower, or from other flowers of the same cluster. This work was performed on the dates as tabulated, May 14–18 inclusive. The pistils were at this time in good condition, the stigmas appreciably viscid. The pollen was also in good condition, and the stigmas were copiously covered.

The examination June 6 showed 113 apparently well formed fruits, and 105 imperfect fruits, those that showed some development of the ovary, but did not appear to be well fertilized. In other words it appeared on June 6 that 17.94 per cent. of the flowers had produced good fruits, and 16.69 per cent. had set imperfect fruits. At the final examination June 23 there remained 6 fruits representing a fraction less than 1 per cent. of the flowers pollinated.

In the following tabulation the number of flowers treated is given for each variety, together with the number of fruits formed, and also the estimated stand of fruit on the trees.

SELF-POLLINATION OF PLUMS. SPRING OF 1898.

Tabulation of Hand-pollinated Set.

	When pollinated.	No. of flowers.	Fruits Jun. 6 Good.	Fruits Jun. 6 Imp.	Fruits June 23.	Stand of fruit estimated.
American Eag'e	May 14	16	2	2	1	light
Apricot	" 17	7	0	1	0	medium
Cheney	" 14	8	0	5	0	very light
Colorado Queen	" 14	13	5	2	1	medium
Comfort	" 14	4	0	0	0	very light
Cottrell	" 18	18	10	2	0	medium
Deep Creek	" 14	23	0	1	0	medium
Deep Creek	" 17	19	0	0	0	medium
Forest Rose	" 14	17	0	3	0	medium
Hammer	" 18	8	4	0	0	none
Harrison	" 14	9	0	6	0	heavy
Hawkeye	" 14	13	4	1	0	medium
Hilltop	" 14	17	0	2	0	very light
Ida	" 14	14	4	3	0	very light
Idall	" 14	12	0	8	0	very light
Illinois Ironclad	" 17	23	0	0	0	light
Joe Hooker	" 14	10	0	1	0	very light
Kampeska	" 14	15	0	4	0	medium
Kickapoo	" 17	8	5	0	0	medium
Kopp	" 14	19	0	8	0	medium
Le Duc	" 17	14	5	4	0	very light
Leonard	" 18	22	8	0	0	very light
Little Blue Damson	" 17	13	2	1	0	medium
Maryland	" 14	19	0	0	0	very light
Miner	" 18	22	8	0	0	very light
Minnetonka	" 18	13	1	2	1	very light
Missouri Apricot	" 14	10	2	3	1	light
Moon	" 17	27	9	7	0	light
Ocheeda	" 17	15	4	6	0	medium
Peffer's Premium	" 17	12	2	6	0	medium
Prairie Flower	" 18	13	8	0	0	very light
Purple Yosemite	" 14	10	6	1	0	heavy
Quaker	" 18	20	1	2	0	none
Rockford	" 17	4	0	0	0	very light
Speer	" 17	15	4	5	0	very light
Van Buren	" 17	34	7	9	2	medium
Weaver	" 14	7	0	0	0	very light
Weaver	" 14	6	2	1	0	very light
Winnebago	" 14	26	2	3	0	heavy
Wolf (young tree)	" 14	20	0	4	0	heavy
Wyant	" 14	26	8	2	0	very light
Yellow Sweet	" 14	8	0	0	0	very light
		629	113	105	6	

The self-pollinated set embraced 48 clusters containing 699 flowers and represented 41 varieties. At the time the pollen was applied to the flowers of the other set, these clusters were examined and such flowers as then had dead pistils were removed, otherwise they were not disturbed until the count of June 6 was made.

SELF POLLINATION OF PLUMS. SPRING OF 1898.

Tabulation of Set Not Hand-pollinated.

	Number of flowers.	Fruits June 6 Good.	Imperfect.	Fruits June 23.	Stand of fruit estimated.
American Eagle	10	2	2	0	light
Apricot	16	0	0	0	medium
Cheney	8	0	0	0	very light
Colorado Queen	19	3	8	0	medium
Comfort	2	0	2	0	light
Cottrell	19	4	4	0	medium
Deep Creek	11	0	2	0	medium
Deep Creek	12	0	0	0	medium
Forest Rose	14	0	2	0	medium
Hammer	8	2	1	0	none
Harrison	11	0	0	0	heavy
Hawkeye	11	4	1	0	medium
Hilltop	11	0	0	0	very light
Ida	14	1	4	0	very light
Idall	15	4	4	0	very light
Illinois Ironclad	22	0	0	0	light
Joe Hooker	15	5	1	0	very light
Kampeska	14	0	2	0	medium
Kickapoo	10	6	2	0	medium
Kopp	25	0	8	0	medium
Le Duc	9	3	5	0	very light
Leonard	16	0	5	0	medium
Little Blue Damson	15	7	0	4	medium
Maryland	20	0	0	0	very light
Miner	21	8	0	0	very light
Minnetonka	10	0	2	0	very light
Missouri Apricot	14	0	9	0	light
Moon	28	11	8	0	light
Ochaeda	18	6	2	0	medium
Peffer's Premium	17	4	10	0	medium
Pennock's Hybrid	37	0	3	0	light
Prairie Flower	13	8	0	0	very light
Purple Yosemite	15	9	6	1	heavy
Quaker	18	1	1	0	none
Rockford	2	1	0	1	very light
Speer	10	3	4	0	very light
Van Buren	90	15	18	0	medium
Weaver	9	1	0	0	very light
Weaver	7	0	0	0	very light
Winnebago	20	0	4	0	heavy
Wolf (young tree)	24	6	6	1	heavy
Wyant	15	9	3	0	very light
Yellow Sweet	4	0	0	0	very light
	699	123	129	7	

It appears from the table that on June 6 there were 123 well formed fruits and 129 imperfect fruits. Or of 699 flowers covered, 14.73 per cent. set good fruits and 15.59 per cent. set imperfect fruits. On June 23 the number of fruits remaining was 7 which represents practically 1 per cent. of the flowers covered.

The number of fruits produced by the hand-pollinated flowers was 6.

In final results, then, there is a remarkably close agreement between the two sets. The natural conclusion is that the infertility did not lie in the failure of the stigmas to receive pollen, but must be looked for either in an inherent antipathy which the plant has for its own pollen or in some outside influences. One factor comes in here which makes the test unsatisfactory, and prevents drawing definite conclusions as to the cause of the infertility, and that is the extent of the "June drop" from all parts of the trees. This was so great that even the trees that set full, matured but a light crop. The same influences acting upon the covered flowers would account, in part at least, for the results recorded. Further discussion of the cause is reserved until additional observations suggested by the work this year can be made.

INSECTS AND DISEASES.

INSECTS.

The insects commonly injurious to the plum, such as the Plum Gouger, Curculio and Plum Aphis are treated in bulletin No. 47 by Prof. Gillette, and for information concerning them the reader is referred to that bulletin.

FUNGUS DISEASES.

There are several parasitic fungi reported from different parts of the country as injurious to the plum. At least four of these are present in Colorado, although only two have thus far worked to an injurious extent upon the cultivated plums. The fungus at present doing greatest injury, and having widest distribution, is the Leaf-spot or Shot-hole fungus (*Cylindrosporium Padi Karst*). It has been present in the station orchard for four seasons, but has been controlled by spraying so that no serious injury has resulted from it.

The disease makes its appearance early in the summer or about the time the leaves reach full size. Small circular spots of a red or purplish color are first seen; these enlarge somewhat, becoming an eighth of an inch in diameter. As the fungus matures. the spots become dark brown, shading to light brown at the center. The effected tissue shrivels, and finally drops out, leaving circular holes. Frequently several spots may run together so that the holes left in the leaf are irregular in form. Under conditions favorable to the fungus the spots become so numerous as to destroy the leaves attacked, and thus check the growth of the tree, and prevent the development of fruit. If stocks in nursery are attacked the bark tightens and the stocks cannot be budded. The injury to orchard trees by this disease is in direct proportion to the percentage of leaves destroyed, but no matter how slight the attack it should receive attention. The tree is entirely dependent upon the leaves for the elaboration of its food, and any injury to them that interferes with the fulfillment of this important office, checks growth and injures vitality.

Various remedies have been tried and of these the Bordeaux mixture gives the most general satisfaction. In our practice with this remedy we have made two applications; the first as soon as the leaves are developed, and a second about three weeks later. In some seasons a third and possibly a fourth application may be necessary, as the development and spread of the fungus is in a measure dependent upon weather conditions. The appearance of leaves attacked by this fungus is shown in Plate III.

POWDERY MILDEW OF THE PLUM AND CHERRY.

(*Podosphæra oxyacanthæ* (DC.) DBy.)

This disease has not appeared in the station orchard, but has been reported to us from two counties of the state as injurious to both plum and cherry trees. The fungus works entirely on the surface of the leaves, drawing its nourishment from the cells by means of minute suckers called haustoria. Badly effected leaves appear as if dusted with a white powder and this suggested the common name. Being on the surface the fungus is easily reached by any of the fungicides in common use. Finely powdered sulphur, which has been successfully used in combatting the closely related Powdery Mildew of the Grape, would probably be equally effective in destroying this parasite. The fungus does not usually appear until late in summer; our specimens were received the last week in August.

BLACK KNOT. (*Plowrightia morbosa.* (Schw.) Sacc.)

The fungus causing Black Knot has proved destructive to plums and cherries in many of the eastern states. It has not, so far as my information goes, attacked cultivated plums in Colorado, but from its presence as a common disease of the wild plums of the foothills, it seems likely that it may at any time appear in orchards.

Black Knot has been known as a disease of plums for a long time, but the cause was for many years a mystery. The larvæ of insects being commonly found in old knots, led many to believe that the trouble was due to them, but entomologists proved that the larvæ found were only using the abnormally developed tissue as food and had nothing to do with its production. The fungus was named as early as 1821, but discussion regarding the true cause continued until Dr. Farlow,* of Cambridge, worked out the life-history of the fungus and established beyond controversy that it was the cause of the trouble.

The presence of the disease is first seen in swellings on twigs; these are due to an abnormal growth induced by some irritative action of the fungus threads. As development proceeds the bark is ruptured, the exposed inner surface becomes covered with spore bearing threads, and assumes a greenish-brown color. These spores are carried by winds and insects and serve to infect other branches or trees. The knot continues to enlarge, becomes hard and changes to a brown and finally black color. Later in the fall cavities form in the tissue of the knot and in these are produced a second form of spores which may escape in spring to further disseminate the fungus. Two other spore forms have been found in connection with the fungus, but further mention of them is not necessary here. The threads of the fungus are perennial within the tissues of the plant, and when once started, growth will continue until the tree dies. While spraying at the proper time may be of use in preventing spreading to other trees, the only effective remedy for trees attacked, is to cut and burn the knots as soon as discovered. One of the characteristic knots is shown in Fig. 1, Plate 4.

* Bulletin Bussey Institution Part V pp. 440-453 (1876).

PLUM POCKETS. (*Exoascus Pruni Fckl.*)

This disease is quite common on the wild *Prunus Americana* of the foothills, but no case of attack upon cultivated varieties has come to my notice. The effects produced by the growth of this fungus are perfectly characteristic. Not long after the fall of the blossoms the young plums begin to enlarge rapidly; they become spongy or bladdery, and may vary in size from one-half inch to an inch and a half in diameter. In color they are pale green or yellowish. By the middle of June they shrivel somewhat, becoming wrinkled, and finally drop. Sometimes only a portion of the fruits on a tree are effected and again no normal fruits can be found. The fungus sometimes attacks the leaves and young twigs, but more commonly the fruit only is effected. From observations on wild plums it appears that trees once infected continue to produce pockets each year, and it is doubtful if these trees can be cured; but spreading to other trees can be prevented by gathering and destroying the pockets before the spores are discharged. Where the disease attacks cultivated plums it seems to be quite local and does not spread rapidly. It is never epidemic and there seems to be little danger of serious injury from it. Plum pockets as they occur on the wild plum are illustrated in Fig. 2, Plate 4, which was photographed from a dry specimen.

A BLIGHT DISEASE.

Late in the summer of 1897 twelve trees in the orchard were attacked by a blight, the nature of which is obscure. The leaves began turning brown at the edges; this spread, involving the whole leaf surface and the trees died. Examination failed to reveal the presence of fungi, and it seems most probable, from the appearance and development of the disease, that its cause must be sought in some bacterium. The disease, while possessing the same general nature as pear blight, is certainly distinct from it. The trees attacked were all old and in bearing. No young trees suffered, and there was no reappearance of the disease this season.

VARIETIES.

The following notes on varieties are based almost wholly upon observations made in the station orchard.

This orchard, as originally set, contained the following varieties:

Coe's Golden Drop.	Prairie Flower.
Wolf.	Marion.
Russian No. 2.	Forest Garden.
Miner.	Little Blue Damson.

We have no record of the planting, and do not know the year, or the original number of trees, or the source from which they were obtained. The original planting is now represented by 1, Coe's Golden Drop; 29, Wolf; 1, Russian No. 2; 10, Miner, and 9, Prairie Flower.

The following additions have been made: In 1894, 57 varieties; in 1895, 10 varieties; in 1896, 1 variety; in 1897, 62 varieties; in 1898, 31 varieties. The total number of varieties planted for trial is 169. Seventeen varieties have been lost through winter-killing, so that there are now living representatives of 152 varieties. Some of these give no promise of value and will be discarded. The number that have proved suited to our conditions is not large, and nearly all of them are of the American group. Detailed descriptions are given only of those varieties that are fruited. A few others are briefly mentioned.

AMERICAN EAGLE. (*Prunus Americana.*)

Represented by nine trees planted in the spring of 1894. Trees well formed, spreading in habit, of moderate vigor. Leaves large; young stems and petioles densely puberulent. Bore heavily in 1897, followed by a light crop in 1898. Fruit large, round-oblong, dark red or mottled with small yellow spots; stem of medium length; skin thick; flesh firm, reddish yellow, of excellent quality. Stone rather small for the size of the fruit, cling, rounded at apex, prolonged into a sharp point at stem end, strongly convex on the sides, margin sharp, but not otherwise prominent. Ripe September 20.

APRICOT. (*Prunus Americana.*)

Planted in 1894. Of bushy habit, forming a close, compact head. Leaves large, broad, sharply serrate, stalks pale red, pubescent. Fruit medium in size, round-oblong, color red, where shaded mottled red on yellow ground, bloom slight; suture inconspicuous, skin thick; flesh reddish-yellow, quite firm, juicy, sweet and of good flavor when fully ripe. Stone cling, rather large, flat, moderately pointed at both ends, no prominent margin, roughish. Ripe September 4.

BOTAN. JAPANESE GROUP. (*Prunus triflora.*)

Our trees were planted in 1897 and have not yet had sufficient test as to hardiness. They have made a vigorous growth and are now well set with fruit buds. Leaves of medium size, glossy, light green, sharp-pointed at both ends; stalks short and stout.

BURBANK. JAPANESE GROUP. (*Prunus triflora.*)

Trees planted in 1897 bore a few fruits this season. Habit of growth upright, very vigorous. Leaves of medium size, broadly lanceolate, short acuminate, stalk short and stout. Fruit large, peach-like in shape; color deep red, on yellow ground, which appears in small spots; flesh firm, deep yellow; suture evident; stone small, semi-cling. Ripe September 12.

CHAMPION. (*Prunus Americana.*)

Trees planted in 1894 have made a vigorous spreading growth, smooth, less thorny than most members of the group. Leaves large, light glossy green, strongly recurved, stalks red, short, somewhat pubescent. Not yet fruited.

CHENEY. (*Prunus Americana.*)

Planted in 1894. Very vigorous in growth and upright in habit, producing no virgate drooping branches; quite thorny; leaves obovate, acuminate, three to five inches long, veins prominent, pubescent below, light green, leathery in texture, stalks stout, about an inch long; fruit large, somewhat oblique, pointed or rounded at apex; stem short, stout, set in a large cavity, suture evident; color dull red, mottled on a greenish-yellow ground; stone cling; skin thick, flesh firm, sweet, of good flavor. Ripe September 4. One of the most promising of the Americana varieties. Fruit fig. 1, plate V; tree, plate VIII.

CHOPTANK. WILD GOOSE GROUP. (*Prunus hortulana.*)

Trees planted in 1894 have made a vigorous growth each year, and have regularly killed back nearly to the ground each winter. Evidently too tender for this locality.

CLARK. WILD GOOSE GROUP. (*Prunus hortulana.*)

Trees well formed and of moderately vigorous growth. Kills back at the tips each year. Leaves of medium size, rather broad for the species; fruit of medium size, nearly spherical, but somewhat irregular; color red in the sun, shading to light red on green ground in the shade; suture distinct; flesh firm, orange-red, very acid; stone cling. Ripe Aug. 30. The quality of the fruit does not commend the variety.

CLINTON. MINER GROUP. (*Prunus hortulana* var. *Mineri.*)

Trees planted in 1894. A vigorous grower, but has killed back repeatedly; worthless here,

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COE'S GOLDEN DROP. (*Prunus domestica.*)

This well-known English variety is perfectly hardy in tree, but the fruit buds are yearly killed to such an extent that it is not at all productive. Trees are upright in habit and of slow growth. Leaves of medium size, dull dark green, obtusely crenate, stalks glandular, pubescent, as are also the lower surfaces of the leaves; young wood dark purplish-red, glabrous. Fruit large, roundish-oblong, projected into a slight neck, and indented at insertion of stem, suture deep, sides somewhat unequal; color pale yellow or greenish; flesh firm, of excellent quality; stone free, nearly straight on one edge, curved on the other, margin irregular, sharp, rough. Ripe September 20.

COLORADO QUEEN. (*Prunus Americana.*)

Trees planted in 1894 are well formed and of vigorous growth, much inclined to the production of long drooping or pendulous branches. Leaves of medium size, broad, sharply serrate, light green, stalks slender, young wood light colored, glabrous. Fruit below medium in size, spherical, slightly indented at lower end; color dark purplish-red over yellow ground which shows as small dots; suture hardly apparent; stem long, rather stout; skin thin, flesh juicy, sub-acid, of fair quality; stone circular, convex. Ripe September 4.

COMFORT. (*Prunus Americana.*)

Of slow growth and straggling habit, very thorny, producing many drooping branches; leaves of medium size, ovate-lanceolate, sharply and irregularly serrate, stipules large and rather broad, soon falling. Hardy. Although planted in 1894 the trees have not yet fruited.

COTTRELL. (*Prunus Americana.*)

Planted in 1894. Trees vigorous, but irregular in habit, hardy; young wood brownish-red, glabrous; leaves above average size, dull light green, broad, coarsely and irregularly serrate; stalks glandular, rather short and stout, red, pubescent. Fruit medium to large, round-oblong, color red, nearly uniform, on lemon-yellow ground, and covered with a thin rosy bloom; skin thin, flesh firm, of superior flavor; stone semi-cling, large, smooth, elliptical with a prominent rounded margin, convex portion relatively small; stalk long, slender. Ripe September 14. Quality and productiveness place this among the desirable varieties.

DEEP CREEK. (*Prunus Americana.*)

Our trees were planted in 1894 and 1895. They are inclined to be irregular in habit and are of slow growth as compared with Weaver or Cheney. They are very thorny and in general appearance resemble wild trees; young wood glabrous. Leaves large, oblong-lanceolate, coarsely and bluntly serrate, stalks red, slightly pubescent, rarely glandular. Fruit small to medium, roundish or slightly oblong; suture apparent, or in some fruits inconspicuous; color uniformly deep red when fully ripe, bloom abundant; stem of medium length, slender; skin thick; flesh firm, juicy, sweet when ripe; stone semi-cling, oblong, sides strongly convex, pointed, smooth. Ripe August 30. Fairly productive. Trees planted in 1894 bore a light crop in 1896, a heavy crop in 1897 and a light crop in 1898. Fruit fig. 2, plate V; tree, plate IX.

FOREST GARDEN. (*Prunus Americana.*)

Tree typical of the class; leaves of medium size, light green, sharply serrate, the teeth overlapping, stalks reddish, nearly glabrous, glandless. Fruit medium in size, round;

color dark purple-red; stem long, slender, skin thick; flesh moderately firm, of sub-acid flavor; stone semi-cling, rounded at lower end, sides convex, prolonged into a flattened point at upper end, roughish. Ripe September 16. Tree a heavy bearer.

FOREST ROSE. MINER GROUP. (*Prunus hortulana* var. *Mineri.*)

Represented by two station-grown trees. They were grafted in the spring of 1894, one on Myrobalan stock, the other on Americana stock; grown one year in nursery and set in orchard in 1895. Both fruited in 1897. The trees are alike except that the one on Myrobalan stock is slightly larger than the other. Both are of good form and vigorous growth. Leaves medium, rather broad, dull light green, sharply serrate; stalk slender, puberulent, glands commonly wanting. Fruit medium in size, round, or somewhat oblique, dark red on yellow ground which shows as minute dots; stem long, slender; skin thin, suture obsolete, flesh firm, sweet and of fine flavor; stone cling, circular, but drawn into a point at the upper end, somewhat rough. Season medium, ripe September 4. A good and productive variety. Fruit fig. 1, plate VI; tree, plate X.

GARFIELD. WILD GOOSE GROUP. (*Prunus hortulana.*)

Trees planted in 1894 have killed back so badly each winter that we may class this as too tender for this locality.

HAMMER. (*Prunus Americana.*)

Four trees planted in 1894 are of erect habit, but of slow growth, nearly free from thorns. Kills back at the tips to some extent and has not fruited. Leaves large, oval-oblong, doubly crenate, light green, flat, stalks glandular; young wood light-red, glabrous.

HARRISON. HARRISON'S PEACH. (*Prunus Americana.*)

Trees of moderate vigor, forming round symmetrical tops; hardy. Leaves large, broad, margins loosely crinkled, very irregularly and sharply serrate; stalks stout, glandular, densely puberulent. Fruit medium to large, round-oblong; color light red on a translucent light yellow ground, covered with a thin rosy bloom; stem long, slender, skin thick; flesh rich, juicy; stone cling, rather long pointed, convex on the sides, smooth. Season medium; ripe September 11. A promising variety.

HAWKEYE. (*Prunus Americana.*)

Trees planted in 1894 are well formed and vigorous, but not quite as large as those of Wolf, Weaver or Cheney of the same age. Leaves large, obovate, glossy green, sharply and irregularly serrate. Fruit large to very large, round, slightly flattened; color dark red shading to light red on yellow ground, which shows as conspicuous dots; bloom thin, suture apparent; stem stout, of medium length; skin thick; flesh very firm; flavor excellent, sub-acid; stone cling, very large, round oval, very flat, rough. Ripe September 18. A desirable variety. Plate XI.

HILLTOP. (*Prunus Americana.*)

A vigorous variety of spreading habit. Leaves medium to large, obovate, acuminate, irregularly serrate, leathery in texture, pubescent below; stalks red, pubescent, usually glandless. Trees were planted in 1894, but have not yet fruited.

HOLT. (*Prunus Americana.*)

Planted at the same time as Hilltop and resembling that variety in vigor and habit. Trees killed back slightly during the winter of 1895-6. Leaves large, acuminate, sharply and irregularly serrate, upper surface crimped, stalks glandular. Not yet fruited.

IDA. (*Prunus Americana.*)

Trees planted in 1894. Very thorny, of slow irregular growth; young shoots somewhat pubescent; leaves large, broadly ovate-lanceolate, irregularly serrate, leathery in texture; stalks glandless or occasionally with a single small gland. Fruit of medium size, round oblong; suture evident; color mottled and shaded with red on yellow ground, stem of medium length, stout; skin thick, flesh pale yellow, inferior in flavor; stone cling, roundish, rather flat, blunt at both ends, with no prominent margin. Season medium to late. Ripe September 18. Fairly productive.

IDALL. MINER GROUP. (*Prunus hortulana* var. *Mineri.*)

Trees planted in 1894 have passed through four winters without injury and are apparently perfectly hardy. They are vigorous and have formed symmetrical heads. Leaves large, obovate, doubly serrate, dull dark green, stalks glandular and pubescent. Not yet fruited.

ILLINOIS IRONCLAD. (*Prunus Americana.*)

Planted in 1894. Growth slow. Trees much smaller than those of Wolf and Weaver of the same age. Leaves large, dark green, sharply doubly serrate, the veins pubescent below; stalks red, pubescent, glandular. Fruit of medium size, oblong, truncate at base, cavity large and deep, suture inconspicuous; stem long, stout; color red on lemon-yellow ground; stone cling, oval, flat, no prominent margin or point; flesh firm, sub-acid, of good flavor. Season medium to early; ripe September 6.

INDIANA RED. MINER GROUP. (*Prunus hortulana* var. *Mineri.*)

Trees planted in 1894 have killed back every year and the variety is classed as too tender.

JOE HOOKER. (*Prunus Americana.*)

Trees of moderate vigor, forming well-shaped heads, but showing a tendency to the production of long drooping shoots. Leaves rather small, ovate-oblong, stalks slender. Fruit medium to small in size, roundish-oblong; color red on yellow ground. Ripe September 11.

KAMPESKA. (*Prunus Americana.*)

Trees planted in 1894. Growth stocky and slow, branches stiff. Leaves below average size, light green, obovate, sharply acuminate and very sharply serrate; stalks pubescent, glandular. Fruit small, round, dark purplish-red, bloom rather thick, stem of medium length, stout; skin thick; flesh of fair quality; stone semi-cling, oval, strongly convex on the sides, sharp on the edge but not margined. Ripe September 11. Tree productive, but fruit too small to be ranked as valuable.

KICKAPOO. (*Prunus Americana.*)

Planted in 1894. Not yet fruited. Trees of slow growth and straggling habit. Leaves large, broadly lanceolate, sharply and irregularly serrate, stalks glandular.

KOPP. (*Prunus Americana.*)

Trees of good form and fair vigor, prôducing some drooping branches. Leaves large, dark green, sharply serrate; stalks red, pubescent, mostly glandless. Fruit medium to small, round, deep red, shading into the green ground, this mottled with white dots; skin thick; flesh firm, of good sub-acid flavor, sweet when fully ripe; stone nearly free, oblong, pointed, strongly convex, smooth. Ripe September 1. A productive variety.

LATE ROLLINGSTONE. (*Prunus Americana.*)

Trees of moderate vigor, forming round compact heads. Leaves of medium size, obovate-oblong, short acuminate, irregularly and unequally crenate; young shoots red, smooth, shining; stalks glandular, pubescent. Fruit medium in size, round, flattened at both ends, deep red, shading into light red; stem of medium length; skin thick; flesh firm, of excellent quality. Stone cling, broad-oval, sides moderately convex, smooth. Ripe September 11. Not to be distinguished from Rollingstone. Even in time of ripening there appears to be no difference here.

LE DUC. (*Prunus Americana.*)

The trees planted in 1894 are still rather small, but stocky and well-formed; they fruited heavily in 1897. This year they bloomed full, but matured a very light crop. Leaves large, light green, sharply serrate; stalks glandular, pubescent on inner side; young wood glabrous. Fruit of medium size, round, waxy yellow shaded with red; skin thick; flesh juicy, sweet and rich; suture obsolete; stone roundish-oval with convex sides, semi-cling. Ripe August 25. Very productive. A good variety.

LEONARD. (*Prunus Americana.*)

Trees of same size and appearance as those of Le Duc. Leaves large, rather short and broad, doubly and sharply serrate, stalks glandular. Fruit medium in size, round, dark red and mottled red on green ground; flesh not firm, quality only fair, acid; stone cling, small, smooth, roundish-oblong, with a rather sharp margin. Ripe September 1.

LITTLE BLUE DAMSON. (*Prunus domestica.*)

Represented by three trees grown at the station, two of which are on Marianna stocks, one on *Prunus Americana.* They were set in 1895. There is no appreciable difference in size, but the one on *Prunus Americana* is overtopping the stock and will probably be short-lived. In habit the trees are upright and the growth is vigorous. Leaves of medium size, dark glossy green, only moderately crinkled, stalks usually without glands. Fruit small, oblong, cavity scarcely apparent, no suture; color very dark blue, almost black with heavy blue bloom; stem short and stout, flesh firm, decidedly acid; stone free, small, oblong, flat, rough. An abundant bearer, but fruit too small to be valuable.

MARION. (*Prunus Americana.*)

Trees forming round, symmetrical heads; leaves of medium size, oval, sharply serrate, the teeth overlapping; stalk slender, glandless, or occasionally with one or two small glands; young shoots slender, glabrous. Fruit medium to large, round, flattened at lower end; purplish-red on orange ground, bloom thin; stem long and slender; skin thick; flesh sweet, juicy, of good flavor; stone semi-cling, rounded at base and pointed at the stem end; sides convex, margin rounded. Ripe September 15. Productive.

MARYLAND. (Classed by J. W. Kerr with *Prunus Besseyi.*)

This variety originated with J. W. Kerr of Denton, Md., and is a seedling of Utah Hybrid. The latter is of doubtful origin. Professor Waugh thinks it a probable hybrid between *Prunus Watsoni* and *Prunus Besseyi.** Our trees came from Mr. Kerr in 1894. They are the most straggling in habit of any in the orchard, producing many very long, slender, light red shoots, which are projected horizontally or downward. Apparently perfectly hardy here. Leaves of medium size, elliptical, acute or short acuminate, crenate; stalks glandular. Fruit small, spherical, color dark brownish-red, shading to light red on green ground; suture obsolete; flesh soft, watery, quite sweet and pleasant to the taste; stone cling, short, obliquely-oval, rounded at both ends, rough. Ripe August 20.

MINER. (*Prunus hortulana* var. *Mineri.*)

One of the varieties planted in the original orchard. There are now ten trees, all well formed and healthy. They have borne for several years and are productive, but occasionally the season is too short and the fruit does not mature. Leaves large, broad, often obovate, short acuminate, evenly crenate; stalks glandular. Fruit medium in size, nearly spherical or round-oblong; deep red over greenish-yellow ground; stem long, slender; flesh firm and of very good flavor; stone cling, broad, short pointed at both ends, slightly roughened. suture obsolete. Ripe September 29 in 1897; September 22 in 1898.

MINNETONKA. (*Prunus Americana.*)

Planted in 1894. Trees of slow growth, small, with bushy tops, quite free from thorns; young branches densely pubescent. Leaves large, broadly oval, dark green, coarsely serrate, stalks stout, usually glandless. Fruit small, oblong or oval, red on yellow ground; skin thick, flesh firm, rather acid, stone cling. Ripe September 11.

* Vermont Station, 10th Report (1896-7), p. 105.

MISSOURI APRICOT. WILD GOOSE GROUP. (*Prunus hortulana.*)

Trees grown at the station and set in orchard in 1895; fruiting first in 1897. Of moderate vigor, inclined to be irregular in habit. Leaves of medium size, ovate, coarsely and sharply serrate, pubescent below; stalks glabrous, mostly glandless. Fruit medium to large, roundish, slightly narrowed at stem end, truncate at apex, sometimes indented, stem long; color waxy yellow with red cheek next the sun, mottled all over with small light-colored dots; flesh firm, sweet, rich; stone cling, short and broad, rounded at apex, pointed at stem end, sides convex. Ripe August 29. One of the desirable varieties.

MOON. (*Prunus Americana.*)

Trees planted in 1894 bore a few fruits in 1896, a heavy crop in 1897, and a light crop in 1898; they are not vigorous in appearance, and grow very slowly; young branches light colored; leaves medium in size, obovate, coarsely and irregularly serrate, stalks glandular. Fruits medium, round or slightly oblong, deep red or mottled on yellow ground, suture obsolete; skin thin, flesh moderately firm, of good flavor, sub-acid; stone cling, short oval, strongly convex, with no prominent margin. Ripe September 5.

OCHEEDA. (*Prunus Americana.*)

Trees of slow growth, forming round tops and producing many drooping branches, very thorny. They were planted in 1894, began bearing in 1896, gave a good crop in 1897 and a medium crop in 1898. Leaves large, oblong, acuminate, dark green, sharply and deeply serrate, pubescent below; stalks glandless or occasionally with two small glands, red, pubescent. Fruit of medium size, round-oblong; red on lemon-yellow ground with thick bloom; stem long; skin thick, flesh firm, of good flavor; stone cling, large, long-pointed, strongly convex on the sides, margin sharp, surface smooth. Ripe September 11.

OGON. JAPANESE GROUP. (*Prunus Americana.*)

Trees of very vigorous growth, but killing back to such extent each winter that they have borne no fruit. Young twigs light-colored, outer bark on two-year-old wood greenish-brown, showing many lenticles and cracks, on older wood becoming dark colored. Leaves lanceolate, glossy, light-green, crenate and glandular-denticulate; stalks short, glandular. Top grafts on native *Prunus Americana* inserted in 1894 have fruited for four seasons. Our description of the fruit is drawn from specimens produced in 1897. Round-oblong, slightly flattened at apex, oblique at stem end, cavity rather shallow; suture inconspicuous; color dull yellow with thin whitish bloom; stem short, stout; stone free, oval, sides strongly convex, margin prominent and sharp; flesh thick, firm, meaty, of inferior quality. Ripe Augt 14. Plate XII.

PEFFER'S PREMIUM. (*Prunus Americana.*)

Trees planted in 1894 are still quite small, but well formed; young wood glabrous. Leaves medium, broadly-ovate, light green, more or less doubly serrate, the teeth short, stalks red, with or without glands. Fruit of medium size, round, rather abruptly flattened at both ends; suture obsolete; color deep red on yellow ground, conspicuously marked by "leather cracks" about the stem end; bloom thin; flesh firm, quality good; stone cling, circular, sides convex, sharp on the margins, smooth. Season medium; ripe September 11.

PENNOCK'S HYBRID. (*Prunus Besseyi* X *Prunus Americana.*)

A few years since, in the nursery of Mr. C. E. Pennock, of Bellvue, there appeared among a lot of seedlings of *Prunus Besseyi*, one tree that, while bearing the flowers of *Prunus Besseyi* had the habit and foliage of *Prunus Americana*. The fruit borne by this tree is nearly the size of wild *Prunus Americana* but in color and flavor like *Prunus Besseyi*. The mixture of characters suggested hybridity and led Mr. Pennock to experiment in that direction. Pollen of *Prunus Americana* was successfully used on the stigmas of *Prunus Besseyi* and several hybrids resulted. These all resemble the plum in habit, but have the small flowers of the cherry. The leaf characters are intermediate, but generally most like the male parent. The fruit of most of the trees is not valuable, being small and very acid. The color in all is dark, and in general much like the cherry. One tree, however, produces fruits that are considerably larger and much better than any of the others. It is to be introduced and may prove an acceptable addition to the list of varieties. This tree is of spreading habit, in general appearance like varieties of *Prunus Americana.* Leaves medium in size, varying from ovate to lanceolate. Flowers small, produced in profusion. Fruit of medium size, spherical; color deep blue, with light bloom; flesh firm, of excellent flavor, possessing none of the astringency so noticable in the fruit of the other hybrids. The tree in bloom is illustrated by plate XIII, and a branch showing fruit in figure 1, plate XIV. It is worthy of further trial.

PRAIRIE FLOWER. (*Prunus hortulana,* var. *Mineri.*)

Represented by nine old trees of uncertain age, and one tree planted in 1894. The young tree fruited in 1897, the others have born for several years. The old trees are fully developed, as large as the trees of Miner, and of the same appearance. Leaves large, broadly to narrowly ovate-lanceolate, evenly crenate, lower surface pubescent, stalks long, stout, glandular. Fruit of medium size, round-oblong, obscurely pointed; color red on yellow ground, flecked all over with small light dots; suture evident; stem of medium length, stout; skin thin; flesh firm, sub-acid, of fair quality; stone cling, rather broad, short pointed at both ends, margin rather sharp, slightly roughened. Ripe September 21. Very productive.

PURPLE YOSEMITE. (*Prunus Americana.*)

In character of tree very closely resembling the wild plant: very thorny, and irregular in habit. Leaves of medium size, ovate or obovate, acuminate, doubly serrate, dark green, pubescent below; stalks glandless, or occasionally with two small glands. Fruit large, round-oblong, flattened laterally; color deep purplish-red; skin thick; suture obsolete; flesh firm, of fair quality; stone cling, flat, rounded at the ends, rather rough, margins not sharp. Season medium to late. Ripe September 24.

ROCKFORD. (*Prunus Americana.*)

Our trees planted in 1894 are still rather small, but thrifty in appearance, forming round regular tops. Leaves large, coarsely and deeply serrate, short acuminate; stalks dark red, pubescent, mostly glandless. Fruit of medium size, oblong, somewhat pointed, broad at base; color dark red on green ground; skin thin; suture inconspicuous; flesh firm, very acid until quite ripe, then of good quality; stone cling, broad at stem end and tapering to a rather acute, thick apex, sides strongly convex, margin narrow, but sharp. Productive, early; ripe August 31.

ROLLINGSTONE. (*Prunus Americana.*)

Trees typical of the species, well-formed and of fair vigor. Leaves large, broad, irregularly crenate; color dark green, stalks mostly glandless. Fruit large, round, flattened at both ends; deep red shading to pink on yellow ground; stem of medium length, skin thick; flesh firm, good; stone cling, broad oval, sides convex, margins sharp, smooth. Season medium, ripe September 12.

RUSSIAN No. 2. (*Prunus domestica*)

Trees forming roundish heads, and making less growth than other varieties of the same class. Leaves of medium size, broad, dull green, evenly crenate; stalks short, glandless. Fruit of medium size, inclined to be irregular in shape, often more or less constricted at stem end, and sometimes flattened at distal end; suture apparent, more deeply colored than surrounding parts; color deep purple, with heavy blue bloom, stem sout, of medium length; flesh firm, sub-acid; quality only fair; stone free. Season early, ripe August 15.

SPEER. (*Prunus Americana*)

Small, but vigorous trees of spreading habit, producing long, slender branches. Leaves large, broad, acuminate, deeply and sharply serrate, dark green; stalk red, nearly glabrous, usually bearing small glands. Fruit medium in size, round-oblong, often contracted about the stem; suture evident; color purple-red on yellow ground; stem short, slender; skin thick; flesh firm and of good quality; stone cling, short-oblong, rather flat, ends blunt. Season medium, ripe September 17. Very productive.

SUNSET. (*Prunus Americana.*)

This variety originated with Mr. C. E. Pennock, of Bellvue, Colorado. We have one tree planted in 1897 that produced a few fruits this season. The tree is well-formed with a somewhat spreading habit. Leaves of medium size, broadly lanceolate, margin doubly and irregularly crenate, stalks glandular. Fruit medium to large, oval or oblong, stem rather long, slender; color deep red on yellow ground, beautifully shaded as it approaches ripeness; suture apparent; flesh firm, of excellent quality. Early; ripe August 25. The original tree shows great productiveness, which with the handsome appearance of the fruit, and its good quality, recommends the variety as a valuable acquisition. Fig. 2, Plate XIV.

VAN BUREN. (*Prunus Americana,* var. *mollis.*)

Trees of slow growth, appearing like dwarfs; tops well-formed, spreading; leaves broad, doubly serrate, dark green, stalks ashy-pubescent, glandular; fruit of medium size, spherical, suture obsolete; color deep waxy yellow, in part over-spread with light red and having a deep red cheek; stem stout, of medium length; skin thick; flesh sweet and rich; stone free, flat, rather broad, margin sharp but not winged. Ripe September 22. Very productive. One of the most promising varieties. Plate XV.

WEAVER. (*Prunus Americana.*)

Our trees planted in 1894 are larger than those of any other variety planted at the same time. They are vigorous and well-formed. The tendency to produce long slender branches is quite marked in this variety. Leaves large, obovate or oval, acuminate, somewhat pubescent below, leathery in texture, dark green, deeply serrate; stalk long, stout, glandless, or with occasional small glands. Fruit medium to large, round-oblong; suture evident, sides often unequal; color purplish-red on yellow ground, the red mottled with light dots; flesh firm, sweet when ripe, of good flavor; stone semi-cling, abruptly pointed, smooth. Ripe September 18. Plate XVI.

WINNEBAGO. (*Prunus Americana.*)

Trees very vigorous, well-formed. Leaves large, broad, sharply serrate, produced in great abundance; stalks short, stout, glandular. Fruit medium to small, round, inclined to be irregular and one-sided; stem long, slender, cavity deep; color deep red on yellow ground; skin thin; flesh yellowish, soft, of inferior flavor, granular in texture; stone nearly free, elliptical, somewhat oblique; rather flat, rounded at both ends, roughish. Ripe September 18. Plate XVII.

WOLF. (*Prunus Americana.*)

Vigorous growing trees of spreading habit. Leaves large, ovate, acuminate, closely and sharply serrate, leathery in texture; stalks stout, ashy pubescent; on some trees wholly glandless, on others small glands are not uncommon. Fruit medium to large, round to round-oblong, slightly flattened, sometimes tapering somewhat toward the stem; stem short, stout, set in a small cavity; suture obsolete; color when ripe uniformly deep red, with heavy purple bloom; skin thick; flesh firm, of good quality; stone free, rather small, pointed at stem end, sides strongly convex, margin sharp and prominent, smooth. Season medium, ripe September 16. Fruit Fig. 2, Plate VI; Tree Plate XVIII.

WYANT. (*Prunus Americana.*)

Trees stocky, forming round heads, of slower growth than Wolf or Weaver. Leaves medium, crisp in texture, sharply serrate, dark green; stalks pubescent and glandular. Fruit large, round-oblong, flattened at apex; cavity large and deep; color purple red on yellow ground; stem short, stout; skin thick; flesh firm, of good flavor; stone free or nearly so, large, oblong, flat. Ripe September 18. Fruit Fig. 1, Plate VII.

YELLOW SWEET. (*Prunus Americana.*)

Trees small, stocky, very thorny; leaves large, oval-oblong, irregularly crenate, stalks commonly glandless. Fruit large, round, color yellow, lightly shaded with red, bloom thin; suture apparent; stem short, stout; skin thin; flesh firm, juicy, rich; stone cling, oval, pointed at both ends, sides convex, margin sharp. Ripe August 31. A very promising variety. Fruit Fig. 2, Plate VII; Tree Plate XIX.

REFERENCE TO PLATES.

PLATE I.

Fig. 1, Yellow Sweet; Fig. 2, Wolf, showing lack of affinity between stock and scion. The stock is being overgrown.

Fig. 3, Plate of Weaver plums, reduced nearly one-half.

PLATE II.

Illustrates the system of irrigation practiced.

PLATE III.

Showing the effects of the "Shot-hole fungus" *(Cylindrosporium Padi Karst.)*

PLATE IV.

Fig. 1, Black knot of the plum and cherry, ***(Plowrightia morbosa*** (Schw.) Sacc.*)*

Fig. 2, Plum pockets. ***(Exoascus Pruni Fckl.)***

PLATE V.

Fig 1, Cheney; Fig. 2, Deep Creek; reduced nearly one-half.

PLATE VI.

Fig. 1, Forest Rose; Fig. 2, Wolf; reduced nearly one-half.

PLATE VII.

Fig. 1, Wyant; Fig. 2, Yellow Sweet: reduced nearly one-half.

PLATE VIII.

Cheney.

PLATE IX.

Deep Creek.

PLATE X.

Forest Rose.

PLATE XI.

Hawkeye.

PLATE XII.

A branch of Ogon from top graft on P. Americana.

PLATE XIII.

One of Mr. C. E. Pennock's hybrids between P. Besseyi and P. Americana in bloom.

PLATE XIV.

Fig. 1, Fruit of Mr. C. E. Pennock's hybrid between P. Besseyi and P. Americana.

Fig. 2, Sunset plum, originated by Mr. C. E. Pennock.

PLATE XV.

Van Buren.

PLATE XVI.

Weaver.

PLATE XVII.

Winnebago.

PLATE XVIII.

Wolf.

PLATE XIX.

Yellow Sweet.

Plates 13 and 14 are from photographs by S. H. Seckner, all others from photographs by the author.

PLATE I.

Fig. 1.

Fig. 2.

Fig. 3—Weaver.

PLATE II.—Irrigation.

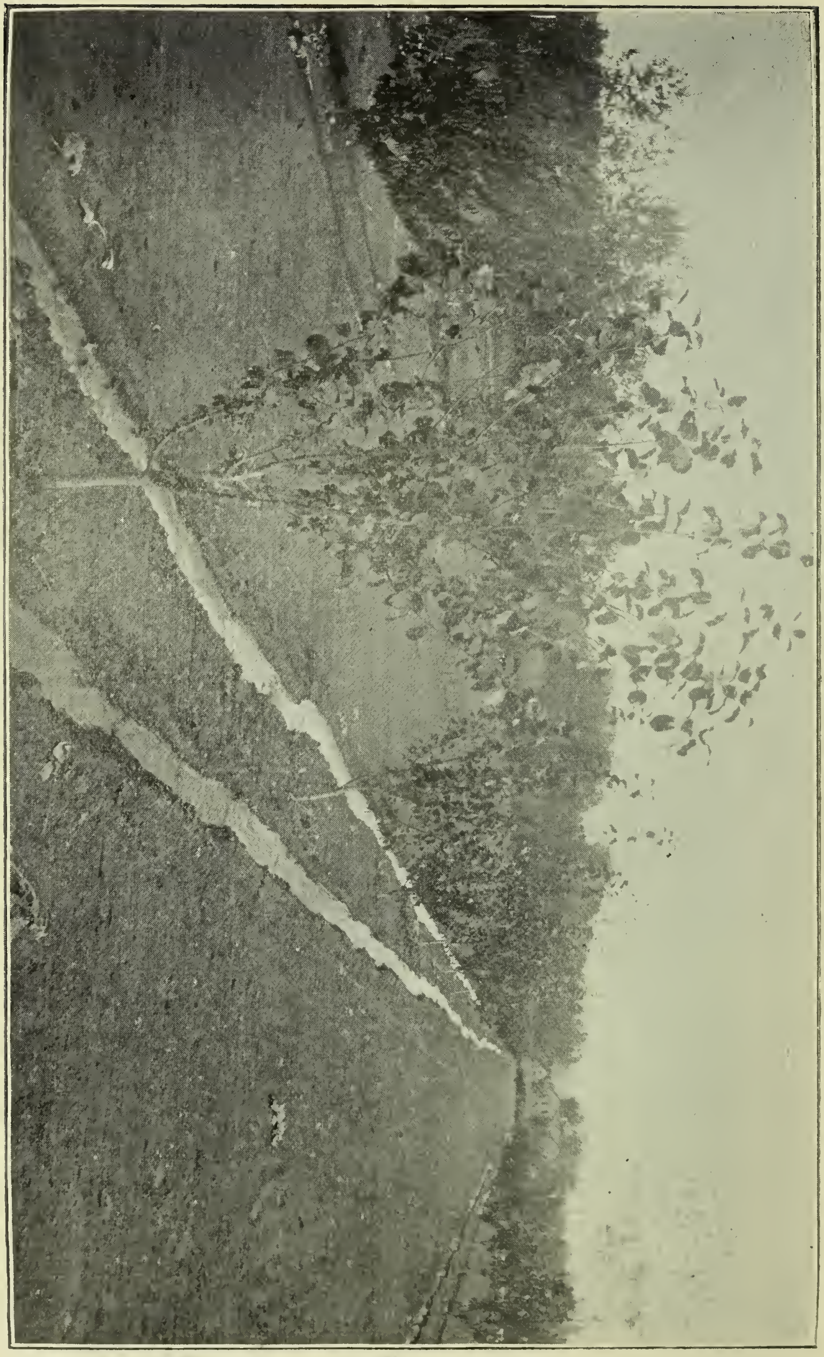


PLATE III.

Plum Leaves.

PLATE IV.

Fig. 1—Black Knot.

Fig. 2—Plum Pockets.

PLATE V.

Fig. 1—Cheney.

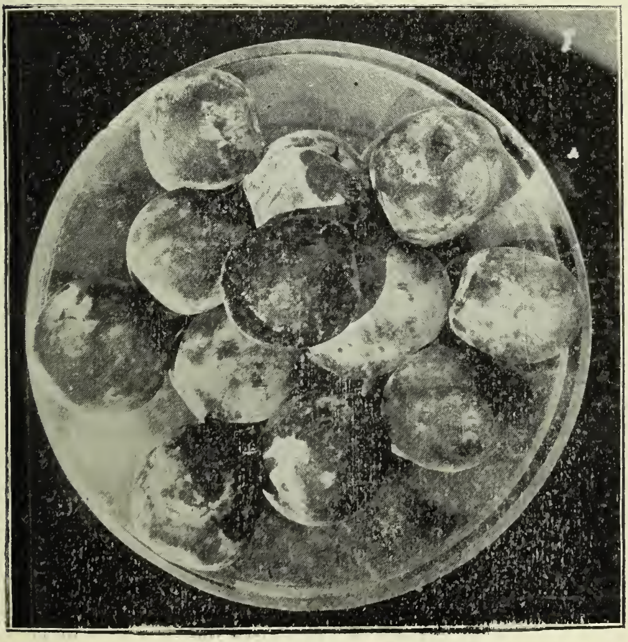


Fig. 2—Deep Creek.

PLATE VI.

Fig. 1—Forest Rose.

Fig. 2—Wolf.

PLATE VII.

Fig. 1—Wyant

Fig. 2—Yellow Sweet.

PLATE VIII.

Cheney.

PLATE IX.

Deep Creek.

PLATE X.

Forest Rose.

PLATE XI

Hawkeye.

PLATE XII.

Ogon.

PLATE XIII.

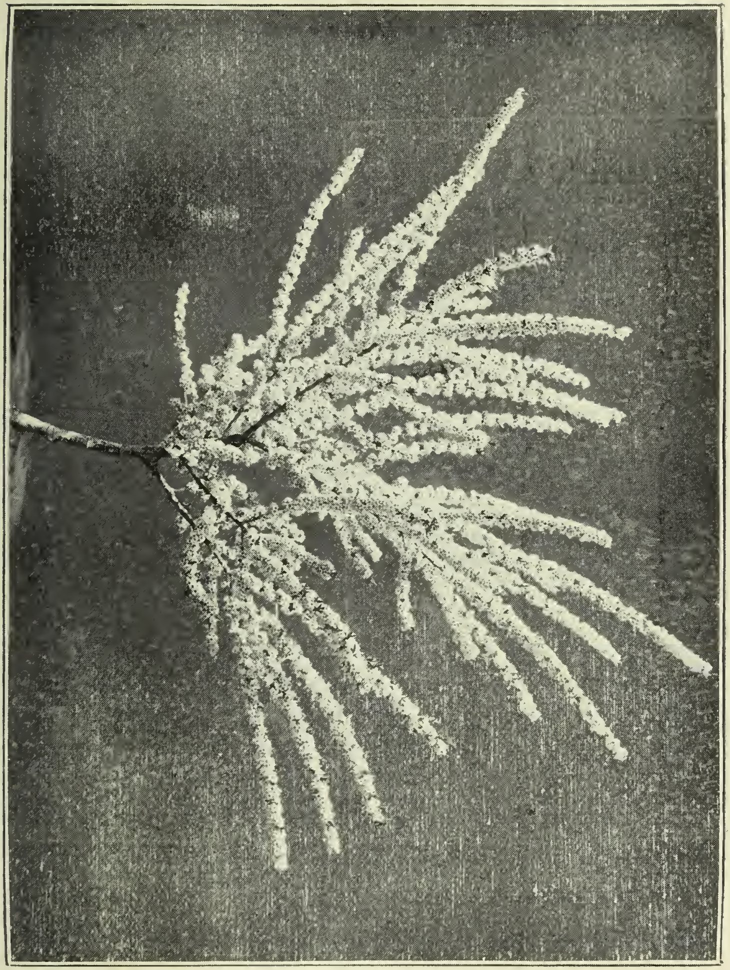


PLATE XIV.

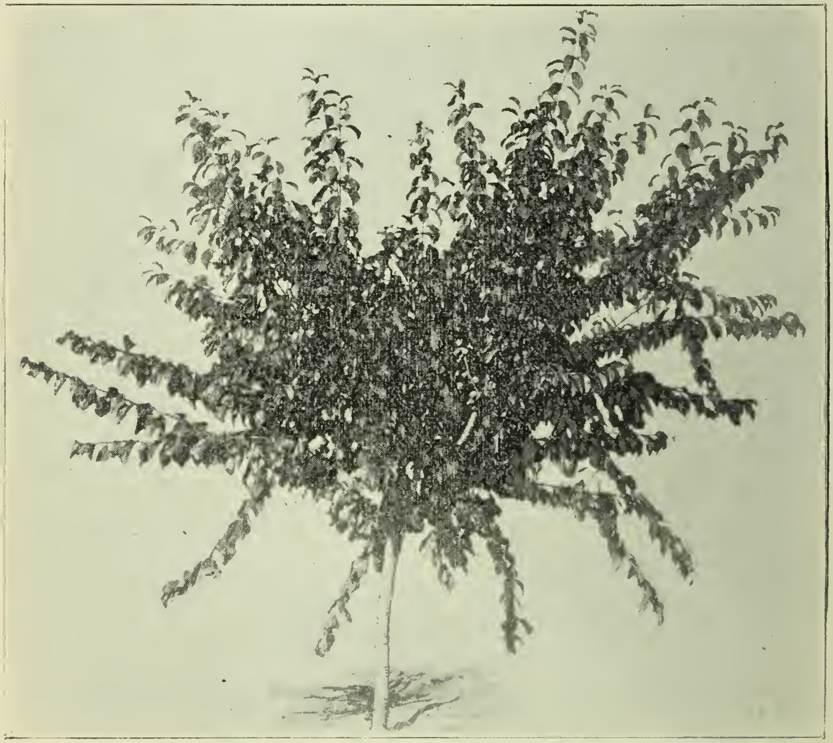
Fig. 1—Hybrid.

Fig. 2—Sunset.

PLATE XV.

Van Buren.

PLATE XVI.



Weaver.

PLATE XVII.

Winnebago.

PLATE XVIII.

Wolf.

PLATE XIX.

Yellow Sweet.

THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 51.

SUGAR BEETS IN COLORADO IN 1898.

Approved by the Station Council.

ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

MARCH, 1899.

Bulletins will be sent to all residents of Colorado, interested in any branch of Agriculture, free of charge. Non-residents, upon application, can secure copies not needed for distribution within the State. The editors of newspapers to whom the Station publications are sent are respectfully requested to make mention of the same in their columns. Address all communications to the

DIRECTOR OF THE EXPERIMENT STATION,
Fort Collins, Colorado.

COURIER JOB ROOMS PRINT

The Agricultural Experiment Station,

FORT COLLINS, COLORADO.

SUGAR BEETS IN COLORADO IN 1898.

By W. W. COOKE.

For several years the Station has been carrying on experiments in Colorado on the adaptation of the sugar beet to the conditions of soil and climate found here. During 1898 these tests were conducted on a larger scale than ever before. It can be said in general that the results of the season of 1898 are so conclusive, that we may feel justified in saying that Colorado can raise as good sugar beets and as large crops of beets as any place in the world. We purpose now to consider this point as settled, and future experimental work with sugar beets will be directed toward some of the minor points of methods of irrigation, times and distances of planting, etc.

The work of 1898 was distinguished from that of previous years in that it was done largely in connection with the Denver Chamber of Commerce, and cash prizes were offered for the best crops of sugar beets, thus affording an incentive to better care of the crop. It is believed that the inducement thus offered was a powerful factor in the good results obtained, yet the value of the prizes was as nothing compared with the value of the crop if raised for a factory. So that it is a fair presumption that what was done under the stimulation of the Denver Chamber of Commerce, prizes would be the common result under factory conditions.

The work of the season of 1898 may be grouped under four headings:

1. The experiments conducted on the College Farm at Fort Collins and on the sub-station at Rocky Ford, with reference to methods of growing sugar beets.

2. Experiments conducted at these two places and at about twenty other places in the State, with reference to the quantity and quality of sugar beets grown from seed raised in the United States as compared with seed grown in Europe.

3. Competitive tests for the prizes offered by the Denver Chamber of Commerce in connection with the County Commissioners of various counties.

4. General tests in the parts of the State above irrigation or in those irrigated sections that did not take interest enough in the matter to co operate in the matter of prizes.

The beet seed was obtained principally from the United States Department of Agriculture, but some, also, from the Oxnard Sugar Co., of Grand Island, Nebraska, through the efforts of the officials of the Union Pacific, Denver & Gulf Railroad ; some from the sugar factory at Rome, N. Y., through the efforts of Mr. M. B. Colt, of Alamosa, and when all these sources of supply failed, the Denver Chamber of Commerce bought, in open market, enough seed to supply the remainder of the requests. In all, about four thousand pounds of seed were distributed to two thousand three hundred persons. In each case the seed was delivered free of charge to the person making the tests.

All the analyses on which this bulletin is founded were made by the Chemical Section of the College at Fort Collins. There were eight hundred and twelve samples analyzed at Fort Collins.

Through the courtesy of the U. S. Department of Agriculture the franking privilege was given to the Station for the sugar beet work, and all the seed and several thousand pounds of the beets for analysis were sent through the mail postage free. In addition the railroads of the State, particularly the Union Pacific, Denver & Gulf, Denver & Rio Grande, and Atchison, Topeka & Santa Fe, took a lively interest in the experiments and furnished transportation that materially facilitated the work.

EXPERIMENTS AT FORT COLLINS AND ROCKY FORD ON METHODS OF RAISING SUGAR BEETS.

These tests can be grouped under the following headings:

1. Different dates of planting.
2. Planting on freshly plowed ground as compared with ground plowed a few days before planting.
3. Seed irrigated at planting as compared with that not irrigated.
4. Soaking seed before planting.
5. Sowing at the bottom of a three-inch furrow.
6. Different depths of planting.
7. Transplanting.
8. Different distances of thinning.
9. Different dates of thinning.
10. Variety tests.
11. Number of irrigations.

Each of these tests will be considered by itself, but at the outset it is necessary to make some explanations.

The following general statements apply to all the experiments at Fort Collins. The piece selected was a rather heavy clay loam, sloping slightly to the south. The ground had been heavily manured the spring of 1896 at the rate of nearly sixty tons per acre of well-rotted stable manure. It was cropped during 1896 and 1897 with corn. The spring of 1898 it was plowed in sections. A part of the section was planted the day it was plowed, the rest was allowed to lie from two to four days before it was planted. The seed was sown with an ordinary wheat drill in rows twenty-four inches apart. A few rows that will be specially mentioned were sown with a hand garden drill in rows eighteen inches apart. As soon as the beets broke through the ground so as to define the rows, they were wheel-hoed by hand. Later they were thinned, hand-hoed, cultivated three times with a horse cultivator, and twice irrigated, on June 27 and July 19.

The first set of samples was taken the last of September, after a period of long continued and severe drought. The last samples were taken October 22. Between these two dates there had been several rains, giving a total precipitation of three-fourths of an inch and dampening the beets to the bottom of the furrow. The beets were dug during the following week, with no further rain. Each of the 176 rows was dug in two parts and each part weighed separately. Every beet on the field was counted, to get the stand under the various conditions, and about half of them were counted the second time. This work involved about a thousand weighings and the counting of over sixty thousand beets.

The plantings at Fort Collins were made May 10, May 27 and June 15, with supplementary plantings May 13 and May 31. It had been expected to make four plantings, but a very heavy snow storm set in the last of April, with a total precipitation of three inches. None of this ran off and the ground was thoroughly soaked to a depth of eight inches. It was not until the second week in May that the soil dried out enough so that it could be worked.

This storm had a far reaching effect on the sugar beet work of the season. It saturated the ground without packing it, and to this is largely due the almost perfect germination obtained and the small influence observed from soaking the seed or irrigating at time of planting. The influence of this storm was still felt at the time of the second planting, the last of May, and the ground was hardly dried out by the last planting, the middle of June. The same storm will be referred to later with reference to its effect on the beets at Rocky Ford.

Before giving the detailed record of the various tests, it may be well enough to notice the analyses of the two sets of samples. Both sets were taken in the same way. Every tenth beet was taken from two contiguous rows until about a dozen beets had been dug. These were at once topped, cleaned by brushing or scraping, or in a few cases by washing, and weighed on scales accurate to the quarter of an ounce. If they were analyzed the same or the next day no account was taken of the small amount (about two per cent.) that they had dried out between digging and analyzing. If they stood longer than two days before they were analyzed, a correction was made in both total solids and sugar for the water that had dried from the beets after the second day. All of the analyses given in this section on methods of raising beets and in the section of this bulletin on tests of different sources of seed are the corrected analyses after making allowance for the drying out after the second day. In actual factory practice the beets seldom reach the factory until the third day after digging, and often not until much longer periods. So that it is probable that had these beets been raised and delivered to a factory they would have dried out a little more and tested a little higher than the figures given in this bulletin.

About fifty samples were taken the last of September, and an equal number October 22. The average of the first set is 15.43 per cent of sugar in the beet and 78.6 purity. The second set averaged 16.38 sugar and 78.1 purity, thus indicating a small gain in sugar and slight loss in purity between the first and second samplings. If these fifty tests are divided into five sets, according to the dates of planting, as will be given later, the last four sets give 14.97 sugar and 77.2 purity for the first samples, and 16.24 sugar with 77.6 purity for the samples three weeks later. Thus, they show an increase in sugar with but little change in purity. The samples from the first planting average 17.28 sugar and 84.2 purity for the first set, and 16.96 sugar with 79.7 purity for the last samples. A study of the ground gives some explanation of the cause of these differences. The ground first planted was so damp at the time it was worked, that it was somewhat packed by the working, and consequently suffered more from the late drought. At the time the samples were taken, the last of September, the leaves of the beets on this part of the field were so badly wilted as to touch the ground. The beets were really dried out in the ground. When the rain came they absorbed water and showed a lower test, with a change in purity, from a slight second growth.

It can be said, then, that, on the whole, the beets gain one per cent. of sugar during the three weeks between the two times of sampling. but there are so many apparent exceptions to this general statement, due to differences in sampling and analyzing, that it is deemed best to use the analyses of both sets of samples.

1. Different Dates of Planting.

A section of the ground was plowed May 10, part planted at once and the remainder planted May 13. A second section was plowed May 27, and planted on that day and on May 31. The third section was both plowed and planted June 15. The rows were two feet apart and 177 feet long; the intention was to thin to six inches, so as to have one beet for each square foot of surface. In the following table, a "perfect stand" would have been one beet for each six inches of row:

Row.	Date planted.	Per ct. of perfect stand.	Average distance apart in row. Inches.	Average weight of beets. Lbs.	Test.	Sugar in beet.	Purity.	Weight of crop in tons per acre.	Pure sugar per acre. Lbs.
21-92.........	May 10	....	....	....	First	17.28	84.2	....	......
"	"	....	....	....	Second	16.96	79.7	....	......
"	"	88	6.8	0.92	Average	17.12	82.0	17.8	6095
103-120.......	May 13	....	....	....	First	15.24	74.3	....	......
"	"	....	....	....	Second	17 26	78.8	....	......
"	"	83	7.2	0.90	Average	16.25	76.6	16.3	5296
141-155.......	May 27	....	....	....	First	16.18	79.9	....	......
"	"	....	....	....	Second	16.54	77.4	....	......
"	"	72	8.3	1.09	Average	16.36	78.7	17.4	5693
156-161......	May 31	....	....	....	First	15.37	77.3	....	......
"	"	....	....	....	Second	17.05	78.9	....	......
"	"	71	8.4	0.91	Average	16.21	78.1	14.2	4604
165-176... ..	June 15	....	....	....	First	13.01	77.5	....	......
"	"	....	....	....	Second	14.11	75.5	....	......
"	"	34	18.0	1.27	Average	13.56	76.5	9.3	2522

For the purpose of studying the effect of the main three different dates of planting, the preceding table may be summarized as follows:

Row.	Date planted.	Per cent of perfect stand.	Average distance apart in row. Inches.	Average weight beets. Lbs.	Per cent of sugar in beet.	Per cent purity.	Weight of crop in tons per acre.	Pure sugar per acre. Lbs.
21-120................	May 10-13	87	6 9	0.91	16.85	79.3	17.5	5897
141-162................	May 27-31	72	8.3	1.00	16.31	78.3	16.6	5415
165-176................	June 15	34	18.0	1.27	13 56	76.5	9.3	2522

The showing against the late planting is very decided. It produced less than half as much sugar as either of the others. It is evident that the small weight of crop is due, primarily, to the poor stand, since, even planting the middle of June, the beets average larger than those planted earlier. But, with only a third of a stand and the beets eighteen inches apart, the extra size did not compensate for the smaller number of beets. The poor stand is due to hot, dry weather, and, as will be noticed more at length in another place, even irrigating at the time of planting did not much increase the germination.

The difference between the crops of the May 10 planting and that of May 27, is not large, indicating that profitable crops may be raised, even though the seed is not planted until the last week in May. The difference in the stand in this case is, undoubtedly, due to the drying out of the ground, rather than to the greater heat. Though differences in sugar and purity are not large, yet these differences are in favor of the earlier planting. The analyses of the beets from the June 15 planting, show that the crop did not reach nearly to the degree of ripeness attained by the earlier plantings.

There is nothing in these experiments to show whether still better returns would be obtained by planting in April, and, unfortunately, the test of this point, made at the Rocky Ford sub-station, was so injured by a severe hailstorm as to offer little light on this point.

The beets at Rocky Ford were planted at four different dates, April 18, May 2, May 16 and June 1. As the season there is about two weeks earlier than at Fort Collins, these dates are about the same, so far as the season is concerned, as those used at Fort Collins, with the addition of one earlier date. The beets were planted in good mellow garden soil, in rows eighteen inches apart and thinned to nine inches apart in the row.

As noted above, a severe hailstorm, on June 6, interfered seriously with the experiment. The plantings of April 18, May 2 and May 16, were well up at the time and were cut even with the ground, allowing the later planting to approach them in growth. When the present writer visited the field, the middle of July, the eye could scarcely tell any difference between the first three plantings.

Two sets of samples were taken of each of these plantings, the first October 8 and the second October 29. The crop was harvested during the next week and the beets counted from several rows of each planting, so as to get the stand and the average size :

Date of planting.	Per cent of full stand.	Average distance apart in row. Inches.	Average weight of beets. Pounds.	Weight of crop in tons per acre.	Pure sugar per acre. Pounds.
April 18	63	9.5	0.96	18.4	6097
May 2.............	57	10.5	0.89	15.1	5138
May 16............	85	7.0	0.64	15.6	5338
June 1............	90	6.7	0.50	13 8	4857

Date of Planting.	Test of October 8.		Test of October 29		Average.	
	Sugar in beet.	Purity.	Sugar in beet.	Purity.	Sugar in beet.	Purity.
April 18	16.98	84.6	16.07	86.9	16 57	85.7
May 2	16.79	83.7	17.32	85.2	17.05	84.4
May 16	16.75	86 2	17.47	86.7	17.11	86.4
June 1................ ..	18.02	87.0	17.17	85.5	17.59	86.2

The beets at Rocky Ford ripened better than those on the College Farm. They show for the first three plantings about half a per cent more sugar and more than six per cent. better purity than the first two plantings at Fort Collins. The crops from the earlier plantings at the two places are about equal. But while the last planting at Fort Collins never ripened and produced less than two-thirds the crop of the earlier plantings and not half as much sugar per acre, the last planting at Rocky Ford gives the best beets of all in quality and not much below the others in quantity. At both places the last of May seems to be as late as it is advisable to sow, although a crop can be obtained from beets sown considerable later. The averages of the two sets of samples at Rocky Ford are identical, showing that the beets had fully ripened before the first samples were taken. The intention was to take some earlier samples, but the letter of instructions was lost in the mail.

2. Planting on Freshly Plowed Ground.

One of the greatest troubles in raising sugar beets is getting a good stand. If the seed is planted deep and the planting is followed by a rain, the ground packs and the seed cannot get through; if planted shallow and dry weather follows, the seed cannot get enough moisture to grow well. In the present case, there was a large amount of moisture in the ground at the time of plowing and the question was, will the amount that dries out in the first few days after plowing be enough to influence germination and growth. The table already given contains the figures of the test and the results are strikingly in favor of planting on freshly plowed ground. In the first case three days elapsed between plowing and planting; in the second case four days intervened. The four items of germination, sugar, purity and weight of crop are in each case in favor of the beets planted as soon as possible after the ground is plowed. These differences are not always large, though in the case of the weight of the crop they amount to one-seventh, but in the aggregate the difference would have a decided influence on the sugar value of the crop. The average of the two plantings on freshly plowed ground is 16.74 per cent sugar, 80.3 purity and 17.6 tons per acre. The beets planted three or four days after plowing give 16.23 per cent sugar, 77.3 purity and 15.3 tons per acre. Combining these figures, the first gives 4731 pounds of available sugar per acre, while the latter yields but 3839 pounds, a difference of nearly a thousand pounds of sugar, or something over ten dollars per acre in favor of immediate planting. In the light of these figures, it can be seen how important it is that if large areas are to be planted, they should be plowed in sections and each section planted the day of plowing.

3. Irrigating at the Time of Planting.

Three tests were made of irrigating the ground as soon as the seed was planted, as compared with allowing the seed to germinate from the moisture in the soil. In each case a small furrow was made some six inches from the seed, and water run in this furrow until it soaked sideways and wet the seed.

Irrigated at Planting.					Not Irrigated at Planting.				
Rows.	Number beets per row.	Tons per acre of crop.	Sugar in beet.	Purity.	Rows.	Number beets per row.	Tons per acre of crop.	Sugar in beet.	Purity.
27-32	232	15.8	17.48	84.7	21-26	243	16 0	17.84	85 7
45-56	338	18.4	17.77	86.4	33-44	271	17.8	16.97	84.6
165 170	112	9.9	12.12	76.5	171-176	128	8.1	13 08	76.2
Average	227	14.7	15.79	82.5	Average	214	14.0	15.96	82 2

The results are closer than would be expected had the treatment been exactly alike, showing that so far as these tests are concerned there was no advantage from irrigating up the seed. It should be remembered, however, that this was on a soil very retentive of moisture, and which at the time the first two of these tests were made, was already well supplied with water. This soil also bakes easily and of course the bad effects of the hardening of the soil would go far toward counteracting the good effect of the extra moisture. It was expected that if irrigating up the seed was an advantage it would show most clearly in the last case, which was sown June 15 after the ground was quite dry. Here, however, the irrigation seemed to be a detriment, due probably to the baking of the soil.

While the above results are not favorable to the practice of irrigating up the seed when sown in ground as heavy as that of the College Farm, it does not follow that this may not be advantageous under other conditions and in other parts of the State. The present writer visited the farm of Mr. B. F. Wyckoff, at Rocky Ford, the past season, and saw there a large field of sugar beets with a perfect stand, that had been secured by irrigating up the seed. This field produced over 23 tons of beets to the acre. At Lamar he saw another perfect field of beets produced in the same way, on the farm of Mr. M. D. Parmenter. On remarking to Mr. Parmenter that at the College our greatest trouble was to get a stand, Mr. Parmenter replied that he always felt perfectly sure of that part of the business. His land was sandy enough so that it would not bake and had plenty of slope. He planted whenever he got ready, and then turned on the water. His perfect stand in 1898 was obtained with about four pounds of seed per acre.

On the lighter soils of the Arkansas valley, irrigating up the seed is a necessity, as the ground will not hold enough moisture to make a complete germination.

4. Soaking Beet Seed.

Two rows were sown with dry seed; two with half each of dry and soaked seed, and two with soaked seed, *i. e.*, seed that had been soaked in water for twenty-four hours before it was planted. Unfortunately, these tests being made on a small scale, were sown with a hand drill that did not do good work. Good results were obtained with the soaked seed, but no better than were obtained on neighboring rows with unsoaked seed. The test shows, therefore, neither advantage nor disadvantage from soaking the seed.

5. Sowing at the Bottom of a Three-Inch Furrow.

It was thought that, adopting the idea of the trench method of raising potatoes, there might be some advantage from getting the beet seed deep in the ground. A small furrow was made with a hand plow, and then the beet seed sown with a hand drill at the bottom of this furrow. This put the beet seed nearly four inches below the surface of the ground, but left it only lightly covered. Three tests were made, including both early and late sowing. The stand was not so good as in the rows on each side sown at ordinary depths. The yield was once as good and twice poorer than from similar rows of ordinary planting. The sugar and purity were not perceptibly different from other plantings.

In connection with this and some other tests, there is a chance to compare the results of planting with a hand planter and a horse planter. Though we have a good hand planter, yet on the whole the horse planter, which with us is an ordinary wheat drill, has given the better stand and the larger weight of crop.

6. Different Depths of Planting.

The following tests were made with the grain drill, set to plant as nearly as possible at the desired depths.

Row.	Depth of planting.	Number beets per row.	Weight of crop per row.	Sugar in beet.	Purity.
57–68	½ inch	360	313	15.51	76.1
147-149............	" "	233	237	16.10	79.0
69–80..............	1 inch	358	281	17.00	78.7
150–152............	" "	239	284	15.78	79.6
81–92............	1½ inches	315	279	17.31	80.0
153-155............	" "	270	313	16 76	85.0

With the first lot, rows 57–92, sown May 11, there is not much difference, but this slight difference both in stand and yield is in favor of the shallow planting. But it should be remembered that this seed was put into thoroughly damp, freshly plowed ground that was over a damp, almost wet, subsoil. The analysis is enough in favor of the deeper plowing to make the available sugar per acre the same for all three depths of planting.

At the later planting, May 27, rows 147–155, the ground was freshly plowed but had dried out considerably since May 11. In this test the stand, yield and quality are all in favor of the deepest planting, amounting in the comparison of the half inch with the one and a half inch to more than a third of the crop.

7. Transplanting Beets.

Some beet seed was sown in the greenhouse April 20 and the young beets transplanted to freshly plowed ground May 10. The rows were 18 inches apart and the beets 9 inches apart in the row. In the first part of the rows about three fourths of the beets lived, but less than half of them in the rest of the rows, making an average of about one beet to each two square feet. The growth of the beets was satisfactory so far as weight was concerned. They averaged a little over one and a half pounds each, or 16.3 tons per acre. Not a single tap root grew in the whole four hundred beets; they were a mass of fibrous roots that lost at least a fifth in trimming. Their quality was the lowest of all the beets planted early in May, being 14.44 sugar and 74.3 purity.

The above beets were planted in damp ground without irrigation. The next day some more from the same lot were transplanted and irrigated as soon as set. The stand was even poorer than before, though it was supposed that the work had been done with greater care. The size of the beets and the quality were the same as in the first lot. The fibrous roots were not quite so numerous, but there was not a good beet in the whole lot. Seed was sown in the ground at this date, May 10, and on June 8 some of the small beets were transplanted to some neighboring rows. They grew poorly and not one-fourth of them lived. They were not so bad in shape as those from the greenhouse and the quality was better, but as a method of raising beets it proved a financial failure.

Transplanting from the greenhouse, both with and without irrigation, was tried on another lot of plants May 26. It was a hot day, and in spite of the immediate irrigation only a few of the beets lived.

On June 15 transplanting was again tried with some larger beets that had been sown in the ground May 13. These beets were set in running water, and though in the middle of the summer at least nine-tenths of them grew. They were far from good shaped, but they made a crop of 19.3 tons per acre, testing 15.91 sugar, with 79.7 purity.

On June 27 some more transplanting was done from the beets sown May 27. These beets were quite small. They were planted in running water and nearly all grew. They made a crop of 18.9 tons per acre, testing 17.00 sugar with 80.1 purity. Judged by yield and test, these beets show quite well, but they were not good shaped. They were transplanted with the greatest of care into running water and afterwards irrigated several times, so as to give the best possible chance. Better results could hardly be expected, but the method would not be a financial success.

8. Different Distances of Thinning.

The attempt was made to thin beets to 4 inches, 6 inches and 8 inches, but the thinning was so poorly done that the 4-inch and the 6-inch each averaged 8 inches apart, and the 8-inch rows averaged 10 inches apart. Three trials were made. The first two tests on beets planted May 10, show no regularity of results and only slight differences. The 4-inch and 6-inch rows are excellent duplicates. By combining these two and comparing with the other rows, there is a slight showing in favor of the first two in yield, sugar and purity, which leads one to judge that 8 inches is a better distance than 10 inches for two-foot rows. The late planting of May 27 is quite decidedly in favor of the thicker stand for yield, sugar and purity. The full figures are given below:

Row.	Intended distance apart. Inches.	Actual distance apart of beets. Inches.	Number of beets in One row.	Weight of crop in tons per acre.	Sugar in beet.	Purity.
21 and 24	4	8	301	16.1	16.97	79.8
27 and 30	4	8	251	15.6	18.31	86.0
103 and 104	4	8	272	16.5	16.52	75.1
22 and 25	6	8	215	16.5	17.63	83.0
28 and 31	6	8	251	15.5	17.55	83.2
105 and 106	6	8	293	14 9	16.54	78.3
Average.............	....	8	264	15.8	17.26	80.9
23 and 26	8	10	211	15.5	18.38	80 3
20 and 32	8	10	196	16.2	17.03	81.5
107 and 108	8	10	198	13.4	15.12	68.7
Average.............	....	10	202	15.1	16.69	78.6

Seeing that this form of the test was a failure, another trial of the same point was made by going through the rows that were intended to have the beets 4 inches apart and selecting twelve beets, each of which was just four inches on each side from the next nearest beet. The same was done with the 6 inch rows and the 8-inch rows. The following results were obtained :

Row.	Distance apart of beets Inches.	Average weight of beets. Pounds.	Weight of full stand in tons per acre.	Sugar in beet.	Purity.
21 and 24...........	4	1.12	36.6	17.58	80.6
22 and 25...........	6	1.01	22.0	17.67	79.9
23 and 26...........	8	1.21	19.8	18.34	80.3

The beets at 8 inches apart are a little heavier than the others, and this is about the only noticeable difference. The generally accepted belief is that these beets at 8 inches apart should be poorer in quality than those growing closer together. In this particular case they are a little better. The most noticeable result is the computation on a full stand. If a field had a complete stand of beets four inches apart and of the same size as these, it would yield 36.6 tons of beets. While, at 6 inches apart, the yield would fall to 22.0 tons, and at 8 inches, to 19.8 tons. Judged in this way, the results are favorable to the thicker stand.

Lastly, a third test of the same point was tried with rows 27 and 30, that had been intended to be thinned to four inches apart, by selecting from the two rows twelve beets 4 inches apart on each side, another twelve beets from the same rows 6 inches apart, and a third twelve beets from the same rows 8 inches apart:

Row.	Distance apart of beets. Inches.	Average weight of beets. Pounds.	Weight of full stand. in tons per acre.	Sugar in beet.	Purity.
27 and 30..........	4	0.73	24.0	17.71	76.3
27 and 30..........	6	0.89	19.5	17.10	81.2
27 and 30..........	8	1.08	17.8	18.15	80.7

The differences in weight, owing to the different amount of space occupied by each beet, is quite noticeable, but the beets having the most room do not grow correspondingly larger in size, *i. e.*, the beets eight inches apart are not twice as large as those four inches apart, hence the weight of crop per acre is again in favor of the closer stand. The differences in the analyses are not great, but, here again, the larger beets test slightly better than the smaller beets.

Combining the five sets of tests, it can be said that, as a whole, they show that the distances apart of the beets, from four inches to ten inches, has but slight influence on the quality of the crop as to sugar and purity. It can also be said that it has some effect on the weight of the crop, and, if the stands are equal, more tons per acre will be raised at less that eight inches apart than at over this distance. Even this latter statement can be given as only a general tendency, liable to many exceptions. Rows 57–92 were sown under as nearly as possible like conditions, were all thinned by the same person at nearly the same time, and the thinning was intended to be to six inches. As a fact, the rows vary from an average distance of four inches between the beets to more than eight inches. If, now, there are selected the four rows with the greatest number of beets and the four rows with the least, the following results are obtained: The crop from four rows, 708 feet long, with 1,711 beets, or an average of five inches apart, weighed 1,199 pounds; the other four rows of the same length, with 1,137 beets, or eight inches apart, yielded 1,191 pounds. So that, in this case, the beets grew in size exactly proportional to the space they occupied.

To get still further light on the question of the relation of size and quality, a test was made with row 53. The whole row was dug and the six largest beets selected, also six of medium size and the six smallest.

Size.	Average weight of beets. Pounds.	Total solids in juice.	Sugar in beet.	Purity.
Largest..............................	1.73	21.87	16.34	78.6
Medium	0.85	23.27	17.33	78.8
Smallest..............................	0.30	24.53	19.15	82.5

The above results show that in these extreme cases, the smaller the beets the better the sugar and purity. Even here, however, the difference is not large, being, in both cases, about one per cent of sugar for doubling the size of the beet. The previous tests seem to indicate that, for sizes from three-quarters of a pound to a pound and a half, the size of the beet has but little influence on its quality.

9. Different Dates of Thinning.

Most rules for the culture of sugar beets say that the thinning should be done as early as possible. Four tests were made to note the effects on the quantity and quality of the crop of thinning at different dates. The earliest thinning was done when the plants were quite young, from 18 to 26 days after planting, while the last thinning was 29 to 40 days after planting. These are not very wide extremes, but they cover the time at which most of the thinning would be done in beets raised for a factory.

No. of Test.	Date of thinning.	Days from planting to thinning.	Number of beets per row.	Weight of crop in tons per acre.	Sugar in beet.	Purity.
1....................	June 6	26	260	16.7	15.90	77.4
2....................	" 6	26	363	19.0	17.54	83.1
3....................	" 8	26	385	17.4	17.22	81.0
4....................	" 14	18	241	17.1	16.59	85.4
Average	....	24	312	17.5	16.82	81.7
1....................	June 16	36	297	17.0	16.77	81.8
2....................	" 16	36	283	17.3	17.08	83.5
3....................	" 16	34	283	16.4	....	....
4....................	" 17	21	270	20.3	15.76	75.0
Average............	....	32	283	17.7	16.54	80.1
1....................	June 20	40	268	16.8	17.22	85.3
2....................	" 20	40	305	17.7	18.43	85.1
3....................	" 20	38	327	15.5	16.00	78.0
4....................	" 25	29	288	18.7	17.31	81.6
Average...........	....	37	297	17.2	17.24	82.5

The average results are closely alike for the different dates, and the individual records are so irregular as to indicate that these different dates of thinning had little or no effect on either the quantity or the quality of the crop.

As all the results are excellent, the tests would seem to show that the work of thinning can be extended over a period of at least two weeks without injury to the crop. As one person can thin an acre of beets in about four days, it follows that a given planting can be thinned at the rate of one person to each three or four acres.

10. Variety Tests.

During the spring of 1898, the Station received from the U. S. Department of Agriculture, the seed of six varieties of sugar beets, with the request that they be given special tests. Two rows of each variety were sown, but, although the seed was sown at the rate of more than forty pounds of seed per acre, the stand was not so good as was gotten with the bulk of our beets. The seed of these six varieties was sown May 20, with a hand drill, in rows 18 inches apart, two rows of each kind, 177 feet long. The plants were thinned June 9 to nine inches apart, and the attempt was made to fill in the vacancies by transplanting, but nearly all of the transplanted beets died.

The first samples for testing were taken October 1, and the second samples October 22. The rest of the beets were dug October 26. The figures of analyses in the following table are the actual analytical results obtained on the beets three days after they were dug, with no allowance for drying out. During these three days, the beets had dried out about one-twenty-fifth of their weight. The beets were planted in the following order:

1. Zeringer, grown by Strandes.
2. Vilmorin's Improved, grown in Russia.
3. Kleinwanzlebener, grown by Vilmorin.
4. Pitschke's Elite.
5. Vilmorin's French, very rich.
6. Schreiber's Elite.

In the following table there has been added by way of comparison:

7. Average of eighteen rows of Kleinwanzlebener beets sown May 13 on the west side of the above varieties.

8. Average of fifteen rows of Kleinwanzlebener beets, sown May 27 on their east side. These last two were sown in rows 24 inches apart, and the intention was to thin them to six inches in the row.

Variety.	Per cent of full stand.	Average distance apart in row Inches.	Average weight per beet. Pounds.	Crop in tons per acre.
1	24	38	1.30	11.7
2	60	15	1.16	13.3
3	46	20	1.91	16.8
4	30	30	1.71	9.4
5	32	27	2.09	13.2
6	32	26	2.13	14.7
7	83	7	0.90	16.3
8	72	8	1.09	17.4

Variety.	Test of October 1.		Test of October 22.		Average.	
	Sugar in beet.	Purity.	Sugar in beet.	Purity.	Sugar in beet.	Purity.
1	14.73	75.4	15.44	76.9	15.08	76.6
2	16.48	84.9	16.96	79.0	16.72	81.9
3	14.82	78.9	15.68	77.7	15.25	78.3
4	17.20	87.1	17.20	76.3	17.20	81.7
5	15.49	80.4	14.73	77.6	15.11	79.0
6	16.15	80.3	15.06	76.7	15.60	78.5
7	15.54	74.3	17.80	78.8	16.67	76.5
8	16.50	79.9	16.87	77.4	16.68	78.6
Average	15.85	80.3	16.22	77.5	16.04	78.9

It will be noticed that the principal difference in the analyses of the two sets of samples is in the purity. The sugar in the beet improves about half a per cent, while the purity decreases nearly three per cent. The average analysis of these six varieties is almost exactly the same as of the Kleinwanzlebener beets we raised for our other tests on both sides of them.

Tests of several other varieties were made on the College farm in connection with the general test of European as compared with American grown seed. The results will be reported with the figures obtained on the same test throughout the state.

11. Number of Irrigations.

A plot of beets at the Rocky Ford substation was divided into three sections; the first received no irrigation during the season; the second was irrigated once, while the third was given four irrigations. The results are given in the following table:

Number of Irrigations.	Weight of crop in tons per acre.	Sugar in beet.	Purity.	Pure sugar per acre. Pounds.
None	12.0	15.68	79.5	3763
One	12.4	17.58	85.1	4395
Four	11.9	15.53	78.7	3696

The results are somewhat different from those expected when the experiment was planned. They are to be explained by the fact that the unusually heavy rains of the season were almost enough to raise beets in that locality without any irrigation. The one irrigation gave the beets all the water they needed and the other three irrigations were a positive detriment.

In connection with the tests of seed from different sources, Mr. C. K. McHarg, of Pueblo, made for us some tests in regard to late irrigation.

All of the plot, containing three-fourths of an acre, was treated alike until the latter part of the season, then one-half received no further irrigation, while the other half was given two irrigations additional.

The crop was weighed for each variety separately and yielded the following results:

Variety.	Weight of crop from half not irrigated after August 20. Pounds.	Weight of crop from half irrigated twice after August 20. Pounds.
Original Kleinwanzlebener	1018	1133
Utah Kleinwanzlebener	1069	1125
Eddy Kleinwanzlebener	787	927
Elite Kleinwanzlebener	964	1111
Vilmorin	885	931
Mangold	694	1041
Total	5417	6268

In this case there was a gain of one-seventh in the weight of the crop by irrigations late in the season.

An average sample of the Original Kleinwanzlebener from the part receiving the extra irrigations tested 16.42 sugar in beet and 81.0 purity, while a sample from the other half tested 15.79 sugar and 81.7 purity. Here there was an advantage in both quantity and quality from the late irrigation.

AMERICAN-GROWN SUGAR BEET SEED COMPARED WITH THAT GROWN IN EUROPE.

An extensive series of tests was made of beet seed grown in the United States as compared with seed grown in Europe. Six varieties were used; one grown in France, one in Saxony, two in Germany, and two in the United States. The sources of the seed are as follows:

1. *Utah Kleinwanzlebener.*—This seed was grown at Lehi, Utah, by the Utah Sugar Company. The seed first used was the Original Kleinwanzlebener from Germany, and the seed tested this year was the second generation of American seed grown from the German seed.

2. *Original Kleinwanzlebener.*—Imported from Germany and sent to us by the Utah Sugar Company. Of course this is not the identical seed that was used as the ancestor of the Utah Kleinwanzlebener seed above mentioned, but it is from the same seed farm, of a crop a few years later and is presumably of about the same quality.

3. *Vilmorin.*—Sent us by the United States Department of Agriculture and imported by them from the original growers in France.

4. *Mangold.*—Grown by M. Knauer, Grœbers, Saxony, and imported for us by the agent, H. Cordes, LaGrande, Oregon.

5. *Eddy Kleinwanzlebener.*—This seed was grown at Eddy, New Mexico, during the season of 1897 from the beets of 1896 that were grown from seed obtained from Maison Carlier, Orchies, North France. It is, therefore, the first generation of American seed from the original French seed. This is the first crop of seed raised at Eddy.

6. *Elite Kleinwanzlebener.*—Imported from Germany by the United States Department of Agriculture.

Seed of these six varieties was sent to quite a number of persons in the various irrigated portions of Colorado, who had promised to take special pains in the test. Some of the tests were to be on a small scale with the richest of ground and the best of conditions. Another set of tests was to be on a larger scale under general farm conditions.

Great credit is due the experimenters for the large amount of labor and painstaking care that were bestowed on these tests. The first samples were taken the last week in September, being the Utah Kleinwanzlebener and the Original Kleinwanzlebener. Two weeks later samples were requested of the Vilmorin and Mangold, and the next week the growers were asked to send samples of the other two varieties. About the first of November instructions were sent to harvest the crops and send samples of all six varieties.

Here are therefore two sets of samples, one set in three pairs and the other set from ripe crops in which the samples of the six varieties were taken at the same time and under the same conditions.

The earlier samples are all from the larger plots under field conditions. The later samples are given from the two plots separately.

UTAH KLEINWANZLEBENER.

Name.	Place.	Date of taking sample.	Wdth be-twe'n rows. Ins.	Average distance apart of beets in row. Ins.	Average wght of beets. Lbs.	Crop per acre. Tons.	Sugar in beet.	Purity.
S. M. Scott	Fort Morgan	Sept. 14	30	11.3	0.75	6.5	15.55	73.1
S. S. Abbott	Canfield	" 14	18	9.6	1.12	22.5	16.00	80.0
J. A. Davis	Berthoud	" 15	24	9.8	1.62	26.8	14.71	80.4
J. D. Payne	Grand Junction	" 15	18	9.1	3.25	26.6	9.09	64.6
C. K. McHarg	Pueblo	" 17	24	8.9	0.72	10.6	12.80	76.5
M. D. Parmenter	Lamar	" 15	18	6.7	1.10	28.0	14.71	78.3
Adam May	Debeque	" 17	18	8.4	1.12	23.5	15.22	82.3
F. M. Wright	Berthoud	" 19	18	25.7	1.00	7.0	12.80	70.3
E. K. Smith	Fort Lupton	" 22	18	.....	.....	.....	20.10	91.1
J. W. Dove	Alamosa	" 23	18	10.3	1.06	18.1	12.38	81.1
J W. Douthitt	Montrose	Oct. 3	18	6.0	1.06	30.8	15.60	81.9
Average		Sept. 18	20	10.8	1.28	20.1	14.09	78.1

ORIGINAL KLEINWANZLEBENER.

Name.	Place.	Date of taking sample.	Wdth be-twe'n rows. Ins.	Average distance apart of beets in row. Ins.	Average wght of beets. Lbs.	Crop per acre. Tons.	Sugar in beet.	Purity.
S. M. Scott	Fort Morgan	Sept 14	30	11.1	0.62	5.4	14.82	69.8
S. S. Abbott	Canfield	" 14	18	9.6	1.00	18.2	14.09	78.5
J. A. Davis	Berthoud	" 15	24	10.3	2.00	25.4	13.89	79.5
J. D. Payne	Grand Junction	" 15	18	8.9	2.37	46.3	11.83	71.8
C. K. McHarg	Pueblo	" 17	24	11.1	0.60	7.2	16.74	83.0
M. D. Parmenter	Lamar	" 15	8	6.9	0.81	17.4	13.20	79.8
Adam May	Debeque	" 17	18	8.5	1.75	35.8	13.02	73.7
F. M. Wright	Berthoud	" 19	18	25.7	0.75	5.4	10.72	63.3
E. K. Smith	Fort Lupton	" 22	18	.....	.....	.....	15.04	76.1
J. W. Dove	Alamosa	" 23	18	9.4	0.75	14.3	11.81	77.6
J. W. Douthitt	Montrose	Oct. 3	18	7.2	1.25	30.7	16.13	85.0
Average		Sept 18	20	10.9	1.19	20.6	13.75	75.3

VILMORIN.

Name	Place.	Date of taking sample.	Wdth between rows. Ins.	Average distance apart of beets in row. Ins.	Average wght of beets. Lbs.	Crop per acre. Tons.	Sugar in beet.	Purity.
S. M. Scott	Fort Morgan	Oct. 25	30	13.6	0.95	7.2	16.44	87.7
S. S. Abbott	Canfield	" 13	18	9.2	1.45	27.2	16.44	......
J. A. Davis	Berthoud	" 14	24	15.6	1.42	11.4	15.48	81.0
J. D. Payne	Grand Junction	" 17	18	7.6	1.15	28.9	17.05	78.6
C. K. McHarg	Pueblo	" 18	22	13.2	0.84	9.2	17.38	......
M. D. Parmenter	Lamar	" 13	18	12.4	1.54	21.7	16.67	88.6
Adam May	Debeque	" 18	18	10.0	1.40	24.5	16.87	72.5
F. M. Wright	Berthoud	" 25	18	24.0	1.37	11.5	16 15	81.3
E. K. Smith	Fort Lupton	" 12	18	8.6	0.64	13.1	17 42	......
J. W. Dove	Alamosa	" 17	18	8.0	0.87	20.0	11.80	78.5
J. W. Douthitt	Montrose	" 24	18	4.8	0.68	21.4	18.22	88.3
Average		Oct. 18	20	11.5	1.12	17.8	16.30	82.1

MANGOLD.

Name	Place.	Date of taking sample.	Wdth between rows. Ins.	Average distance apart of beets in row. Ins.	Average wght of beets. Lbs.	Crop per acre. Tons.	Sugar in beet.	Purity.
S. M. Scott	Fort Morgan	Oct. 25	30	9.8	1.39	14.6	13.06	73.8
S. S. Abbott	Canfield	" 13	18	9.2	1.52	29.0	16.39	78.0
J. A. Davis	Berthoud	" 14	24	15 2	1.57	13.5	12.58	74.2
J. D. Payne	Grand Junction	" 17	18	8.0	1.50	32.7	13.82	83.5
C. K. McHarg	Pueblo	" 18	22	15.2	1.02	10.0	17.42	......
M. D. Parmenter	Lamar	" 13	18	13.2	1.75	23.1	16.70	87.4
Adam May	Debeque	" 18	18	8.8	1.44	28.0	13 69	67.2
F. M. Wright	Berthoud	" 25	18	24.0	0.65	5.0	18.05	84.5
E. K. Smith	Fort Lupton	" 12	18	8.8	0.77	14.6	16.06	90.9
J. W Dove	Alamosa	" 17	18	7.2	1.12	27.2	10 86	77.8
J. W. Douthitt	Montrose	" 24	18	5.2	0 69	23.1	16.04	83.7
Average		Oct. 18	20	11 3	1.22	20.1	14.97	80.1

EDDY KLEINWANZLEBENER.

Name.	Place.	Date of taking sample.	Wdth be-twe'n rows. Ins.	Average distance apart of beets in row. Ins.	Average wght of beets. Lbs.	Crop per acre Tons.	Sugar in beet.	Purity.
S. S. Abbott	Canfield	Oct. 29	18	7.6	1.00	23.1	14.26	78.1
C. K. McHarg	Pueblo	Nov. 2	24	10.4	0.94	12.0	17.09	81.6
F. M. Wright	Berthoud	Oct. 31	18	......	1.35	.....	13.03	73.7
J. W. Dove	Alamosa	Nov. 1	18	7.2	0.62	24.5	12.70	83.3
Adam May	Debeque	" 14	18	......	1.30	......	16.39	85.8
J. D. Payne	Grand Junction.	" 7	18	11.7	1.61	26.7	14 82	77.9
Average		Nov. 4	19	9.2	1.15	21.6	14.71	80.0

ELITE KLEINWANZLEBENER.

Name.	Place.	Date of taking sample.	Wdth be-twe'n rows. Ins.	Average distance apart of beets in row. Ins.	Average wght of beets. Lbs.	Crop per acre Tons.	Sugar in beet.	Purity.
S. S. Abbott	Canfield	Oct 29	18	9.3	1.25	23.6	16.35	81.1
C. K. McHarg	Pueblo	Nov. 2	24	8.0	0.88	14.4	18.49	89.1
F. M. Wright	Berthoud	Oct. 31	18	......	1 25	......	14.43	73.7
J. W. Dove	Alamosa	Nov. 1	18	8.0	1.12	24 5	9.37	69.7
Adam May	Debeque	" 14	18	......	1.30	......	16.39	82.3
J. D. Payne	Grand Junction	" 7	18	11.7	1.61	23.4	14.58	79.0
Average		Nov. 4	19	9.2	1.23	21.5	14.93	79.1

AVERAGES.

Utah Kleinwanzlebener	Sept. 18	20	10.8	1.28	20.1	14.09	78.1
Original Kleinwanzlebener	" 18	20	10.9	1.19	20.6	13.75	75.3
Vilmorin	Oct. 18	20	11 5	1.12	17.8	16.30	82.1
Mangold	" 18	20	11.3	1.22	20.1	14.97	80.1
Eddy Kleinwanzlebener	Nov. 4	19	9.2	1.15	21.6	14.71	80.0
Elite Kleinwanzlebener	" 4	19	9.2	1.23	21 5	14.93	79.1

RIPE CROPS.

UTAH KLEINWANZLEBENER.

Name.	Place.	Date when crop was harvested.	Average distance apart of beets in row. Inches.	Average weight of beets Lbs.	Crop per acre. Tons.	Sugar in beet.	Purity.
Small Plot.							
S. S. Abbott	Canfield	Oct. 29	9.4	1.05	19.4	16.26	83.8
M. D. Parmenter	Lamar	" 28	7.1	1.15	28.3	14.08	82.1
C. M. C. Woolman	Sterling	" 31	9.0	0.80	16.1	18.40	85.4
C. M. Rulison	Parachute	Nov. 12	5.3	1.36	44.6	16.91	81.9
C. K. McHarg	Pueblo	" 9	7.1	1.32	24.5	14.80	80.0
J. D. Payne	Grand Junction	" 12	9.2	5.10	105.5	8.88	64.6
Chas. Milne	La Jara	" 7	8.5	1.00	20.6	15.88	80.1
J. W. Douthitt	Montrose	" 8	6.7	1.18	31.2	12.63	74.5
Average		Nov. 4	7.6	1.12	26.4	15.57	81.0
Large Plot.							
M. D. Parmenter	Lamar	Oct. 28	9.6	1.11	20.1	16.00	87.8
C. M. Rulison	Parachute	Nov. 12	5.0	1.18	41.8	15.27	80.8
Substation	Rocky Ford	Oct. 29	7.4	0.67	15.6	17.55	84.6
College Farm	Fort Collins	" 26	12.4	1.16	16.3	17.87	82.8
Average		Nov. 1	8.6	1.03	23.4	16.67	84.0

ORIGINAL KLEINWANZLEBENER.

Name.	Place.	Date when crop was harvested.	Average distance apart of beets in row. Inches.	Average weight of beets Lbs.	Crop per acre. Tons.	Sugar in beet.	Purity.
Small Plot.							
S. S. Abbott	Canfield	Oct. 29	9.6	0.85	15.5	14.89	78.6
M. D. Parmenter	Lamar	" 28	9.6	2.18	39.9	12.46	76.6
C. M. C. Woolman	Sterling	" 31	9.0	0.87	18.0	16.57	76.9
C. M. Rulison	Parachute	Nov. 12	5.0	1.13	41.8	17.10	86.3
C. K. McHarg	Pueblo	" 9	8.9	1.59	23.4	14.13	79.6
J. D. Payne	Grand Junction	" 12	9.6	6.00	123.4	8.93	66.3
Chas. Milne	La Jara	" 7	8.0	0.97	21.2	15.75	79.8
J. W. Douthitt	Montrose	" 8	6.7	1.62	42.1	13.11	72.4
Average		Nov. 5	8.1	1.32	28.8	14.86	77.7
Large Plot.							
M. D. Parmenter	Lamar	Oct. 28	10.0	1.82	23.2	14.70	86.9
C. M. Rulison	Parachute	Nov. 12	5.3	1.22	39.6	16.39	81.7
Substation	Rocky Ford	Oct. 29	8.2	0.84	17.9	16.45	82.7
College Farm	Fort Collins	" 26	8.2	0.87	18.5	15.21	74.7
Average		Nov. 1	7.9	1.19	24.8	15.69	81.5

VILMORIN.

Name.	Place.	Date when crop was harvested	Average distance apart of beets in row. Inches.	Average weight of beets Lbs.	Crop per acre. Tons.	Sugar in beet.	Purity.
Small Plot.							
S. S. Abbott	Canfield	Oct. 29	8.8	1.33	26.4	16 79	87.3
M. D. Parmenter	Lamar	" 28	7.0	1.13	28.3	14.38	76.1
C. M. C. Woolman	Sterling	" 31	9.0	0.94	18.0	15.31	78.6
C. M Rulison	Parachute	Nov. 12	5.2	1.10	37.2	15.31	83.6
C. K. McHarg	Pueblo	" 9	8.0	1.27	22.3	14.42	78.3
J. D. Payne	Grand Junction	" 12	9.0	4.46	90.2	9.65	67.9
Chas. Milne	La Jara	" 7	8.0	0.95	20.6	13.48	76.5
J. W. Douthitt	Montrose	" 8	6.7	1.06	27.7	13.80	74.2
Average		Nov. 4	7.5	1.11	25.8	14.78	79.2
Large Plot.							
M. D. Parmenter	Lamar	Oct. 28	16.0	1.82	14.4	14.95	84.8
C. M. Rulison	Parachute	Nov. 12	6.0	1.12	38.5	15.92	80.6
Substation	Rocky Ford	Oct. 29	7.0	0.50	12.5	18.00	89.2
College Farm	Fort Collins	" 26	10.9	0.92	14.7	17.15	78.5
Average		Nov. 1	10.0	1.09	20.0	16.50	83.3

MANGOLD.

Name.	Place.	Date when crop was harvested	Average distance apart of beets in row. Inches.	Average weight of beets Lbs.	Crop per acre. Tons.	Sugar in beet.	Purity.
Small Plot.							
S. S. Abbott	Canfield	Oct. 29	8.6	1.18	24.0	13.00	68.4
M. D. Parmenter	Lamar	" 28	6.7	1.32	34.5	13.42	80.6
C. M. C. Woolman	Sterling	" 31	9.0	0.78	15.5	14.43	74.9
C. M. Rulison	Parachute	Nov. 12	5.8	1.27	38.2	14.66	78.3
C. K. McHarg	Pueblo	" 9	8.3	1.28	20.0	13.71	78.3
J. D. Payne	Grand Junction	" 12	9.0	4.00	81.1	9.11	65.5
Chas. Milne	La Jara	" 7	8.0	1 06	23.0	14.32	74.8
J. W. Douthitt	Montrose	" 8	6.7	1.60	41.4	13.44	71.0
Average		Nov. 4	7.4	1.21	28.1	14.00	75.2
Large Plot.							
M. D. Parmenter	Lamar	Oct. 28	20.4	1.55	13.5	14.57	87.5
C. M. Rulison	Parachute	Nov. 12	5.0	1.18	42.3	15 88	82.7
Substation	Rocky Ford	Oct. 29	10.4	1.00	16.7	15.84	82.7
College Farm	Fort Collins	" 26	9.4	1.04	19.2	17.15	78.0
Average		Nov. 1	11.3	1.19	22.9	15.86	82.7

EDDY KLEINWANZLEBENER.

Name.	Place.	Date when crop was harvested.	Average distance apart of beets in row. Inches.	Average weight of beets. Lbs.	Crop per acre. Tons.	Sugar in beet.	Purity.
Small Plot.							
S. S. Abbott	Canfield	Oct. 29	8.0	1.04	22.0	....	......
M. D. Parmenter	Lamar	" 28	6.7	1.67	43.6	13.56	81.8
C. M. C. Woolman	Sterling	" 31	9.0	0.94	19.1	16.76	82.9
C. M. Rulison	Parachute	Nov. 12	5.6	1.12	34.4	16.04	84.8
C. K. McHarg	Pueblo	" 9	8.0	1.60	26.1	13.39	75.7
J. D. Payne	Grand Junction	" 12	9.2	5.00	98.5	10.36	69.5
Chas. Milne	La Jara	" 7	7.3	1.00	23.0	15.80	81.7
J. W. Douthitt	Montrose	" 8	6.7	1.22	31.0	12.70	70.8
Average		Nov. 4	7.3	1.25	27.0	14.71	79.4
Large Plot.							
M. D. Parmenter	Lamar	Oct. 28	10.8	0.95	15.5	14.22	81.8
C. M. Rulison	Parachute	Nov. 12	5.1	1.18	39.6	16.50	83.3
Substation	Rocky Ford	Oct. 29	8.4	0.70	14.4	16.82	87.5
College Farm	Fort Collins	" 26	11.1	1.06	16.5	15.80	78.1
Average		Nov. 1	8.6	0.97	21.5	15.83	82.7

ELITE KLEINWANZLEBENER.

Small Plot.							
S. S. Abbott	Canfield	Oct. 29	8.0	1.00	21.8	15.90	78.5
M. D. Parmenter	Lamar	" 28	6.7	1.60	40.4	15.75	84.0
C. M. C. Woolman	Sterling	" 31	9.0	0.92	19.2	17.23	83.4
C. M. Rulison	Parachute	Nov. 12	6.0	1.36	40.9	16.84	85.3
C. K. McHarg	Pueblo	" 9	7.7	1.50	25.6	15.38	80.0
J. D. Payne	Grand Junction	" 12	9.0	5.00	102.2	10.45	70.6
Chas. Milne	La Jara	" 7	8.0	1.11	24.2	15.50	85.7
J. W. Douthitt	Montrose	" 8	6.7	1.22	31.9	15.08	77.0
Average		Nov. 4	7.4	1.24	29.1	15.95	82.0
Large Plot.							
M. D. Parmenter	Lamar	Oct. 28	12.8	0.82	10.9	16.61	85.6
C. M. Rulison	Parachute	Nov. 12	4.9	1.14	40.7	15.42	84.2
Substation	Rocky Ford	Oct. 29	6.8	0.67	17.3	17.38	86.1
College Farm	Fort Collins	....	....	....	....	....	......
Average		Nov. 1	8.2	0.88	23.0	16.47	85.3

AVERAGES.

Variety.	Plot.	Crop per acre. Tons.	Sugar in beet.	Purity.
Utah Kleinwanzlebener	Small	26.4	15.57	81.0
	Large	23.4	16.67	84.0
Original Kleinwanzlebener	Small	28.8	14.86	77.7
	Large	24.8	15.69	81.5
Vilmorin	Small	25.8	14.78	79.2
	Large	20.0	16.50	83.3
Mangold	Small	28.1	14.00	75.2
	Large	22.9	15.86	82.7
Eddy Kleinwanzlebener	Small	27.0	14.71	79.4
	Large	21.5	15.83	82.7
Elite Kleinwanzlebener	Small	29.1	15.95	82.0
	Large	23.0	16.47	85.3
Utah Kleinwanzlebener	Both.	24.9	16.12	82.5
Original Kleinwanzlebener	"	26.8	15.27	9.6
Vilmorin	"	22.9	15.64	81.2
Mangold	"	25.5	14.93	78.9
Eddy Kleinwanzlebener	"	24.2	15.27	81.0
Elite Kleinwanzlebener	"	26.0	16.21	83.6
Average	....	25.1	15.57	81.3

Variety.	Per cent of perfect stand. Weight.	Average weight of beets. Pounds.	Pure sugar per acre. Pounds.	Available sugar per acre. Pounds.
Utah Kleinwanz ebener	86	1.07	8060	6650
Original Kleinwanzlebener	87	1.25	8184	6514
Vilmorin	80	1.10	7163	5816
Mangold	75	1.20	7650	6036
Eddy Kleinwanzlebener	88	1.11	7390	5986
Elite Kleinwanzlebener	89	1.06	8429	7047
Average	84	1.13	7813	6341

A comparison of the results from the different kinds of seed shows, first of all, that they are all good seeds. An average of 25.1 tons of beets per acre testing 15.57 sugar and 81.3 purity is a very high yield. There is, however, considerable difference in the results from the different varieties. The Elite Kleinwanzlebener and the Vilmorin were sent us by the United States Department of Agriculture as the best beet seed that they could get. The Original Kleinwanzlebener was selected by the Utah Sugar company as in their judgment the best brand of seed on the market from which to raise their own seed. If we take the average of these three first-class seeds and compare it with the seed raised in Utah, the comparison is in favor of the Utah-grown seed in per cent of sugar and purity, while the crop per acre is equal. The Utah seed is, therefore, superior in pure sugar per acre and in available sugar per acre. The Utah seed is superior to the seed from which it is descended in sugar and purity, but a little inferior in quantity of crop.

The seed grown at Eddy does not give so good results as the Utah seed, but it equals the Vilmorin and is not far behind the Original Kleinwanzlebener. The germinating quality of the seeds is quite satisfactory. The four Kleinwanzlebener varieties give 87 per cent of stand, while the Vilmorin gives 80 per cent, and the Mangold 75 per cent.

In the light of these experiments there can be no doubt that sugar beet seed can be grown in the United States fully equal to the best of the imported seed.

The tables of the yield of the small plots include the figures from the field of Mr. J. D. Payne, of Grand Junction, but these figures are not used in making the averages, because they are so different from those of the other experimenters and so different from the average of Colorado results.

Mr. Payne planted his beets in a deep sandy loam, where the roots had unlimited room to grow downward. The soil below was full of water that was constantly being brought up to the roots by capillary action. The ground was also full of plant food. These beets, therefore, had the very best possible conditions and they improved their opportunities. The rows were 18 inches apart, and the beets thinned to 9 inches apart in the row. The stand was perfect and the growth enormous. Toward the latter part of the season the tops crowded so that the patch seemed one large beet. It was impossible to see any ground or to distinguish one beet from another. The beets averaged five pounds each and almost touched each other, making practically a solid row of beets.

As would be expected under these conditions, they never ripened and their quality is low. The figures of the crop are as follows:

Variety.	Crop per acre Tons.	Sugar in beet.	Purity.
Utah Kleinwanzlebener	105.5	8.88	64.6
Original Kleinwanzlebener	123.4	8.93	66.3
Vilmorin	90.2	9.65	67.9
Mangold	81.1	9.11	65.5
Eddy Kleinwanzlebener	98.5	10.36	69.5
Elite Kleinwanzlebener	102.2	10.45	70.6
Average	100.1	9.56	67.4

This is over 19,000 pounds of sugar per acre.

A SHIPMENT OF SUGAR BEETS TO GRAND ISLAND, NEBRASKA.

As will be given more in detail later, the Business Men's Association, of Loveland, Colorado, in connection with the Denver Chamber of Commerce, offered prizes for the best crops of sugar beets raised in the vicinity of Loveland. The officials of the Union Pacific, Denver and Gulf Railroad considered that this would be a good opportunity to test the beets of northern Colorado on a commercial scale. They obtained several hundred pounds of beet seed from the Oxnard Sugar Company, of Grand Island, Nebraska, and distributed this to the farmers of Loveland and vicinity, free of charge, on condition that the growers ship their beets to Grand Island. Instructions in regard to the methods of growing beets were sent to each one, by the College; the present writer visited a good many of the farms during the growing season and took notes on the crop and the care it had received, and as the season advanced he took samples for analysis at various times until it was evident that the crops were ripe enough to ship.

The changes of the crop in the process of ripening and the date when the crop was ready for harvesting, can be gathered from the following samples that were among those taken at Loveland:

Name.	Dated when sample was taken.	Sugar in beet.	Purity.
R. S. Cox	Sept. 22	12.45	73.4
" " "	Oct. 4	12.73	78.5
" " "	" 20	13.40	75.7
John Hahn	Sept. 22	14.21	76.6
" "	Oct. 4	14.54	83.7
" "	" 20	17.39	83.7
C. C. Smith	" 4	13.87	79.4
" " "	" 27	14.73	79.0
N. R. Faulkner	" 4	10.93	72.1
" " "	" 22	12.07	74.0
Alvin Shields	" 3	13.30	81.2
" "	" 29	15.96	86.8
J. S. Steele	" 4	13.06	76.6
" " "	" 29	15.68	82.9
Harvey Skinner	" 3	16.53	84.5
" "	" 27	17.38	85.3
I. W. Clapper	" 4	16.15	83.9
" " "	Nov. 1	18.53	80.4
D. Hershman	Oct. 18	12.11	77.5
" "	" 31	14.06	74.9
P. C. Benson	" 3	17.96	83.6
" " "	" 20	17.77	84.0
" " "	" 31	19.05	86.0

According to these figures, a factory could have found beets in proper condition for working the last week in September, and ten days later nearly half the crops were of excellent quality. All of the fields improved in quality during October, and some of the more backward were hardly ripe before the end of the month.

Harvesting for shipment to Grand Island began on October 28 and was completed November 2. Six carloads were shipped from Loveland, two from Fort Collins and one from Greeley. Each wagonload of beets was weighed when brought to the cars and samples of the beets taken for analysis. When the cars reached Grand Island they were weighed, the beets again analyzed, and also a sample was cleaned to ascertain how much dirt was attached to the beets.

Name.	Date of harvesting.	Sugar in beet.	Purity.
E. E. Bassett, No. 1	Oct. 28	17.48	85.3
Harvey Skinner, No. 1	" 28	15.06	79.4
" " No. 2	" 28	17.32	83.1
" " No. 3	" 28	18.15	87.4
H. L. Boyd, No 1	" 28	17.10	85.0
John Hokanson	" 28	17.39	84 2
J. M. Naylor	" 28	16.15	84.7
G. O. Whelchel, No. 1	" 28	15.63	86.8
John Derby	" 28	18.77	84.5
Pugh and Merry, No. 1	" 29	13.73	75.4
" " " No. 2	" 29	14.73	81.8
R. S. Cox, No. 1	" 29	13.82	78.2
" " No. 2	" 29	12.83	75.4
J. S. Steele	" 29	15.68	82.9
E. E. Bassett, No. 2	" 29	17.77	84.8
J. W. Flinn	" 29	16.63	83.4
H. L. Boyd, No. 2	" 29	16.91	84 5
J. R. Samuels	" 29	14.96	83.0
I. O. Hollowell. No. 1	" 29	16.58	78.1
" " No. 2	" 29	16.63	82.6
P. C. Benson, No. 1	" 29	19.33	87.9
" " No. 2	" 29	19.14	87.5
C. H. Brown	" 29	16.34	84.7
H. C. Caldwell. No. 1	" 29	12.97	73.7
W. H. Fairbrother	" 29	15.87	80.9
W. M. Pugh	" 29	14.20	78.1
J. J. Youtsey	" 29	18 00	87.2
G O. Whelchel. No. 2	" 29	18.53	86 6
W. S. Warner, No 1	" 29	17.53	80.1
Alfred Wild	" 31	15.25	80.7
F. G. Bartholf, No. 1	" 31	13.83	78.0
D. Hershman	" 31	14.06	74 9
E. F. Abernathy	" 31	15.34	78.2
W. S. Warner. No. 2	" 31	18.24	84.0
Alvin Shields, No. 1	" 31	14.39	77.8
" " No. 2	" 31	15.96	86.8
H. C. Caldwell, No. 2	" 31	16.15	82 0
John Hahn	" 31	15.01	75 5
P. C. Benson, No. 3	Nov. 2	19.05	86.0
F. G. Bartholf, No. 2	" 2	15.68	85.3
C. A. Anderson, No. 1	" 2	15.96	86.0
" " No. 2	" 2	15.44	87.7

The six cars of beets from Loveland were several days on the road, and of course dried out considerably. This would tend to lower the weight and raise the analysis, as is seen in the table below

Car.	Loveland weight.	Grand Island weight.	Loveland Analysis.		Grand Island Analysis.	
			Sugar in beet.	Purity.	Sugar in beet.	Purity.
U. P. 27599............	31070	29600	16.00	84.8	17.1	84.8
O. R. & N. 6147........	30850	30000	15.24	81.5	16.8	83.7
U. P. 40847............	31870	30800	15.60	82.3	16.9	80.8
U. P. D. & G. 26964...	19000	17700	14 50	80.7	16.0	82.8
U. P. 66800............	29460	25800	15.19	81.0	15.8	80.2
U. P. 41001	17590	16700	15.62	85.7	15.8	79.8
Average.....	26640	25100	15.36	82.7	16.4	82.0

The above shows a shrinkage, during the time of shipping, of 1,540 pounds per carload, or 6 per cent. In addition to this shrinkage, there was a still further deduction made for the "tare," or the dirt on the beets, and improper trimming. After making both these allowances, the record stands as follows :

Car.	Grand Island weight.	Per cent of tare.	Net weight.	Sugar in beet.	Purity.	Price for beets per ton.	Pure sugar per car.
U. P. 27599..................	29600	11.0	26344	17.1	84.8	$4.75	4505
O. R. & N. 6147..............	30000	7.0	27900	16.8	83.7	4.75	4687
U. P. 40847.........	30800	9.0	28028	16.9	80.8	4.75	4737
U. P. D. & G. 26964...........	17700	5.0	15930	16.0	82.8	4.50	2549
U P. 66800..............	25800	13.0	22446	15.8	80.2	4.50	3547
U. P. 41001.....................	16700	10.0	15030	15.8	79.8	4.50	2375
Average....................	....	10.0	....	16.4	82.0	$4.62	....
Total	150600	....	135678	....	....	....	22400

No complete records were kept of yield per acre. There was some trouble about getting the cars for shipment, and owing to a shortage of cars there were so many beets that had been raised that were not shipped that it was impossible in several cases to tell the amount of land on which the part of the crop grew that was shipped. We have the records of about three-fourths of the beets, and the average of these is a trifle less than nineteen tons to the acre, gross weight, or, after taking out the tare, a little over seventeen tons net per acre. This gives about 5,300 pounds of pure sugar per acre, or about 300 pounds more sugar per acre for these crops at Loveland raised under field conditions, than is found as the average of the whole state for the crops grown in competition for the sugar beet prizes.

This shipment of beets is one of the best ever made where the crop came from so many different farms, and shows conclusively that Colorado soil and climate are wonderfully adapted to the sugar beet.

In this connection, it seems proper to add the records of some shipments of sugar beets made in 1893 and 1894 from Grand Junction and vicinity to the sugar factory at Lehi, Utah:

Date of shipment.	*No. of cars.*	*Sugar in beet.*	*Purity.*
Nov. 15, 1893	1	15.7	84.0
" 20, "	1	16.2	84.0
" 20, "	1	15.0	84.0
1894	1	14.7	88.4
"	2	14.2	84.2
"	1	12.6	78.5
Average of seven cars		14.7	83.7

SUGAR BEETS AT GRAND JUNCTION.

The bulletins of the Agricultural College contain nearly all of the analyses that have ever been made of Colorado sugar beets. In order to make the record complete, it is deemed best to insert here two sets of analyses made in the years 1893 and 1894 of beets raised in the valleys of the Grand and the Gunnison.

The seed was furnished by the Utah Sugar company of Lehi, Utah, the samples of the beets were taken with the greatest care by men sent out for that special purpose, and the analyses were all made at the sugar factory at Lehi. The first table gives the results of the season of 1893:

Name.	Date planted.		First Sampling.				Second Sampling.			
			Date.		Sugar in beet.	Purity.	Date.		Sugar in beet.	Purity.
P. A. Rice	Apr.	20	Sept.	27	13.0	73.5	Oct.	25	13.6	73.6
Mr. Currie	"	20	"	27	12.2	73.5	"	25	12.7	76.1
A. A. Miller	"	20	"	19	10.2	72.3	"	25	14.1	81.3
Indian School	"	26	....		....	....	"	19	16.0	84.0
A. J. McCune	"	22	"	27	10.0	67.1	"	25	11.7	70.9
Ed. Bravier	"	22	"	27	13.4	76.1	"	19	15.7	85.0
Eugene Allison	"	28	....		....	....	"	25	16.5	81.3
Ovid Turnill	"	29	....		....	....	"	25	13.3	78.2
W. H. Benkitt	May	3	"	27	12.0	74.1	Nov.	4	14.0	78.3
W. D. Spencer	"	4	"	27	11.5	71.4	Oct.	31	13.8	78.5
N. Poffenberger	"	8	"	19	11.6	73.5	"	16	14.7	81.0
L. Johnson	"	8	"	19	9.5	67.5	"	25	12.6	84.0
W. F. Shewel	"	9	"	27	9.0	67.7	"	25	10.4	76.5
Joseph Smith	"	9	....		....	....	"	25	14.8	83.9
John Vaughn	"	10	"	27	12 4	72.1	....		....	....
M. S. Hildreth	"	11	....		....	....	"	31	12.8	77.2
J. C. Sullivan	"	12	....		....	....	"	31	12.3	72.2
Frank Leach	"	15	"	19	12.7	76.4	"	25	15.0	82.0
Geo. Davis	"	17	....		....	....	"	31	17.2	76.3
C. N. Cox	"	23	"	27	10.4	68.3	"	25	15.1	81.5
Smith Bros	"	15	....		....	....	"	25	16.1	83 7
Mr. Almes	"	15	....		....	....	"	31	12.5	78.8
Frank Rich	"	23	"	27	11.6	70.0	"	25	17.0	84.5
W. E. Renick	"	25	"	19	12.3	77.7	"	16	11.6	68.9
John Peugh	"	26	"	19	11.0	75.3	....		....	....
J. O'Keefe	"	30	"	27	11.0	78.8	....		....	....
J. A. Lawton	"	30	"	27	10.9	69 4	....		....	....

During the month from the latter part of September to the last of October the beets improved about two per cent in sugar and nearly ten per cent in purity. The shipments of carload lots were not made until late in November, and the beets of those that shipped had made by that time a still farther gain of one per cent in sugar.

The above crops represent all kinds of soil from one end of Grand valley to the other.

This was the first season that these farmers had raised sugar beets, and the general tendency was to give too much water and too little cultivation. Some of the fields had one cultivation, a smaller number were cultivated twice, and most of them had no cultivation at all. In only a few cases was the thinning done with any degree of care.

In every case where the last analysis has shown a purity less than 80, the crop was irrigated from two to four times.

The work was repeated in 1894, and as many of the growers had had the benefit of the previous year's experience, the tests as a whole show an improvement. Only one set of samples was taken, and the results show that several of these were taken before the beets were ripe.

Sample Number.	Number of beets in sample.	Sugar in beet.	Purity.	Sample Number.	Number of beets in sample.	Sugar in beet.	Purity.
1	6	16.0	84.4	21	6	16.1	85.0
2	9	13.0	78.2	22	6	12.8	79.4
3	9	15.8	78.0	23	4	12.2	73.1
4	6	12.5	72.0	24	9	14.4	81.3
5	5	16.8	86.2	25	4	11.9	75.3
6	4	15.0	74.5	26	4	12.8	76.7
7	4	14.2	78.8	27	7	12.5	69.6
8	6	15.8	86.3	28	9	15.1	84.6
9	7	12.0	78.8	29	4	13.3	81.4
10	4	17.5	87.4	30	18	17.6	85.6
11	3	16.0	83.3	31	7	13.9	81.6
12	4	18.0	87.0	32	8	15.0	84.0
13	4	17.5	86.1	33	5	14.3	77.3
14	8	17.0	86.2	34	2	12.8	79.0
15	4	14.7	82.9	35	9	15.2	82.0
16	5	12.1	74.2	36	4	12.6	74.3
17	5	16.9	85.6	37	8	15.0	83.7
18	6	13.5	79.3	38	1	15.7	84.6
19	5	14.6	81.5	39	11	14.5	83.1
20	7	15.0	82.9				

Several of these samples deserve special attention. Numbers 2, 18 and 34 grew very large beets, from four to six pounds weight each, and had an enormous weight per acre, and yet, although these beets are not so rich as some of the others they are above the standard required by factories and would have brought a large return per acre. Numbers 27 and 28 came from the same field, the first from sandy soil and the other from heavy adobe soil. Number 39 is also from sandy soil, while number 30 is from new land and heavy adobe. In both cases the sandy soil gives poorer beets than the heavy soil. The same has been noted in northeastern Colorado, where the heavy soil, though harder to work, gives a better quality of beet.

Numbers 1, 5, 10, and 17 had had previous experience in raising beets, and their crops averaged 16.8 sugar and 85.9 purity, showing that care and experience are all that are needed to raise the best of beets in the valley of the Grand.

SUGAR BEET PRIZES.

It was recognized in the spring of 1898, that the time had come when there should be a well organized effort to get the most exact information possible on the adaptation of the sugar beet to Colorado soil and climate. Nearly all the estimates of previous beet crops in Colorado have been based on the yield from a hundred square feet of ground. It was recognized by all that this was too small a plot for commercial estimates. It had been adopted because the beet growers disliked to spend the large amount of time and trouble necessary to make exact experiments on a large scale. It was seen that some substantial inducement must be offered before it could be expected that better results could be obtained than those of former years.

Acting on this idea, the Denver Chamber of Commerce offered $1,000 in cash prizes to those who grew the best crops of beets, these to be grown on a commercial scale, and each to cover 2,700 square feet of ground. The offer was conditioned on the appropriation of certain sums for the same purpose by the County Commissioners of each county. This was done by the County Commissioners of the following counties: Conejos, Costilla, Delta, Logan, Mesa, Otero and Weld. In Larimer county the money was subscribed by the business men of Loveland; in Fremont county by the Canon City Chamber of Commerce; while in Garfield county prizes were offered by the Denver and Rio Grande and by the Colorado Midland railroads.

The following instructions were sent to those who desired to compete for these prizes:

COLORADO AGRICULTURAL COLLEGE.

Directions for Harvesting the Crop.

The plot of beets selected to compete for the prizes must contain, as nearly as possible, one-sixteenth of an acre, and must be all in one continuous piece. Call in a neighbor to witness harvesting and certify to the weights and measures.

Begin on one side and harvest every other row, *but no row harvested should be an outside row, i. e.*, if the plat selected is on the outside of the field, begin with the second row and harvest every other row.

Cut off the tops of the beets just at the base of the leaves, Shake the beets free from any loose dirt, and weigh the crop in this condition. This is the one referred to later as the "gross weight."

Throw the beets into a pile and roughly divide the pile in the middle, and again divide one of the halves in the middle, giving one-fourth of the original crop. Throw this fourth into a pile and treat it the same way, so that you have a fourth of a fourth, or about one-sixteenth of the crop. Weigh this lot and record it as the "gross weight of one-sixteenth of crop." Scrape these beets with a dull knife until they are free from dirt, fibrous roots and any stubs of leaves that may have been left on the crown. Weigh again and call this the "net weight of one-sixteenth of crop."

Count the number of beets in this last lot, and then select from it four to eight beets that together will weigh about eight pounds, and will be representative of the crop, *i. e.*, select big, medium and little, good shaped and bad, so as to get a fair sample of the lot. Weigh these beets together *very carefully*, and record this as "weight of sample for analysis."

Wrap each of the beets separately in paper and then do them up in two packages, not to exceed four pounds in each package, sew each package up securely in cloth and attach the mailing tag, which will enable the package to be sent postage free.

The harvesting, weighing and preparing the sample for analysis should all be done on the same day, and as quickly as possible to prevent drying out.

Three blanks are sent you; one to be filled out and enclosed in each package, and the other to be kept by you for your own information.

Mail the sample for analysis as soon as possible after it is ready. The receipt of the sample for analysis will be acknowledged by return mail.

Do not harvest the rest of the plot until you receive word that your sample and records are satisfactory. By this means it may be possible to correct mistakes, if any have accidently been made.

It will be seen from the instructions, that it was desired that the crops be harvested and sampled between October 15 and November 1. In the case of Logan county, the crops were harvested the last week in September, so that they could be exhibited at the county fair. The crops were not then ripe and the results are much poorer, both in quantity and quality, than would have been obtained had the beets remained in the ground a month longer. At the request of the present writer, two of these fields were but partly harvested, and the rest of the beets were pulled the latter part of October, when the beets in the other counties were being harvested. In each case the beets tested in sugar more than three per cent higher than during September.

It was desired that the contest be put as nearly as possible on a commercial basis, *i. e.*, the prizes be awarded to the crops in the order of their real value for sugar making purposes. It was necessary then, to take into account three things: The weight of the crop, the amount of sugar in the crop, and the amount of sugar that could be gotten out in the factory. These items are given in the accompanying tables. The column headed "Gross weight of trimmed beets per acre," gives the weight of the beets in the same condition as they would ordinarily be brought to a factory, *i. e.*, with the tops cut off, but no attempt made to remove the dirt that naturally sticks to the beet. At a factory, a sample of the beets, usually about half a bushel, is taken and cleaned and the calculation made as to how much dirt there is in the whole load.

The column headed "Sugar in the beet," represents the character of the beet at the time it was analyzed. On the average, this was about three days after harvesting. During this time, of course, the beets had been drying out, which would tend to raise the per cent of sugar in the sample. The first two columns, therefore, represent the gross weight of beets and dirt together and the analysis of a partly dried sample, in both cases making the crops apparently better than they were. To offset this, the column headed, "Pure sugar per acre," is obtained by multiplying the other two together and deducting one-fifth for tare and drying out. It is probable that this is a larger shrinkage than would have been made had these crops been sent to a sugar factory, but it is deemed best to make sufficient reduction so there could be no possible appearance of an attempt to exaggerate Colorado's sugar beet crops. The figures. even after the 20 per cent reduction, show magnificent crops, and still more so that we can look at them as a slight underestimate.

The column headed "Purity," is the measure of the factory value of the sugar that is in the beet. If a lot of beets test 80 purity, it means that for every 80 pounds of pure sugar they contain, they also have 20 pounds of impurities that are not sugar. These impurities prevent the factory from saving all the pure sugar, and the greater the amount of impurity the greater the amount of pure sugar that will be lost in the process of manufacture. The "pure sugar per acre," multiplied by the "purity" will give the "available sugar per acre," or the approximate amount of sugar that would have been produced from the crops in an ordinary factory. It is considered that this measures the true sugar value of the crop, and it is on the figures of this column that the order of excellence of the various crops is based.

In the table of averages by counties, another column is introduced headed "Factory value per acre." It is obtained by deducting ten per cent tare from the gross weight of the crop and multiplying the remainder by the price paid during 1898 by factories where the price is varied according to the quality of the beets. The prices used are :

$3.75 per ton for beets testing less than 14.4 sugar and less than 78 purity.

$4.00 per ton for the same sugar and more than 78 purity.
$4.25 per ton for tests from 14.5 to 15.4 sugar.
$4.50 " " " " " 15.5 to 16.4 "
$4.75 " " " " of 16.5 sugar or higher.

CONEJOS COUNTY.

Name and Place.	Date of harvesting the crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure sugar per acre. Lbs.	Available sugar per acre. Lbs.
Chas. Milne, La Jara	Nov. 7	28.16	17.65	79.8	7952	6436
W. M. Martin, Alamosa	Oct. 29	24.57	16.96	86.8	6684	5802
W. A. Braiden, La Jara	" 10	20.05	11.45	72.2	3673	2803
D. E. Newcomb, La Jara	" 12	12.80	15.65	80.1	3205	2563
S. J. Parish, Alamosa	" 16	12.06	16.64	80.5	3174	2554
J. L. Rutledge, La Jara	" 15	....	18.91	84.4	....	....
J. W. Dove, Alamosa	....	....	13.19	78.0	....	....
Mrs. N. A. Broyles, Antonito	" 15	....	11.97	70.9	....	....
Average	Oct. 21	19.53	15.67	80.0	4689	3741

COSTILLA COUNTY.

Name and Place.	Date of harvesting the crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure sugar per acre. Lbs.	Available sugar per acre. Lbs.
G. W. Shaw, Alamosa	Oct. 22	12.29	15.30	86.6	3008	2605
A. McKinnon, Alamosa	" 18	7.26	12.54	83.8	1457	1213
Peter Legard, Alamosa	" 20	....	15.58	....	....	....
N. E. Morgan, Hooper	Nov. 7	....	20.43	83.2	....	....
R. W. Maddux, Mosca	Oct. 15	....	12.40	83.8	....	....
Wm. Douglas, Mosca	" 18	22.60	....	....	....	....
Average	Oct. 22	14.05	15.42	84.3	3093	2607

DELTA COUNTY.

Name and Place.	Date of harvesting the crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure sugar per acre. Lbs.	Available sugar per acre. Lbs.
G. H. Hammond, Hotchkiss	Oct. 22	38.51	17.34	77.4	10962	8485
Martin Cade, Delta	" 17	20.57	15.91	89.5	5236	4686
G. W. Umbrell, Delta	" 31	21.78	14.68	80.9	5116	4139
I. S. Hewitt, Delta	" 19	19.96	12.87	71.0	4118	2924
J. M. Trew, Delta	" 19	10.87	13.40	76.5	2331	1783
Charles A. Barnes, Delta	" 28	....	15.44	83.9	....	....
Average	Oct. 23	22.54	14.74	80.0	5301	4241

FREMONT COUNTY.

Name and Place.	Date of harvesting the crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure Sugar per acre. Lbs.	Available sugar per acre. Lbs.
B. F. Rockafellow, Canon City	Oct. 21	30.05	18.05	86.8	8678	7533
William Curtis, Canon City	" 29	29.18	16.63	86.9	7766	6748
L. K. Mortimer, Canon City	Nov. 2	26.35	17.96	83.5	7589	6337
Charles Kaess, Cotopaxi	Oct. 24	29.40	16.63	79.6	7822	6226
G. E. Murray, Howard	" 15	29.80	15.33	84.3	7310	6162
W. A. Dumm, Canon City	" 28	21.33	18.05	82.0	6160	5051
J. M. Murray, Howard	" 15	29.52	13.63	79.4	6444	5117
John Ripley, Canon City	" 27	21.90	16.96	80.3	5942	4772
H. T. Gravestock, Canon City	" 20	14.50	16.48	90.7	3831	3475
E. S. Armstrong, Hillside	" 12	16.13	15.68	77.7	4046	3116
C. H. Gravestock, Canon City	" 28	8.45	19.00	84.8	2569	2178
E. V. Kimmel, Canon City	" 20	....	18.05	93.5	....	....
Phil Sheriden, Canon City	" 18	....	19.10	81.3	....	....
B. F. Rockafellow, Canon City	" 29	....	18.24	81.8	....	....
J. E. Brown, Canon City	....	....	14·42	81.3	....	....
A. C. Haggart, Canon City	" 20	....	12.06	67.7	....	....
Average	Oct. 23	23.36	16.87	84.1	6226	5236

GARFIELD COUNTY.

Name and Place.	Date of harvesting the crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure Sugar per acre. Lbs.	Available sugar per acre. Lbs.
C. H. Harris, Catherin	Oct. 29	37.98	17.20	80.1	10458	8397
D. G. Edgerton, Carbondale	" 18	14.91	17.34	91.8	4113	3776
Jesse Kerlee, Parachute	" 19	10.77	15.68	88.0	2702	2378
Charles H. Miller, Antlers	" 17	12.17	14.25	79.4	2774	2203
W. C. Parker, New Castle	....	....	17.39	82.9	....	....
C. M. Rulison, Parachute	....	....	15.89	82.2	....	....
Harry Brenton, Rifle	....	....	15.91	83 6	....	....
F. W. Mallory, New Castle	" 21	....	15.96	76.1	....	....
E. E. Westhafer, Satank	" 18	....	15.01	86.7	....	....
F. M. Peebles, Satank	....	....	16.29	78.8	....	....
Average	Oct. 21	18.96	16 12	84.8	4901	4153

LARIMER COUNTY.

Name and Place.	Date of harvesting the crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure sugar per acre. Lbs.	Available sugar per acre. Lbs.
J. M. Naylor, Loveland	Oct. 23	36.26	16.53	79.3	9590	7589
I. W. Clapper, "	Nov. 1	31.60	18.53	80.4	9369	7533
C. C. Smith, "	Oct. 27	33.01	14.73	79.0	7781	6147
F. G. Bartholf, "	" 31	28.72	15.68	85.3	7205	6142
Alfred Wild, "	" 27	31.50	15.25	80.7	7606	6138
Alvin Shields, "	" 29	27.47	17.43	79.7	7490	5970
Harvey Skinner, "	" 27	24.80	17.38	85.3	6896	5882
R. O. Joslyn, "	" 27	14.10	18.05	84.8	4072	3453
R. S. Cox, "	" 27	21.05	13.40	75.7	4513	3416
P. C. Benson, "	" 31	10.72	19.05	86.0	3267	2810
N. R. Faulkner, "	" 22	19.35	12.07	74.0	3456	2765
Average	Oct. 28	25.32	15.69	80.9	6356	5091

LOGAN COUNTY.

Name and Place.	Date of harvesting the crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure sugar per acre. Lbs.	Available sugar per acre. Lbs.
Fred Bernhard, Sterling	Sept. 26	34.15	13.40	72.7	7322	5323
W. C. Propst, Merino	" 25	24.50	14.72	76.2	5771	4397
A. F. Krause, Sterling	" 27	21.50	14.50	83.7	4988	4175
J. H. King, Sterling	" 27	18.10	13.30	79.1	3852	3047
C. D. Brownell, Iliff	" 26	14.60	14.72	80.0	3438	2750
C. M. C. Woolman, Sterling	" 27	12.50	14.30	72.4	2860	2071
C. E. Harter, "	" 27	9.50	15.33	78.8	2331	1837
T. A. Whiteley, "	" 26	7.65	14.15	71.5	1730	1239
James Weir, "	" 26	....	14.49	78.2	....	....
M. V. Propst, "	" 26	....	14.25	78.8	....	....
John Landrum, "	Oct. 1	....	14.10	79.2	....	....
R. C. Perkins, "	Sept. 27	....	13.30	79.1	....	....
H. C. Hatch, "	" 26	....	12.63	73.3	....	....
Average	Sept. 27	17.8	14.09	77.3	4013	3102

MESA COUNTY.

Name and Place.	Date of harvesting the crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure sugar per acre. Lbs.	Available sugar per acre. Lbs.
Fred Burmeister, Grand Junction	Oct. 1	36.0	17.10	86.3	9850	8491
J. D. Payne, Grand Jnnction................	Nov. 23	29.3	16.57	76.0	7768	5904
Adam May, Debeque..........................	" 14	22.0	16.41	77.3	5776	4465
W. K. Sterling, Collbran.....	Oct. 26	21.0	14.30	88.2	4805	4234
Joseph Dietz, Fruita	" 29	27.0	13.54	71 6	5850	4183
J. P. Veach, Fruita	" 29	11.2	19.81	85.4	3878	3313
E. B. Bonnel, Grand Junction...............	" 25	23.2	11.40	68 2	4241	2932
C. V. Wasson, Grand Junction	Nov. 5	11.6	16.15	75.8	3019	2289
G. N. Patterick, Grand Junction............	" 2	16.5	11.88	72.7	3142	2284
S. M. Cox, Fruita..............................	Oct. 29	....	15.16	77.0	....	....
H. S. Groves, Fruita..........................	" 29	....	14.16	78.4	....	....
Lee D. Wilson, Grand Junction	Nov. 21	11.7	....	....	....	....
Average	Nov. 2	20.9	15.22	77.9	5114	3984

OTERO COUNTY.

J. W. Ruble, Rocky Ford....................	Oct. 25	31.40	18.19	86.2	9138	7877
J. P. Pollock, La Junta......................	Nov. 7	33.52	18.01	77.7	9652	7500
B. F. Wyckoff, Rocky Ford	Oct. 25	23.21	14.16	78.3	5259	4108
Albert Conner, Rocky Ford	" 27	27.70	10.83	72.8	4800	3494
C. S. McKinley, Fowler......................	" 20	13.27	16.06	84.7	3411	2889
Fred Janrow, Fowler.........................	" 29	18.17	13.30	73.6	3906	2875
Richard Mason, Higbee	" 20	10.70	15.20	78.3	2603	2048
C. S. Heath, La Junta........................	" 26	....	15.39	76.8	....	....
C. W. Ruckman, La Junta....................	" 20	....	14.96	83.3	....	....
M. A. Gordon, La Junta	" 29	....	15.34	76.8	....	....
Marten Sorensen, Fowler	" 17	....	15.39	73.4	....	....
Average	Oct. 26	22.59	15.14	79.8	5474	4379

WELD COUNTY.

Leonard Burch, New Windsor................	Oct. 25	17.17	17.10	83.5	4699	3924
Newton Clegg, Greeley	" 25	12.20	16.25	78.1	3172	2477
Martin Nelson, Greeley......................	" 18	12.58	15.68	74 2	3154	2340
Fritz Niemeyer, Evans	" 26	....	14 54	82.4	....	....
C. F. Mason, Greeley...................... .	" 13	....	14.44	81.2	....	....
Average	Oct. 23	13.98	15.89	79.8	3562	2850

AVERAGE RESULTS BY COUNTIES.

County.	Date of harvesting of crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure sugar per acre. Lbs.	Available sugar per acre. Lbs.	Factory value per acre.
Conejos	Oct. 21	19.53	15.67	80.0	46.89	3741	$ 79.11
Costilla	" 20	14.05	15.42	84.3	30.93	2607	56.92
Delta	" 23	22.54	14.74	80.0	53.01	4241	86 23
Fremont	" 23	23.36	16.87	84.1	6226	5236	99.75
Garfield	" 21	18.96	16.12	84.8	4901	4155	76.98
Larimer	" 28	25.32	15.52	80.2	6278	5023	102.56
Logan	Sept. 27	17.80	14.09	77.3	4013	3102	64.00
Mesa	Nov. 2	20.90	15.22	77.9	5114	3984	79.90
Otero	Oct. 26	22.59	15.14	79.8	5474	4374	86.40
Weld	Oct. 23	13.98	15.89	79.8	3562	2850	56.70
Average	Oct. 22	19.90	15.47	80.8	4950	4000	$ 76.07

In considering the foregoing tables, one is struck at once with the high average excellence of the sugar beets of Colorado as regards both quantity and quality. In the districts of the United States, where beets are raised for factories, 12 per cent of sugar and 78 purity are considered standards, and one who has raised ten to thirteen tons of beets to the acre is thought to have done well. A fair estimate of the cost of raising sugar beets is $30 per acre, while the above table gives $76.07 as the average factory value for the whole state. The difference of $46.07 profit per acre will compare well with any other kind of farming practiced in Colorado, not even excepting the famed cantaloupes of the Arkansas valley, the orchards of the western slope, or the lambs of the northern feeding districts.

In concluding this portion of the subject, it is fitting that grateful appreciation should be expressed of the aid that the Denver Chamber of Commerce has given in this work. The above tables present the largest amount of the most reliable reports that have ever been collected concerning Colorado sugar beets, and their collection was made possible, only through the generosity and public spirit shown in offering the sugar beet prizes.

THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 52.

I. Pasturing Sheep on Alfalfa.

II. Raising Early Lambs.

Approved by the Station Council,

ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

APRIL, 1899.

Bulletins will be sent to all residents of Colorado, interested in any branch of Agriculture, free of charge. Non-residents, upon application, can secure copies not needed for distribution within the State. The editors of newspapers to whom the Station pubications are sent are respectfully requested to make mention of the same in their columns. Address all communications to the

DIRECTOR OF THE EXPERIMENT STATION,

Fort Collins, Colorado.

EXPRESS, FORT COLLINS

THE AGRICULTURAL EXPERIMENT STATION,

FORT COLLINS, COLORADO.

I. PASTURING SHEEP ON ALFALFA.

BY W. W. COOKE.

The high price of sheep and lambs during the years since 1896 has turned the attention of sheep feeders to the question of raising the lambs they feed, in place of depending on the ranges of the south and west. The summer feed for the sheep, where there is no range, is the most difficult problem attending the raising of sheep on the ranches. It has been generally recognized that if it was as safe to pasture sheep on alfalfa as it is to let horses run on the same feed, there would be but little difficulty in raising lambs on any of the farms of the irrigated districts of Colorado. Many have tried pasturing sheep and lambs on alfalfa, but so many sheep have been lost by bloat that most herders have dropped the practice and others have been deterred from attempting it.

The high price of sheep has again awakened interest in the subject and led to the following experiments and investigation:

In the early fall of 1897 we bought eleven ewes for the purpose of making a double test, *i. e.*, the raising of early lambs and the pasturing of these lambs and the ewes on alfalfa during the summer of 1898. The ewes were mixed Shropshire and Merino, weighing about ninety pounds apiece. They were old ewes that had still fairly good teeth, but were so old that it was expected that the 1898 lamb would be the last one raised. They reached the college farm October 29, 1897, and were bred as soon as possible to the fine registered Shropshire ram Bennett's Prince, No. 87674, that stands at the head of the college flock. The eleven ewes dropped eleven lambs, most of them within a week after March 4, 1898. Through the winter the ewes were fed alfalfa hay. They received a small amount of ensilage during part of the winter, but in figuring on the financial side of the transaction this has been counted at its equivalent feeding value in alfalfa. As soon as the lambs were dropped, some grain was added to the feed and both ewes and lambs were turned on to alfalfa April 20. At this time the young alfalfa was barely showing green and the feeding of alfalfa hay and grain was continued until the green alfalfa was about four inches high. At first they were given the run of a field containing about three-fourths of an acre of fairly good alfalfa and half an acre of poor alfalfa, which was considered equal to an acre of medium alfalfa. The season proved very dry and as the field could not be irrigated the alfalfa did not make enough growth to supply them all the food they needed. About the middle of June they were given access to a second field of two acres of alfalfa. Even with the aid of several pigs they could not keep up with both fields, and one cutting of the alfalfa was made for hay. It was estimated that the total green alfalfa eaten by the sheep and lambs was about equivalent to an acre and a half of good alfalfa that would cut from three to four tons of alfalfa hay to the acre during the whole season. The sheep were shut up at night in a small corral to keep them away from dogs and coyotes. During all the summer they were fed half a pound of bran per day per head, of both sheep and lambs. On June 12 one of the ewes died of bloat and on June 20 one of the lambs followed its example, leaving us ten ewes and ten lambs.

The ewes were sheared April 29, yielding 54 pounds of wool from the ten ewes, showing that they were rather light fleeced sheep.

The experiment closed September 6, at which time the ewes weighed an average of 103 pounds and the lambs an average of 94 pounds. We sold the ewes for $3.50 per head. If we could have had the lambs in Chicago at that time they would have sold for $6.00 per head, but we had too few to make a shipment and so they are counted at their value in the Colorado market, *i. e.*, $4.00 per head. Thus the whole experiment was closed up in a few days over ten months.

SUMMARY.—Expenses.

To 11 ewes @ $2.50	$27.50
Service of ram	2.50
Alfalfa hay, 5 pounds per day per head for 180 days, 5 tons @ $4.00 per ton	20.00
1600 pounds of grain @ $11.00 per ton	8.80
Total expenses	$58.80

Receipts.

54 pounds wool, less cost of shearing....	$ 7.00
10 ewes @ $3.50........................	35.00
10 lambs @ $4.00.......................	40.00
Total receipts..................	$82.00
	58.80
Net return......................	$23.20

The above amount, $23.20, represents the return for the labor of caring for the sheep and for the acre and a half of alfalfa pasture. If the estimate is made that it costs thirty cents per head to look after sheep through the winter, which is a close approximation where many sheep are kept, there remain $20.00 as the return for the alfalfa from one and a half acres of ground. This is more than four dollars a ton for alfalfa in the field, with the sheep doing all the haying, or more than five dollars a ton for the hay in the stack. These results also include the estimating the hay eaten during the winter at four dollars per ton.

It should be remembered that these are the financial results, notwithstanding a nine per cent. loss from bloat on both the ewes and the lambs. While it may be that less than nine per cent. loss cannot be safely estimated on the ewes, it is seldom that a lamb bloats on alfalfa pasture and it would be safe to expect no loss from this source.

It is a fair question whether we received an extra growth and corresponding return for the grain fed during the summer. This cannot be told, as we had no check lot not receiving grain. Other sheepmen in Colorado who pasture sheep on alfalfa are not in the habit of feeding grain after the alfalfa gets in good growth. But on the other hand they do not get so large a growth on their lambs as we did. The grain fed through the summer amounted to 700 pounds, or $3.85 and it is probable, though not certain, that the lambs grew the 10 pounds each of live weight necessary to pay for the grain.

The only other person in the vicinity of Fort Collins who pastured sheep on alfalfa during the season of 1898 is C. W. Trimble. He pastured 40 ewes and 40 lambs on two acres of good alfalfa. They remained on the alfalfa day and night, rain and shine, all the season, except three times of four or five days each when the land was irrigated, then they were taken off and fed alfalfa hay. They had forty pounds of corn chop per day, *i.e.*, one pound a day for a ewe and her lamb. None were lost by bloat of either ewes or lambs. After the third crop of alfalfa was cut the ewes and lambs were turned on the stubble to eat the fourth crop. The lambs were taken up in the latter part of September to feed for market. They weighed then about 65 pounds per head. The ewes remained in the fields until late. The same ewes are being kept for a repetition of the test in 1899.

PASTURING ALFALFA IN THE ARKANSAS VALLEY.

More attempts have been made in the Arkansas valley to pasture sheep on alfalfa than in any other part of Colorado. Some years when the feed on the range has been poor quite a large number of sheep have been pastured part of the season on alfalfa, but during the summer of 1898, the range grass was very abundant and nearly everybody turned the sheep and lambs on the range. The center of the sheep industry in the Arkansas valley is the counties of Otero, Bent and Prowers. Statements were obtained from those who had had the most experience in pasturing sheep on alfalfa and they are given herewith as showing what diverse results have been obtained and how various the opinions now held by those most familiar with the subject.

W. E. DOYLE, Pueblo.

We tried raising lambs on alfalfa pasture during the spring of 1898 and got along very well for the first two or three weeks while the pasture was short. But just as soon as the alfalfa got to growing faster than the sheep could eat it down close, they began to bloat, and before I gave it up I had lost about sixty head of fine Shropshire ewes and several lambs. I tried every precaution I knew of, such as not turning out until late in the morning, having them well filled with hay and grain, but it seemed to make no difference. Some days there would be no losses; then would come a day when a dozen would die after they had been grazing four or five hours.

My opinion is that if one had a dog and coyote proof fence around the pasture and kept the sheep on night and day and kept the alfalfa picked down close until they got accustomed to it, the loss would not be so large.

However, from what I have been able to learn from those who have had more experience than myself, they suffer from 15 to 25 per cent. loss, which at the present high price of ewes is rather expensive.

WM. and H. G. GREENE, Olney.

Our late lambs began to come about the tenth of April, and both in 1897 and in 1898 we lambed them on alfalfa. We put the ewes on the alfalfa before it started and kept them there until we were through lambing. We yarded them at night. Until the alfalfa got well grown we fed them hay. When feed began to get plenty, they would bloat more or less, but we never lost a sheep.

The first season after the lambs were a few days old we tried returning the ewes to the alfalfa. But we could not make it work. The ewes would bloat and die, if they were only on for a short time, even fifteen to twenty minutes, Last year we did not try to return the ewes to the alfalfa after they came in, but took them to the prairie which was good feed. By running the dropping band on alfalfa, the ewes have plenty of milk and are in good condition. We expect to run the dropping band in 1899 the same way. We have fine lambs and expect to get nearly one hundred per cent. increase. We have tried other ways of running sheep on alfalfa but cannot make a success of it.

D. C. ROBERTS, Ordway.

My experience in pasturing alfalfa with sheep is on rather a small scale. Among my sheep that I was fattening during the spring of 1898, were eight ewes that dropped lambs in April—fifteen lambs from the eight ewes—while on dry feed in the corral. When I sold my sheep in May, these ewes and lambs were turned loose in the alfalfa fields, twenty-three head in all. They roamed over the farm at their own will, seldom coming near the barn. In September I put them in the corral again and found there were twenty-three head still. On September 10, several of the larger lambs weighed 80 to 90 pounds. They were on the green alfalfa through wet and dry and apparently never bloated.

S. McCARTA, Manzanola.

In October 1896, I bought my first bunch of sheep. I got them home about two o'clock in the afternoon, turned them into an alfalfa field, went on to the house and paid no attention to them except to look from the house and see if they were still in the field. About sundown I turned them into the corral. I thought they looked full, but never thought of bloat, as the party from whom I bought them assured me there was no danger in pasturing on alfalfa. The next morning I turned them into the same field, and continued this practice as long as there was anything in the field to eat, in fact nearly all winter. The alfalfa was nearly a foot high when I turned them in and they were very hungry, for I had driven them thirty miles during the day and a half, and they had had little to eat or drink. This was my first experience in pasturing sheep on alfalfa and I never lost a single one. By the fall of 1897 I had received the advice from all the know-alls in the sheep business. I was warned never to let the sheep on to the alfalfa unless they were well filled up with feed and water, also especially never to turn sheep on alfalfa early in the morning.

I adhered to both of these rules until I lost about forty-five ewes. The last loss was sixteen in less time than it takes to write it. They came off of a hill pasture where they had been all day. This was at four o'clock in the afternoon. Before half-past four they were tumbling in every direction.

The next morning early I opened the gate from the corral and let them into the alfalfa field. Then I told my man not to go near them and I went away for the day, and at night they were all right with not a single loss. After that I continued to shut them up late at night and turn them out early and lost no more from that bunch.

A few weeks later I bought another bunch of 600 ewes. I filled them up well on hay and corn for about a week. Then about the middle of one afternoon I turned them into the alfalfa. In half an hour I had lost nine head. The next morning I. turned them out at daylight and lost no more. In all these cases there was plenty of water in all the fields.

In the spring of 1898 I had about 900 ewes to lamb. Five hundred of them were in one bunch in a corral at one corner of a fifty acre alfalfa field. Early in the morning we opened the corral gate and filled the racks with hay so that the sheep could roam over the field or stay and eat hay if they preferred. This was begun before the alfalfa started. It was kept up until the middle of May by which time the alfalfa was a foot high. Then as we needed the alfalfa for hay we turned the sheep on the range. In all this time we lost only one sheep and it is not sure that this one died of bloat. We were very careful not to drive or bother this bunch of sheep. When they had all gathered in the corral at night the gate was closed and opened again very early in the morning.

The other 400 ewes had no alfalfa field so convenient to their night corral and they had to be both driven and herded. We had almost daily losses with this bunch until finally we made some new fencing that allowed them to roam without herding and after that our losses ceased.

In the light of these three season's experience, it seems to me that if a person wants to make a success of pasturing alfalfa and is so situated that he must corral the sheep at night, then this corral should be in the field where there will be no need ever to drive the sheep or worry them.

In the fall of 1898 I took sheep off the cars and turned them at once into an alfalfa field that had been cut but once during the season and where the alfalfa was so high the sheep could hardly be seen. Yet there were no losses.

In regard to the profit of thus pasturing alfalfa; I have made a little money at it and I believe there is money in it for anyone who has sufficient land and capital so that he can arrange matters properly.

W. B. BALDWIN, Fowler.

We have had considerable experience in pasturing sheep on alfalfa. At first we lost quite a number, but finally found that the loss would be largely reduced if we left the sheep on the alfalfa day and night and kept the alfalfa large. We also found it best to have the sheep's stomach empty when put on alfalfa and then not take them out even if they do bloat. Our theory is that if the stomach is empty there will be room for a large amount of gas if they do bloat, and as soon as they begin bloating they will stop eating and but few will die. This theory is altogether different from the general opinion, but it is all right. Sheep must not change pasture. They must stay on the same pasture all summer if you wish to have success. Good alfalfa will keep about eight ewes and their lambs per acre. It should be irrigated often so as to keep the alfalfa from getting dry. If the alfalfa should get dry and you have to change the sheep to another field, you may expect losses.

Shropshires are the hardiest sheep I have had on pasture or on range.

Lambs do not bloat on alfalfa pasture until they are old enough to wean.

Alfalfa is certainly the best thing to lamb on for spring lambs. We are now (January 1899) having our first experience in lambing ewes in the winter. We have 1100 ewes and so far have saved about ninety-five per cent. of the lambs.

W. H. NEY, Fowler.

The best way to guard against bloat in pasturing sheep on alfalfa is to feed the sheep well on any dry feed just before turning them on the alfalfa and turn them in while full and leave them there night and day. By this method the losses will be light and success assured. Alfalfa pasture has great fattening qualities and early lambs having the run of alfalfa fields during the summer months will make much heavier gains than lambs running on the open range and depending on native grass. We could show lambs the fall of 1898 that were fit for any market and had tasted no grain since the last April. Sheep that run on alfalfa need little or no grain to fit them for market and this makes quite a saving.

The Arkansas valley is well adapted to sheep farming. Hay is cheap for winter feeding and the necessary grain can be raised here as cheaply as anywhere. For either breeding or fattening sheep I know of no place to equal the Arkansas Valley.

J. W. BROWN, Rocky Ford.

This is our first year of pasturing sheep on alfalfa. We pastured 500 ewes and their lambs on alfalfa for two months and then turned them on the range. We did not lose any by bloat. We did not move the sheep off the alfalfa when we irrigated. We have a large breed of sheep, the French Merinos, the ewes weighing from 140 to 200 pounds. We lamb early, feed for awhile in the corrals and this year we pastured on alfalfa for two months. This gives both the ewes and the lambs a good start and they do well on the range. We expect our lambs to weigh 90 pounds the first of October. Alfalfa is all right for sheep.

T. N. ORCUTT, Rocky Ford.

I have never pastured on alfalfa, but make it into hay and feed the year around. I now have only pure bred Cotswold sheep at the home farm. I have two pastures, one of rye and one of blue grass; while one is growing they eat the other.

Alfalfa is not used for pasture for sheep in this section at all. Where it has been tried the losses were heavy. I understand that some feeders think they can afford to lose 5 to 10 per cent. This may do for toothless ewes, but my registered sheep are too valuable to take the risk. One of my neighbors put 1,500 sheep on alfalfa and I understand lost as high as sixteen in one day. Another tried it this spring, but the losses were so heavy he abandoned it. Near Las Animas they succeeded better, but here the alfalfa grows too rank.

A. FORDER, Rocky Ford.

I pastured one year 1200 ewes and their lambs on alfalfa for thirty days without any losses, then changed pastures and lost 75 ewes in about ten days, then changed to the range and will not try alfalfa pasture again. We did not irrigate the land while the sheep were there.

I have pastured old ewes and lambs on alfalfa after it stopped growing in the fall and did not lose any by bloat. We fed corn at the same time and the sheep did well.

J. P. STEVENSON, Rocky Ford.

I have tried for several years to run sheep on alfalfa; the result has been disastrous every time. Some four or five years ago I bought a bunch of New Mexican lambs, put them at first on very short alfalfa and kept them there for several days, then put them on better alfalfa. They commenced to bloat and before I took them out I lost 65 head. I had at the time a bunch of 300 native ewes. I put them on the same ground and gave them the same treatment and never lost one. The next spring these ewes were turned on the alfalfa as soon as it appeared green, but as soon as it got some growth they commenced to die and I had to remove them to native grass. I lost from one to four every day. Last fall I again bought 300 well bred Shropshire ewes. I put them on good alfalfa the first day I got them home and kept them there until night. I did not lose one. Next morning put them on again after dew was dry and kept them on all day; lost one. The third day I waited until grass was dry and then put them on again. By noon I had lost nine head.

This spring I have kept the ewes up, fed them hay and let the lambs run through the fence and graze the alfalfa. They have done fairly well, but I believe if they and the ewes had other green grass and plenty of it as they do on alfalfa, that they would do better than on alfalfa. I have noticed one thing, that these lambs will leave the green alfalfa for dry hay and for a patch of wild grass. Still I have good lambs; some few January and February lambs weighed the middle of June 80 to 90 pounds.

All my sheep were turned on the range in June and I will bring them back the middle of August. Lambs dropped in April and fed as above ought to weigh 70 pounds the first of September.

My experience with pasturing sheep on alfalfa for six years has cost me several hundred dollars on account of bloat and that, too, with only a small bunch of 300 to 500 ewes.

I do not think I shall ever graze sheep on it again. The sooner the farmer who wants to graze his breeding stock on green feed gets something in place of alfalfa the better off he will be. People who have been buying old ewes at 75 cents to $1.00 per head and putting them on alfalfa have not lost much money if they lose ten per cent. of their ewes. But where the ewes are worth four to six dollars per head the case is quite different.

But although pasturing alfalfa has not been a success yet the sheep business, as a whole, has been profitable. This Arkansas Valley is a wonderful place for sheep. Our 1898 account stands as follows :

We had 35 lambs dropped in February and about 250 dropped in April and May. They went to the range June 10 and came back early in August. We commenced feeding bran and oats August 15 and got them on to full feed about the last of September, by which time they were eating one and three-fourths pounds of shelled corn per head per day. The latter part of October we sold 50 picked ram lambs at $10 per head. Fifteen of these came in February and the rest in April. . Their average age was about seven months and they weighed 99 pounds per head. During November we sold 20 more ram lambs for $10 each. In December sold 40 ram lambs for $5 each. This left us 18 cull ram lambs. These 18 with 118 ewe lambs we took to Kansas City the last of December and after an extra hard trip they weighed 81½ pounds and sold for $5.40 per hundred pounds or $4.40 per head. We had, therefore, total receipts of almost exactly $1500.00 from 246 lambs. We consider this a good showing.

JOSEPH CARL, La Junta.

We are pasturing 425 ewes and lambs on alfalfa the season of 1898. They have the run of twenty acres of alfalfa and up to June 8th, we have lost only one sheep by bloat. This is our first trial of pasturing sheep on alfalfa and so far we are well pleased with it and shall go into it on a larger scale next year.

S. H. POLLOCK, La Junta.

I undertook to pasture about 300 ewes and 225 lambs on alfalfa pasture, by feeding them well on corn and hay before turning them on the alfalfa and then leaving them there day and night. I left them three days and lost three ewes. I then gave it up and put them on the range.

GEO. W. PARKER, La Junta.

I have pastured sheep on alfalfa for three or four years and have lost on the average possibly two per cent by bloat. A good acre of alfalfa will support ten ewes and their lambs all summer. We turned the sheep off the land when we irrigated it. A cross bred Shropshire and Merino lamb pastured on alfalfa ought to weigh 75 to 80 pounds, the first of October. From my experience, more especially with old ewes, I think well of lambing on alfalfa when the grass is short on the range and would especially recommend keeping the breeding ewes on the farm and feeding them nice green alfalfa hay before lambing instead of wintering them on the range.

R. A. McKIBBON, Lamar.

We run a few ewes, about fifty, on a small patch of eight acres of alfalfa. We have the lot divided and put the sheep in one while we irrigate the other. This is the second year we have tried it. We have lost two old ewes by bloat. We expect our spring lambs to weigh 75 pounds by the first of October. The season of 1898, we also lost a lamb by bloating.

G. W. MAY, Lamar.

During 1897 we pastured 1,000 ewes on 80 acres of alfalfa. This was our first year's experience and we lost nine per cent with bloat. We left the sheep on the land when we irrigated it. We began pasturing in April and by the middle of July the 80 acres proved not enough and we got 15 acres more. Even the 95 acres did not keep them and about the first of August we turned them onto the range. In 1898 we started with 160 acres, but by the middle of August the alfalfa was all gone and we had to turn them onto the range.

My belief is that not over 100 head of ewes should be pastured in one bunch on alfalfa and that at the rate of five ewes and their lambs to the acre. For larger bunches, if the alfalfa pasture was free of cost, it would be dear to use it on account of the great loss by bloat.

GEO. W. WILSON, Lamar.

We had several thousand ewes on alfalfa for forty days during the spring of 1898. Part of the time we kept them on day and night; part of the time they were corralled at night and turned out after the dew had dried off in the morning. Both plans were failures so far as preventing bloat was concerning and after losing about five per cent by bloat in the forty days, we gave it up and sent them to the range. I have satisfied myself that pasturing on alfalfa in the Arkansas valley is not practicable at least with large bunches much as I should like to have had it otherwise. At the same time I consider it the best district in any country for raising and feeding lambs.

JOHN McNAUGHT, Las Animas.

Have pastured sheep on alfalfa for six years. Fifty acres of good alfalfa will support about 500 ewes and their lambs the whole season. In different years we have lost from eight to ten per cent by bloat. We do not move the sheep off the alfalfa when we irrigate it. We undertake to give plenty of pasture at the start and then not move them. Our May lambs we expect to weigh about 60 pounds the first of October. We fatten our own lambs.

[NOTE—The present writer visited Mr. McNaught, July 14th, 1898 and saw his 500 ewes and their lambs on alfalfa. These were all old ewes, nearly toothless, which is the reason for keeping them at home instead of sending them out on the range. The number lost to date by bloat was fifteen or three per cent. They had some forty acres of alfalfa to run on and were not keeping it at all close. Quite a share of those lost had been when some overflow water ran into one corner of the field. Mr. McNaught says that if the whole field had been irrigated, there would have been less danger of bloating than with merely a single spot. Mr. McNaught's doctrine in regard to pasturing sheep on alfalfa is never to let them get hungry. The best way is to have the fence coyote tight, but if this cannot be done, then corral them at night as he is doing this summer and let them out early in the morning.]

PURVIS BROS., Las Animas.

During the summers of 1897 and 1898 the grass was so good on the range that, as a general thing, it paid to run sheep on the range. Indeed, under these conditions of an abundance of fine grass, the lambs are almost as good as those pastured on alfalfa and the expense is less.

We had only about a hundred sheep on alfalfa during the summer of 1898. They did quite well. We had them, their lambs and ten horses on a twenty acre pasture and we could almost have cut it for hay. When the lambs were weaned the ewes were nearly fat enough for market.

The cause of the greatest loss from bloat is probably the necessity of corralling at night on account of coyotes. Where this plan is practiced the sheep should not be put into the corral until almost dark and turned out in the morning before daylight. The sheep generally bloat in the evening and this is due most likely to the practice of leaving them in the corral too late in the morning. Some actually put them in the corral at 4 o'clock in the afternoon, thinking to avoid the loss, as it is after this time that they generally bloat, and then leave them shut up until after the dew is off in the morning. This makes about sixteen hours in the corral and only eight hours on feed, consequently the sheep do not do well.

This year, 1898, was the fourth season for us of pasturing alfalfa with sheep. On the average we have lost about five per cent. with bloat. We have the field divided into two parts and pasture one while we irrigate the other. These were old ewes and were pastured all summer. We expect alfalfa fed lambs to weigh about 75 pounds the first of October.

[When on a visit to the Arkansas Valley in July the present writer learned that Purvis Brothers have their fences coyote tight and do not have to bother about corralling the sheep at night. To still further lessen the danger from coyotes, they had taken to hunting them with greyhounds and had killed seventeen so far during the season.

To surround a whole farm with coyote tight fence would be rather expensive, but it would not cost much to fence five acres and drive the sheep in there at night, thus diminishing the danger from bloat.]

CHRISTIAN MARLMAN, Las Animas.

Pastured 470 ewes and their lambs on alfalfa during May and June 1898. They ran on about fifty acres of alfalfa. They were turned onto the range June 11 and remained there until the latter part of September. Lost in all about three per cent. by bloat. They ate all the first cutting, so that it cost us one-third of our hay crop. These lambs were dropped in March and weighed between 50 and 60 pounds when brought back from the range. We are well satisfied with the result and shall try it again next season.

JOHN E. DONLON, Las Animas.

In 1896 we pastured 1200 ewes with their lambs on 160 acres of alfalfa and lost about eight per cent. by bloat. That year we fed no grain. In 1897 we fed 1,000 ewes and their lambs on the same field. This second year we fed corn chop to the sheep and lost only 2 per cent. by bloat. Both these years we had aged ewes and kept them on the field all the time, even when we irrigated it. We would not risk young ewes on alfalfa. In 1898 we have had such excellent feed on the prairie that we kept our sheep on the range most of the season.

A. M. LAMBRIGHT, Las Animas.

During 1897 we pastured 750 ewes and their lambs on 100 acres of alfalfa and lost about three per cent by bloat. We kept them on the land the entire season, not changing when the land was irrigated.

In the spring of 1898 we started 1,000 ewes on 160 acres of alfalfa, but the feed on the range was so good that we turned them onto the range the latter part of May. If we had kept them on the farm all the season, I think 130 acres would have been sufficient to feed them.

There have not been very many raising lambs here and what has been done has been done for only a couple of years. We have run simply old ewes on alfalfa so that the test so far as bloat is concerned is hardly a fair one for sheep raising in general. I am sure that old ewes do not bloat so much as young ones. Most of us have not invested in enough for fences to cut our pastures up properly. I think that if we had our pastures fenced so that there would be no danger from coyotes and would leave the sheep on the land all the time, there would be comparatively little danger from bloat if the owner would go around through them a couple of times a day and make them get up and eat a little. Some lost considerable here this year and have been scared out to the range. We have only lost three out of 1,000. Of this 1,000, not over one-third could be classed as old ewes. I have very little doubt but that there is a difference in size in an alfalfa fed lamb and one raised on the range of at least twenty-five pounds. The chances are that we could afford to raise nearer pure bred Shropshire or Hampshire Downs on ranches than we could afford to do on the range (for it is generally supposed here that none but Merinos or Mexican Improved with Merinos will herd on the range), and if this is done we can make a difference of at least fifty pounds.

SCOTT BROTHERS, Las Animas.

In 1898 our sheep are all on the range, the grass is so good.

A good stand of alfalfa will carry ten ewes and their lambs per acre the first year; the next year fewer and the next year still fewer.

Pasturing alfalfa by sheep is hard on the stand, as they bite out the crowns of the plant. We pastured sheep on alfalfa for one whole season and during the fall for three years. When pasturing the whole season we lost about five per cent. by bloat. We are very careful to leave them on the alfalfa all the time after they are once placed there, never changing them when the field is irrigated. Grade Shropshire lambs to which we had fed corn while on alfalfa weighed 75 pounds the first of October. Our grade Mexican lambs weighed 70 pounds. If we had not fed corn they would probably have weighed 5 to 10 pounds less. We fatten our own lambs.

JACOB WEIL, Las Animas.

During 1898 we did not pasture sheep on alfalfa, but have done so on two previous years. We were in the habit of taking them off the field when it was irrigated. Our lambs weighed about 65 pounds the first of October and we fattened them on the farm.

F. T. WIBBER, Fredonia.

We have pastured sheep on alfalfa for five years. The first year we lost ten per cent. Now we do not expect to lose any. We do not move the sheep when we irrigate. In 1898 we pastured 500 ewes and their lambs on 160 acres of alfalfa from early in the season until the first of July. They were then turned on the range and stayed there until fall. We expect lambs so treated to weigh 70 pounds the first of October. We fatten our own lambs.

A. F. KLINKERMAN, Fredonia.

We have pastured sheep on alfalfa part or all of three seasons. One season we lost as high as ten per cent. by bloat, but this was due largely to inexperience. During 1898 we let the ewes run on alfalfa during the six weeks of the lambing season and as soon as that was over we sent them to the range. We lost about one per cent. during the six weeks. We had about 500 ewes and their lambs on 50 acres of alfalfa. We have always left the sheep on the land when irrigating it. We expect May lambs to weigh 60 pounds the first of October if pastured on alfalfa. In 1898 we turned the ewes and lambs on the range the first of June. It probably took two-thirds of the first cutting of alfalfa to lamb the sheep on it, but we consider ourselves well paid in saving of lambs and the start it gave them and the old ewes before turning them on the range. We are satisfied that we saved at least fifteen per cent. more lambs than could be done on the range and also saved in the expenses of herders during lambing.

L. M. CAMPBELL, Fredonia.

We feed on alfalfa exclusively, no grain except to lambs born in the winter.

First make a fence with posts 10 feet apart, nine barbed wires, stretched tight, 4½ feet high. This will turn a wolf or a dog and is the principal essential of running sheep on alfalfa pasture, since they must have free access to the feed day and night. Shade, salt and water are very essential. Have the sheep entirely free from hunger or thirst before turning them on the alfalfa.

In December, 1895, I bought off the range 100 ewes, each with a lamb by its side. They did well until the alfalfa started in the spring. Then we attempted to herd them on the alfalfa in the day time and corral them at night. Our loss by bloat in ten days was 12 ewes and 15 lambs. We put them on native grass for a few days until we could build such a fence as I have described. We enclosed 10 acres of alfalfa and 5 acres of timber. This was in April, 1896. I drove them over a wheat field to the alfalfa pasture to be sure they were full. I have not lost a sheep or lamb since then by bloat and I have no fear of ever losing one.

I have yet five head—four ewes and one buck—of the first 100 bought and they have never been out of that enclosure. The ewes are nine years old, the buck a few years older, and their teeth are as good as the average six-year-old on the range. We never take the buck away from the ewes.

Two of the four ewes had twins last November and the same ewes had twins again this year (1898) in May. The four November lambs weighed in the middle of June 70 pounds each, while the May lambs weighed at the same time twenty pounds each.

We wintered 85 ewes in that pasture during 1897-98 and raised in the spring of 1898 135 lambs, forty of which—the wether lambs—we sold in Kansas City in April, where they averaged 60 pounds and brought 6½ cents per pound, or $3.95 cents per head. The ewes sheared about 7½ pounds of wool apiece.

I think my pasture would support quite a number more sheep than we have on it, or about ten ewes and their lambs per acre. We irrigate with the sheep in the pasture and can see no bad effects. I do not advocate close pasturing. We have never fattened any lambs, selling them when they are three months old.

Sheep do their principal feeding at night. It would not be profitable to corral sheep at night when in alfalfa pasture, even if it were not for bloating. They will do much better when they can have access to feed both day and night.

Alfalfa pasture does not seem to be favorable to scab.

We bought our sheep from a herd that was infested and expected to dip, but so far have had no occasion.

I am a strong believer in pasturing as a method of handling our alfalfa. Conducted on the principles here described there is nothing in my judgment more profitable than handling sheep and I hope to see the day when every farm in Colorado will be supporting a flock of sheep.

The total income from these 87 ewes for the year from November 1897 to 1898 is as follows:

40 wether lambs sold in April @ $3.95..	$158.00
640 pounds wool from ewes @ 10c......	64.00
175 pounds wool from lambs @ 14c.....	24.50
35 ewe lambs saved for breeding @ $3.50.	122.50
52 lambs for market, 75 lbs. each, November 1, @ $3.00..................	156.00
	$525.00

Year's income per ewe $6.04.

IS PASTURING ALFALFA PROFITABLE.

It will be noticed from the foregoing letters that the pasturing of alfalfa by sheep is used for several purposes; sometimes for only a few weeks in the spring while the ewes are lambing; sometimes for very early lambs to fit them for the summer market; more commonly for old ewes that would not thrive on the range and by some as a regular way of keeping sheep.

It will also be noticed that there are certain things about which all are agreed. By inference we may judge that all agree, that for keeping wethers or ewes without lambs, alfalfa pasture cannot compete with the open range. This is undoubtedly true so that the only profitable use for alfalfa pasture is as feed for ewes with lambs.

It is also evident at the outset that alfalfa pasture is not cheap feed, not nearly so cheap as the range. If then it is to be used in competition with the range it must be because more growth is obtained on the lambs when on alfalfa than when roaming the range.

The question of raising early lambs on alfalfa and other feeds will be discussed in the latter part of this bulletin.

Here we are to consider the pasturing of lambs during the whole summer that are to be fattened on the same farm during the fall and winter for the eastern markets.

The practical question is, can this be done with as much profit as to range the lambs through the summer and then bring them to the farm for winter feeding. To the feeder of the Arkansas Valley at the present time, this is the simple proposition. But the time will come when the problem will present itself in another form. In the feeding districts of Northern Colorado that time has already come and the problem as it will appear in the future is this: There is or will be on the farm a certain amount of alfalfa. By which method can I realize the more profit, by making hay of it and feeding it to lambs in the winter or by using part of it as pasture for ewes and lambs during the summer and the rest to support the ewes during the winter?

The average of the statements from the various individuals seems to be about ten ewes and their lambs to one acre of good alfalfa pasture, running on the land from the middle of April until the first of October. This would require very good alfalfa and it is probable that eight ewes to the acre would be nearer average conditions. The ewes would feed on the stubble fields practically without cost during October and November, leaving four and a half months that they would have to be hay fed.

A full grown ewe will eat five pounds of hay per day or two and three-fourth tons of hay to run the eight ewes through the winter. If we estimate an acre to produce four tons of alfalfa, then it would require three-fourths of an acre to supply hay for the winter and one acre to pasture them during the summer.

What return could be expected as the income from this acre and three-fourths of alfalfa? For the last four years lambs have averaged being worth four cents a pound live weight on the farm the first of October. It is fair to presume that a person who was planning for pasturing alfalfa would have the lambs dropped in March and they ought then to weigh 70 pounds the first of October and be worth $2.80 each. The ewes would need to be fed grain for sixty days, one pound per day, costing in all forty cents for each ewe. The ewes should shear seven pounds of wool each, worth at least ten cents per pound.

The whole account would stand thus:

Income.

8 lambs @ $2.80	$22.40
56 pounds wool @ 10c	5.60
Total	$28.00

Expenses.

480 pounds grain	$ 3.20
Difference	$24.80

This difference of $24.80 represents the return from the land that will produce seven tons of alfalfa or about $3.50 per ton for cutting and feeding about half the alfalfa and letting the sheep harvest the other half.

Out of this return would need to be deducted the interest on the investment and any losses by bloat that may occur.

Whether or not any greater return for the alfalfa can be obtained in any other way, each farmer will need to answer for himself. It is believed that the items of income as given above are conservative estimates and that profits much larger than this would often be obtained.

IS PASTURING ALFALFA SAFE.

The answer must be given in the negative. But in view of the statements given by some of those who have had the most experience, the danger from bloat can be largely overcome and the loss reduced to at least not more than five per cent.

On the basis of the estimates already given, a five per cent loss by bloat would reduce the returns for the alfalfa fifteen cents per ton. If there is any profit in pasturing alfalfa, a five per cent. loss on the ewes would not reduce the profit to any serious extent.

There seem to be certain precautions that need to be observed in pasturing alfalfa to prevent bloat and they can be summarized as follows:

1. Have the sheep in small bunches, or if in a large bunch divide into several lots in separate fields.

2. Have a large enough field to supply them with an abundance of food with little effort.

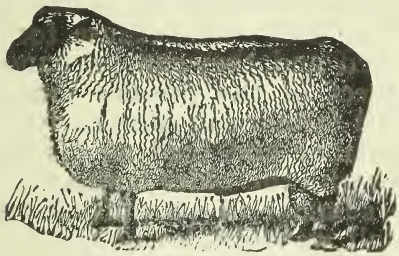
3. Leave them in the field day and night and do not remove them when the field is irrigated.

4. Have water and salt before them all the time and if there are no trees in the field provide some sort of shelter against the sun.

5. Be sure they are filled up with some other food and not thirsty when first turned on the alfalfa.

6. Do not attempt to pasture on alfalfa anything but old ewes and their lambs.

It is probable that by following out the above directions the losses by bloat with old ewes can be reduced to less than five per cent.



II. RAISING EARLY LAMBS.

BY W. W. COOKE.

For many years there have been a few early lambs raised in Colorado. The large markets for early lambs—Chicago, New York and Boston—are so distant that Colorado can hardly hope to compete with the eastern states in supplying lambs in the spring to these cities. Kansas City and Omaha are near enough to be reached, but they are never able to handle very many lambs at one time and their total demand for early lambs is not large. The local market in Colorado is still more limited. It is evident, then, that not many people in Colorado can profitably engage in the raising of early lambs. But there is always a demand for some of these lambs and some one has to supply that demand. At the present time the attention of Colorado feeders is turned more particularly to the feeding of lambs raised in the south and west, because for them the market is almost unlimited and they can be handled by the thousands. The object of the present inquiry was to learn whether the small farmer can raise early lambs and realize as much for his labor and feed as his neighbor with the larger farm does with the older lambs.

During the summer of 1895 fifty ewes were purchased for the test. Half were grades of the Shropshire crossed onto the Merino, and the other half were Horned Dorset and Merino. They were a fine lot of ewes, all of them three years old, having dropped their second lamb the spring of 1895. They cost three dollars per head. Fifteen of the Shropshire ewes were served by registered Shropshire bucks, the other ten by registered Dorset bucks. Fifteen of the Dorset ewes were served by the Dorset bucks the other ten by Shropshire bucks. The lambs were dropped during January and February of 1896.

The fifteen Shropshire ewes that were served by Shropshire bucks dropped 14 lambs, of which 11 were buck lambs and 3 ewe lambs. The ten Shropshire ewes served by Dorset bucks dropped 13 lambs, 5 bucks and 8 ewes. The fifteen Dorset ewes served by Dorset bucks dropped 20 lambs, 16 bucks and 4 ewes. The ten Dorset ewes served by Shropshire bucks dropped 9 lambs, 5 bucks and 4 ewes.

To make the comparison a little easier to see, the above figures have been reduced to the basis of 100 ewes and give the following results:

	Lambs.	Sets of Twins.
100 Shropshire ewes served by Shropshire bucks dropped........	94	7
100 Shropshire ewes served by Dorset bucks dropped............	130	40
100 Dorset ewes served by Dorset bucks dropped	134	33
100 Dorset ewes served by Shropshire bucks dropped	90	0

Figured from the side of the ewe, 200 Shropshire ewes, half served by Shropshire bucks and half by Dorset bucks produced 224 lambs with 47 sets of twins. 200 Dorset ewes, with the same service produced 224 lambs with 33 sets of twins. Figuring from the side of the buck, 200 ewes, half Shropshire and half Dorset and all served by Shropshire bucks, produced 184 lambs with 7 sets of twins. 200 ewes, the same but served by Dorset bucks produced 264 lambs with 73 sets of twins.

It is evident from these last sets of comparisons that the prepotencey toward the production of twins lay with the bucks and not with the ewes. It is generally conceded that the Dorset is one of the most prolific sheep and the bucks ought to have had this quality more pronounced for they were pure bred while the ewes were grades.

So far everything seemed to favor the Dorsets as the more profitable sheep. But these lambs were dropped in the middle of winter and the twins did not seem to have the vigor to stand cold weather so well as those that had been born singly. Moreover the ewes seemed to be able to give an abundance of milk for one lamb but not enough for two.

The ewes were given grain, and a lamb creep was provided where cracked grain was kept all the time. The lambs learned to eat grain before they were a month old and after that, ate nearly as much as the ewes. Yet in spite of this the twin lambs did not do so well as the others and those that we lost were almost entirely from the twins.

We began selling March 10 and sent off the last May 21. The price was 15 cents per pound dressed weight.

The four sets of lambs of different parentage gave the following results:

Record for the Spring of 1896.

Dam......	Sire........	No. of Lambs.	Average Date of Birth.	Average Date of Sale.	Age in Days at Time of Sale.	Live Weight. Pounds.	Dressed Weight. Pounds.	Selling Price Per Head.
Shropshire	Shropshire	13	Feb. 1	April 20	79	47	22	$3 30
"	Dorset.....	10	" 3	" 25	82	48	22	3.30
Dorset.....	Dorset.....	15	" 9	" 16	67	47	22	3.30
" . ..	Shropshire	9	Jan. 22	" 3	72	51	23	3.45
Total and Average...		47	Feb. 1	April 16	74	48	22	$3.30

The reason that the dressed weights are so nearly equal, is that we sold from week to week, selecting the lambs as soon as they were large enough to dress over twenty pounds. We finally sold 47 lambs from the 50 ewes, of which 25 came from the twenty-five ewes that were served by Dorset bucks, while 22 were from the twenty-five ewes served by Shropshire bucks.

In the matter of rapidity of growth the ewe seemed to be the controlling factor, rather than the buck as might naturally have been expected. The lambs from Dorset ewes dressed 22 pounds by the time they were 69 days old, averaging 49 pounds live weight, while the lambs from Shropshire ewes required eleven days longer to reach the same weight.

Taking the whole experiment through, the Dorset ewes served by Dorset bucks gave the best results, giving us fifteen lambs from fifteen ewes that sold for $3.30 per head at 67 days old.

The average for all classes is January 30 for date of birth and April 16 for the date of sale when they were 77 days old, weighed 48 pounds alive, 22 pounds dressed and sold for $3.30 at the farm.

As fast as the lambs were sold the ewes were taken off from grain and when the last lambs were gone, the ewes were sheared and turned out to pasture on native grass until the next winter.

The same method of procedure was adopted in 1897, except that as the lambs were dropped a little earlier, they were allowed to grow a little larger before they were sold.

This season all the ewes were served by Shropshire bucks and though the lambs sold are one more than 1896, the difference in favor of the Dorsets is larger than in 1896.

There are 21 lambs credited to the Shropshires. One more lamb was dropped but so late in the season that it could not be sold with the others in the spring and was carried over until the next season. It is counted in the summary as worth $2.00, though of course we actually received more than that for it at the time of sale.

The record for the spring of 1897 is as follows.

Record for the Spring of 1897.

DAM.	No. of Lambs Sold	Average Date of Birth.	Average Date of Sale.	Age at Date of Sale, Days.	Live Weight, Lbs.	Dressed Weight, Lbs.	Selling Price.
Shropshire	21	Jan. 15	March 27	71	54	27	$4.05
Dorset	27	Jan. 12	April 2	80	56	26	3.90
Total and Average	48	Jan. 13	March 30	76	55	26.5	$3.97

Again for the third year the same experiment was repeated. The ewes were all served by Shropshire bucks, but were getting so old that several did not lamb the spring of 1898.

Instead of selling the lambs for slaughter they were all sold April 13 at $3.50 per head for breeding purposes. This was about the price they would have brought if they had been fed a little more grain and sold for meat.

The following is the record for the spring of 1898:

Record for the Spring of 1898.

DAM.	No. of Lambs Sold	Average Date of Birth.	Date of Sale.	Age at Date of Sale, Days.	Live Weight.	Selling Price
Shropshire	17	Jan. 1	April 13	102	61	$3.60
Dorset	23	Dec. 25	April 13	109	59	3.40
Total and Average	40	Dec. 28	April 13	106	60	$3.50

This closed the experiment. The total records for the three years will be considered first with reference to the two breeds, the Shropshire and the Horned Dorset. Then it will be treated as a whole with reference to the financial side of the question.

Shropshires.

Year.	No. of Lambs Sold.	Age in Days at Date of Sale.	Live Weight.	Dressed Weight.	Selling Price Per Head.	Total Selling Price.
1896	23	80	47	22	$3.30	$75.90
1897	21	71	54	27	4.05	87.05
1898	17	102	61		3.60	61.20
Total...........	61	84	54	26	$3.64	$224.15

Horned Dorsets.

Year.	No. of Lambs Sold.	Age in Days at Date of Sale.	Live Weight.	Dressed Weight.	Selling Price Per Head.	Total Selling Price.
1896	24	69	49	22	$3.30	$ 80.55
1897	27	80	56	26	3.90	105.30
1898	23	109	59	..	3.40	78.20
Total............	74	86	55	25	$3.57	$264.05

The financial results are in favor of the Horned Dorsets. The first year they grew the faster, but in both the other years the Shropshires made the most weight and sold for the most per head. But the Dorsets produced so many more lambs as to more than overbalance their slower growth. On the whole the Dorsets brought in $40 more than the

Shropshires or about one-sixth of the total income. This difference is due entirely to the larger number of lambs reared by the Dorsets. Their record is practically one hundred per cent. since 74 lambs were sold from 25 ewes in three years.

ARE EARLY LAMBS PROFITABLE.

It is a difficult matter to estimate the cost of running sheep in such small numbers as we had in this experiment. But we will give the income side and the winter expenses and each one can estimate for himself what the cost would be, in his own case, of carrying the ewes through the summer.

Year.	No. of Lambs Sold.	Age in Days at Date of Sale.	Live Weight.	Dressed Weight.	Selling Price per Head.	Total Selling Price.
1896	47	74	48	22	$3.30	$156.45
1897	48	76	55	26.5	3.97	192.35
1898	40	106	60	..	3.50	140.00
Total.............	135	..	..	..	....	488.80
Average..........	45	85	54	25	$3.62	$162.93

The above figures show a yearly income from fifty ewes of $162.93 for the lambs. To this should be added the rereturn for the wool. This has amounted to about 70 cents per year per head, or $35.00 for the 50 ewes. This gives a total yearly income of $197.93, or $3.96 per ewe. The ewes were sold at the end of the experiment for a little more than they cost, so there was no loss in that respect.

Here are some items that can be estimated in the expense of these ewes as follows:

The ewes were kept in the corrals and fed hay after about the first of November. As soon as the lamb was dropped grain was given to the ewe and continued until the lamb was sold. When on hay alone, the ewes ate about five pounds of hay per head per day and decreased to about four pounds when a pound of grain was added. The lambs ate a pound of hay and a pound of grain after they were 30 days old until they were sold. This makes 85 pounds of grain for each ewe and 25 pounds of grain for each lamb, or 110 pounds of grain for the ewe and lamb, costing us on an average 64 cents.

Each ewe ate 715 pounds of hay and the lamb 25 pounds or 740 pounds of hay, which at $3.00 per ton comes to $1.11 or a total cost for winter feed of $1.75. Subtracting this from the income of $3.96 leaves $2.21 as the return for the summer feed of the ewes and the labor of caring for the sheep and lambs through the winter.

These returns compare very favorably with any that can be obtained from running sheep on the range. They represent a clear profit of at least forty per cent. on the investment. Indeed so profitable is the business that if one was sure of a market at the above prices there would be thousands and tens of thousands of early lambs raised each year in Colorado. But, as stated at the beginning of this article, the local market that pays these prices is quite limited and will buy only the very best of stock. There is money in the business for a few breeders near each of the larger cities, but if many went into the business they would break the market and themselves.

RAISING EARLY LAMBS IN THE ARKANSAS VALLEY.

The Arkansas Valley in Colorado is naturally tributary to Kansas City. There are more early lambs raised in the Arkansas Valley than in all the rest of the state together and most of these lambs are marketed in Kansas City, though a few are sent west to Pueblo and Colorado Springs.

The following quotations will give an idea of how the business is carried on and what returns are expected. It can be said as a preface to what follows that the early lamb business in the Arkansas Valley is founded almost entirely on the aged ewe. The old ewes that are too weak or have too poor teeth to stand another year on the range, are brought to the farm in the fall, bred to drop their lambs early, are fed heavily during the winter and spring so that by early summer they are in excellent condition for mutton and bring considerably more than could have been gotten for them fresh from the range the preceding fall. Thus there are two sources of income, the return from the lamb and the increased value of the ewe.

WM. AND H. G. GREENE, Olney.

We raised some early lambs in 1898 that were dropped from the latter part of January to the early part of March. Our experience is that owing to the extra care and feed necessary, these early lambs are not so profitable as the later lambs.

W. A. COLT, Manzanola.

We have been quite successful both in raising early lambs and feeding sheep on alfalfa. We breed the ewes to lamb in February and usually feed the ewe well and get her at least half fattened by lambing time. After lambing we feed the ewe all the grain she can eat and provide corn chop for the lambs. We usually have a "lamb creep" into an adjoining lot where the lamb can find corn chop and bran at any time.

As soon as the alfalfa starts we turn both ewe and lamb out during the day and provide grain and hay in the lots at night. The main point is not to compel the ewe to live entirely on the green alfalfa. There is some loss from bloat with the best of management, usually two to three per cent.

We often market the ewe and lamb in the same car, usually when the lamb is about three months old. Some, however, market the lamb and keep the ewe a few weeks and then send her in. All this class of sheep business is done with the old ewes. The ewe and lamb sometimes bring as low as five dollars, while some of our best farmers have received as high as seven dollars.

W. H. NEY, Fowler.

During the months of January and February, 1898, we lambed 350 Shropshire ewes. These were all young ewes and of course harder to handle during lambing than older ewes. We saved over 100 per cent. of large strong lambs. The work was easier than it would have been to lamb in summer time on open range or pasture; the cost no more; a larger per cent. of lambs saved; better lambs and no loss in the ewes. The result has been entirely satisfactory to us and I can see no reason why anyone, properly prepared for it, cannot do equally well.

We have comfortable sheep barns with ample room for all breeding stock. We feed liberally on alfalfa with mixed grain ration of wheat and oats in sufficient quantities to keep the ewes in good condition. The lambs get grain with their mothers and appreciate it.

We have raised California Merinos and Shropshires.

The California Merinos require more care and warmer quarters than the Shropshires. The Shropshires can stand any amount of dry cold and their lambs are soon up and strong. The Merino lambs must have close attention and warm quarters, but the same attention would be necessary during the spring months and then other farm work would be crowding and prevent the expenditure of the necessary time to make a successful lambing.

When spring comes winter lambs are ready to go to the range or pasture with their mothers and will hold their own anywhere.

E. M. SMITH, on the farm of A. M. LAMBRIGHT, Las Animas.

My early lambs in 1897 sold as follows: Lambs dropped in January sold in April at Kansas City for 7c per pound, live weight, and weighed 48½ pounds or $3.40 per head. None of these lambs had any green alfalfa, but the ewes were turned onto the alfalfa after the lambs were sold. These ewes were sold in Kansas City in June, weighing 81 pounds, at $3.85 or $3.02 per head.

My March lambs sold in Kansas City in June for $4.25 per hundred pounds and weighed 61 pounds or $2.60 per head. These lambs were dropped in the corral and were fed alfalfa hay, corn chop and bran until March 26, when they and the ewes were turned onto alfalfa pasture and remained there until they were sold in June. We had 600 ewes and 590 lambs on 95 acres of alfalfa and with the addition of one-fourth pound of corn chop per day for a ewe and her lamb, they kept in fine shape. We commenced selling in June and sold until fall. The ewes were sold as soon as fat, some ewes going with each bunch of lambs. The April lambs in August weighed 71 pounds. In 1898 the feed on the range was so good that we pastured but little on alfalfa.

JOHN McNAUGHT, Las Animas.

In 1898 I lambed 200 ewes in January and sold the lambs in Kansas City in March for 8c per pound. They weighed 53 pounds or $4.24 per head. Two weeks later I sold the ewes for $4.75 per hundred pounds and as they weighed 96 pounds each they brought $4.56 per head. Neither these ewes nor lambs had any green alfalfa.

In April and May I lambed 500 ewes on alfalfa pasture. They remained there until May 26 when they were turned on the range.