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Report on the Locusts
of the San Joaquin Valley
D.W. Coquillett

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LOCUSTS OF THE SAN JOAQUIN VALLEY, CAL.
BY
D. W. COQUILLET.

[Extracted from the Report of the Entomologist, U. S. Department
of Agriculture, for 1885.]

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UNIV. OF
CALIFORNIA

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REPORT ON THE LOCUSTS OF THE SAN JOAQUIN VALLEY, CALIFORNIA.*

By D. W. COQUILLET.

ANAHEIM, LOS ANGELES COUNTY, CALIFORNIA,

September 1, 1885.

DEAR SIR: I herewith transmit to you my report upon the Locusts of the San Joaquin Valley, California.

In accordance with your telegram of the 1st of June, I proceeded to Stockton for the purpose of interviewing Mr. G. N. Milco, one of the members of the State Horticultural Commission, in order to ascertain from him what part of the San Joaquin Valley was most infested with locusts. I learned from him that they were about as numerous in the vicinity of Merced, in Merced County, as in any other part of the valley, and he invited me to pay a visit to the Buhach plantation—of which he is part owner—which is situated about 6 miles west of the village of Merced, adding that if I found the locality to be a desirable one I would be perfectly welcome to remain at the plantation for as long a time as I desired. A few minutes later I had an interview with the other proprietor of this plantation, Mr. J. D. Peters, a prominent business man of Stockton, who, upon learning my mission, also invited me to visit the Buhach plantation and remain there as long as I wished. Accordingly I proceeded at once to the above plantation, accompanied by Mr. Peters, and finding it to be a very desirable location—the locusts being very abundant, and everything necessary being offered me for the prosecution of my studies—I concluded to make this plantation my headquarters.

Already the locusts had almost wholly defoliated several collections of trees and shrubs growing around the residences in this valley, and many alfalfa and grain fields literally swarmed with them.

About the middle of June the superintendent of the Buhach plantation, Mr. G. E. Ladd, who extended me every facility in his power to aid me in studying up the locust problem in this valley, wrote to the superintendent of the Natoma vineyard, near Fol-

*The following letter of instructions will indicate the points upon which information was needed:

DEPARTMENT OF AGRICULTURE,

DIVISION OF ENTOMOLOGY,

Washington, D. C., June 1, 1885.

DEAR SIR: In accordance with my telegram and the inclosed commission, I wish you to give your time for from six to eight weeks or more, as occasion may require, to a thorough examination of the Locust troubles in California. You are doubtless familiar with the work of the United States Entomological Commission on *Caloptenus spretus*, and of course it will not be necessary that you repeat descriptions of any of the remedies there given in detail or illustrated. I wish information as to the amount of damage; as to the range; as to the source and movements both of the young and the winged; the kinds of soil in which they are hatched most abundantly, and everything pertaining to their natural history, which will of course be found very similar to that of *spretus*. Accounts, as far as possible with illustrations, of all particular measures adopted that are different from those adopted in the East; observations on enemies and parasites, and, in fact, as full a statement of the whole subject as will permit you to make a satisfactory report, to be published by the Department.

You should send on specimens properly preserved of the insect in its different stages, together with egg-pods, and particularly all parasites and other enemies found attacking it. * * *

Yours very truly,

C. V. RILEY,
Entomologist.

D. W. COQUILLET,
Anaheim, Cal.

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soni, in Sacramento County, asking him what remedies he had used for destroying the locusts, and also what success he had had with them, and received a reply stating that he had been experimenting with a mixture composed of arsenic, sugar, middlings, and water, and was of the opinion that this would prove a decided success.

About this time Messrs. George West and Thomas Minturn, two of the proprietors of the extensive orchard and vineyard of Kohler, West & Minturn, at Minturn Station, in Fresno County, paid a visit to the Natoma vineyard for the purpose of learning more about the above remedy, and were so much pleased with what they saw of its effects upon the locusts that they determined to try it upon their own orchard and vineyard at Minturn Station, and invited Mr. Ladd and myself to visit them and witness the results of the experiments. Accordingly, on the 24th of June, we proceeded to Minturn Station, and from what we there saw of the effects of this remedy, were convinced that it was a decided success.

About the 12th of July, Messrs. Milco & Peters sent to the Buhach plantation 1,000 pounds of arsenic, an equal quantity of sugar, and about 3 tons of bran, to be used in poisoning the locusts upon about 300 acres of the plantation that was planted out to fruit trees and grape-vines. Bran has been substituted for the middlings, not only on account of its being cheaper, but also from the fact that in drying after having been wet, it forms a jagged mass, which offers the locusts a chance to feed upon it; whereas middlings, in drying, being much finer than bran, forms a smooth, even mass, which gives the locusts no chance to get a bite of it. During the next two days about two-fifths of the above materials were mixed and put out upon the 300 acres mentioned above, and this was repeated about one week later. After the expiration of a week after this second batch had been put out there were at least 400 dead locusts to every living one.

I remained at the Buhach plantation until the first week in August, when, in accordance with your request for me to return to my home and write my report, I took the train for Anaheim on the 8th of August, and arrived at my destination the next day. A few days before this I paid a visit to Messrs. Milco & Peters, at Stockton, but could not prevail upon them to receive any compensation whatever for my board, &c., while at their plantation. During my stay at the plantation these gentlemen did all in their power to aid me in my studies, and Mr. Milco visited the plantation several times while I was staying there, and assisted me much.

To both of these gentlemen, and also to Mr. Ladd, the superintendent, my warmest thanks are due. To Dr. P. R. Uhler I am indebted for the determination of several species of locusts; and last, but by no means least, I am especially indebted to yourself for determinations and other help.

Respectfully yours,

D. W. COQUILLET.

Prof. C. V. RILEY,
U. S. Entomologist.

The following pages comprise a report of my observations upon the locusts of the San Joaquin Valley, California, during the months of June and July, 1885.

I was located at the Buhach plantation, which is situated about 6 miles west of the village of Merced, in Merced County. This plantation consists of about 400 acres, the greater part of which is planted out to fruit trees and grape-vines. It is situated in the midst of a great grain-growing region, and on every side of it grain fields stretch away almost as far as the eye can reach, dotted here and there by the residences of the grain-growers or of their tenants, and by the fruit and ornamental trees which usually surround these residences.

When I arrived at this plantation early in the month of June, the locusts were already in possession, but they were chiefly found in the vicinity of the Lombardy poplar trees which grew along the banks of almost every irrigating ditch upon the plantation. Already many of these trees were beginning to show evidences of the work of the locusts, the leaves presenting the appearance of having been riddled by hail-stones. Many of the grape-vines growing next to these trees were also infested by locusts, which had not only stripped many of them of their leaves, but had also gnawed off the buds and tender bark.

The locusts were confined to the trees and grape-vines growing along

the outer edges of the orchards and vineyards, but later in the season they gradually spread all over the plantation. They seemed to prefer the leaves of poplar trees and grape-vines to any others, and were especially fond of the tender bark of grape-vines. While they would eat the leaves of almost every kind of tree, shrub, and plant growing upon the plantation, yet they manifested an evident preference for certain kinds. The leaves of peach trees were not much relished by them, but the fruit was eagerly eaten, and upon bearing peach trees that had been much infested by the locusts it was no uncommon sight to see nothing but the leaves and naked pits remaining. Fig and pomegranate trees suffered but little from their attack, as did also gum and evergreen trees. I saw a small, barrel-shaped cactus which had its inside eaten out by the locusts.

Plants covered with sacking did not escape the attacks of the locusts, which gnawed holes into the sacking and then entered and devoured the leaves of the inclosed plant. One lady sought to save a favorite plant by turning a washtub over it, but upon removing the tub a few days later she found that the leaves had been entirely stripped from the plant.

Fields of alfalfa suffered very severely from the attack of the locusts; the latter were also very destructive to beans, cabbage, and tomatoes, but corn, melon, and pumpkin vines were not much injured by them.

The pyrethrum plants—from the flowers of which the insect powder known as "Buhach" is produced—were not much injured by the locusts. In places where the plants had been considerably eaten I found many locusts which acted very much as those do that have been sprayed with a solution of buhach and water; they had completely lost the use of their legs and were lying upon the ground in a very helpless condition, occasionally jerking a leg or moving a foot. Several of them were dead, evidently having partaken too freely of the leaves of the pyrethrum plants, as no poison had been put out up to this time.

Wheat fields, as a rule, were but little injured by the locusts, the principal injury being done by biting off a small proportion of the heads and allowing them to fall upon the ground. Late-sown wheat suffered the most, and several fields were injured to such an extent that they were not harvested.

Rye fields were generally much injured by the locusts, which devoured the exposed kernels in the heads; I have examined many heads of rye in which every kernel had been devoured. Mr. D. W. Swain estimated that he had lost fully one third of his crop of rye on 600 acres through the attacks of locusts. The reason that they were more destructive to rye than to either wheat or barley is to be found in the fact that the kernels of wheat and barley are wholly inclosed in a husk, whereas the kernels of rye are exposed to view.

SPECIES OF LOCUSTS MOST DESTRUCTIVE.

I captured in the San Joaquin Valley no less than twenty different species of locusts belonging to the subfamilies *Acridinæ* and *Edipodinæ*, but the principal damage was committed by four species, three of which belonged to the *Acridinæ* or Spine-breasted Locusts.

The species which appeared in the greatest numbers was the Devastating Locust (*Melanoplus devastator* Scudder), which outnumbered all of the other species combined, in the proportion of at least seven to one. It was accompanied by the Ash-colored Locust (*Melanoplus cinereus*

Scudder) which was about one-twentieth as abundant as the former species. These two species were the ones that were the most destructive to the larger fruit and ornamental trees, and they are the only ones that I saw feeding upon the ripe kernels of rye in the fields.

During the hottest part of the day they would sometimes take to their wings and fly to a distance of from 50 to 100 yards at a time. All of them would not start up at once, but one would start up here, another there, and so on, each apparently going entirely independent of the others. When the weather was perfectly calm they would fly in every direction, but whenever there was a gentle breeze blowing they would fly against it; they would not attempt to fly when the wind was blowing hard.

Sometimes when there was a perfect calm one would start up and fly a short distance, when, the breeze starting up, he would turn and fly against it; but when it would begin to blow quite hard he would again turn about and fly with the wind for a short distance and then alight.

In these migrations, if one of the locusts were to fly against a tall tree he would alight there and remain for some time, but if he missed the tree he would continue his flight sometimes until lost to view; at other times he would gradually approach the earth and finally alight, either upon the bare earth or upon any plant, shrub, tree, or other object that chanced to be in his way.

These locusts do not seem to be able to fly in any direction that they may choose, nor to alight in any particular place, alighting as often in the water or upon the bare ground as upon plants. In migrating from the fields to a collection of trees of any kind a very few of them will alight in the trees, but the greater number will drop upon the ground and afterward crawl to a tree and ascend its trunk.

The Ash-colored Locust (*M. cinereus*) flies with greater ease than the Devastating Locust (*M. devastator*). Both species fly in a nearly straight line, and at a distance ranging all the way from 5 to 20 feet from the ground.

These migrations were not always performed for the purpose of obtaining food, as I have frequently seen the locusts start out of poplar trees that as yet had not been much injured by them, of the leaves of which they are very fond. I have also seen them fly out of wheat-fields that had not as yet been harvested, and out of low, waste places that were covered with a rank growth of green weeds.

WHERE DID THESE LOCUSTS HATCH?

As the wind in the San Joaquin valley during the summer season usually blows from the southwest, so the course of the locusts would, in most cases, be directed to the southwest, since they invariably fly against the wind.

Several persons who had visited the foot-hills lying on the east side of this valley early in the season stated to me that the locusts were much more abundant there than they have been in the valley, and that they appeared there much earlier in the season than they did in the valley. These persons were nearly always of the opinion that the locusts which devastated the valley hatched out in the foot-hills, and that as soon as the feed on the foot-hills began to fail, the locusts migrated to the valley; but I arrived too late in the season to definitely settle this question, as the locusts were already very numerous in the valley when I arrived there early in June. I am strongly of the opinion; however, that the greater number of the locusts which appeared

in this valley the present season were produced from eggs that had been deposited here during the preceding autumn.

As above stated, when I arrived at the Buhach plantation the locusts were most abundant along the outer edges of the orchards and vineyards, while the more central parts were almost wholly free from them. Now, if the locusts had migrated to this plantation, would they not have been found as often in the center of the orchards and vineyards as along the outer edges? But if the locusts had hatched out upon the plantation we should expect to find them the most numerous in the vicinity of uncultivated land, where the eggs would not have been disturbed by the plow and cultivator; and this was exactly the situation where they were the most numerous—in the vicinity of the uncultivated land along the outer edges of the orchards and vineyards. Had the eggs been deposited last autumn in the more central parts of the orchards and vineyards, the subsequent cultivating of these would have destroyed the eggs, so that no locusts would have hatched out in such situations; and none were found there.

Moreover, I found upon the uncultivated land referred to above quite a number of young locusts, which were evidently the young of the Devastating Locust (*M. devastator*), since, in their markings, they approach that species more closely than they do any other of the Spine-breasted Locusts which inhabit the San Joaquin Valley. The following is a description of these young locusts, drawn from fresh specimens:

Head, ashen-gray, whitish below each eye. Thorax, ashen-brown; two dark-brownish subdorsal stripes, one on each side, and below each is a whitish line, then a dark spot bordered below by a whitish line. Abdomen, ashen-pink, mottled with dark brown. Venter, whitish, unmarked. Legs, ashen-yellow; hind femora with a longitudinal black stripe on the outer side, interrupted at the middle of the femur and sub-interrupted at the first one-fourth; upper side of hind femora marked with three black spots, the first at one-fifth, the second at two-fifths, and the third at two-thirds the length of each hind femur from its base, the first spot sometimes wanting, the second and third spots extending slightly upon the inner side of each hind femur before the tip. There is a blunt spine between the front legs.

In all of these characters the agreement with the adult Devastating Locust is very close. There are only three species of Spine-breasted Locusts inhabiting the San Joaquin Valley which approach this species very closely in their markings; and from each of these both the adult Devastating Locust and the young locusts above described differ as follows:

Melanoplus cinereus Scudder (the Ash-colored Locust), has no black spots on the hind femora.

Melanoplus sp. (probably only a variety of *devastator*) has no distinct black subdorsal stripes on the thorax.

Paroxya sp. (near *atlantica* Scudd.) has the subdorsal stripes of the thorax well defined, not interrupted, and of nearly the same width throughout their entire length, while in the adult Devastating Locust and the young ones above described these stripes taper posteriorly, are not well defined, and are generally interrupted.

These young ones quite closely resemble those of the Differential Locust (*Caloptenus differentialis* Thomas), but differ in having no black dots on the groove on the under side of each hind femur.

It seems quite evident, therefore, that the young locusts above described are those of the Devastating Locust, the species which committed the most extensive depredations in the San Joaquin Valley the present season; and if they were the young of that species, then the latter breeds in the San Joaquin Valley, since it would have been quite impossible for these young ones—many of which were not more than one-

fourth grown—to have found their way to the Buhach plantation from the foot-hills, a distance of from 15 to 20 miles.

When I first arrived in the valley, the Devastating and Ash-colored Locusts were most numerous in those grain fields that had not been plowed for a year or more, that is, in fields of what is commonly called "volunteer" grain, *i. e.*, self-seeded. Some of the locusts remained in these fields for two weeks after the grain had been harvested; by the latter part of July scarcely a single specimen of either the Devastating Locust or the Ash-colored Locust could be found in these fields, but the low waste places, which were quite numerous in and near all of the grain fields, and which were covered with a rank growth of green weeds, were infested with immense numbers of these locusts, which doubtless will breed in these situations.

These waste places are covered with water during the latter part of the winter season, and sometimes until late in the summer. When the proper time for putting in the seed arrives they are too wet to be plowed and seeded, and are therefore allowed to remain undisturbed from year to year. The green weeds which these waste places contain late in the season, when the surrounding fields contain nothing green, furnish food to the locusts until their egg-laying season arrives, when they will doubtless deposit their eggs in these waste places; and as these eggs do not hatch until the following spring, they must be covered with water for a period of two or three months. This would not necessarily destroy their vitality unless they were covered by the water for too long a time, since Professor Riley has ascertained that the eggs of the Rocky Mountain Locust (*Caloptenus spretus*, Uhler) were not affected by being submerged in water for three months during the winter and early spring.*

CAUSE OF THE ABUNDANCE OF THE DEVASTATING LOCUST IN THE SAN JOAQUIN VALLEY DURING THE SUMMER OF 1885.

If, as we have supposed above and have every reason to believe to be a fact, the Devastating Locusts deposit their eggs in these waste places, we see that in ordinary seasons these locusts will not appear in sufficient numbers to attract attention, since the water will be removed, by evaporation or otherwise, from the more elevated portions of these waste places first, and therefore the eggs which have been deposited in those elevated places will be the first to hatch out, followed by those that had been deposited in less elevated places, and so on. It follows that those hatched out the earliest will be the first to acquire wings and migrate to the adjacent fields, followed after a certain time by those hatched out next, and so on. By coming into the fields so gradually and spreading over so large an area of land, their presence will scarcely be noticed. It is also quite certain that many of the eggs are destroyed by being too long covered by the water, since, in ordinary seasons, several of these waste places contain water until quite late in the summer.

Thus it happens that in ordinary seasons the locusts never appear in sufficient numbers to attract attention.

Last winter, however, but little rain fell, and, as a natural consequence, what little water was collected in the waste places soon evaporated, leaving these places perfectly dry for some time before the time for the locust eggs to hatch out had arrived; consequently, when the time for these eggs to hatch out did arrive, they all hatched out within a short time of each other, and as they would all acquire wings and mi-

* See the First Annual Report of the U. S. Entomological Commission, pp. 359, 360.

grate to the adjacent fields nearly at the same time, their coming all at once, or within a short time of each other, would very naturally attract attention. Moreover, it is very evident that they appeared in greater numbers the present season than they do in ordinary seasons, since none of their eggs were destroyed by being covered with water for too long a time.

As stated above, the locusts left the grain fields this season a few weeks after the latter had been harvested, there being no green food for them to obtain in these fields; but it is quite probable that, as last season was a very wet one, there may have been green weeds in the grain fields as late in the season as the locusts deposit their eggs, and if such was in reality the case, then we may suppose that many of the locusts deposited their eggs in the fields last autumn. This would account for the fact that the locusts were most numerous the present season on those fields which had not been plowed for over one year.

From the above facts it would appear that whenever there is a very dry winter and spring in the San Joaquin Valley there will be an abundance of locusts in that valley during the following summer; but when there is an abundance of rain during the winter and spring months there will not be an unusual number of locusts during the following summer.

In the latter part of July I saw several pairs of the Ash-colored Locust (*M. cinereus*) united in coition, but up to the time that I left this valley—the first week in August—I did not see a single pair of the Devastating Locust thus united.

THE DIFFERENTIAL LOCUST.

The Differential Locust (*Caloptenus differentialis* Thomas) was only about one twenty-fifth as numerous as the Devastating Locust. These two species and the Ash-colored Locust were the only Spine-breasted Locusts that appeared in destructive numbers in the San Joaquin Valley the present season. The only other species of Spine-breasted Locusts that I took in that valley are the *Acridium shoshone* Thomas; the *Hesperotettix viridis* (Thomas), and the *Paroxya* (near *atlantica* Sc.).

When I first came to this valley, early in June, the Differential Locust was mostly in the wingless state, there being only about one winged specimen to ten wingless ones; by the last week in July the greater number of them had acquired wings. On the 23d of June I saw the first pair united in coition, but the majority of them did not pair until about three weeks later. After coition, and before the eggs are deposited, the abdomen of the female increases very much in size.

The first egg-mass which I saw this species deposit was deposited on the 23d of July. The location chosen was a shaded place on the north side of a row of trees and in a sandy soil. A basin-like hole had been dug in the ground at the base of an ornamental tree, and had been filled with water a day or so previously, for the purpose of irrigating the tree. The female locust had worked her abdomen into the ground on the outer edge of this basin. I first discovered her in this position at about 3 o'clock in the afternoon, and at 15 minutes past 4 o'clock she had completed depositing an egg-mass and walked away.

This egg mass is about three-fourths of an inch long, slightly curved, and a little less in diameter than an ordinary lead pencil. The space between the uppermost eggs and the surface of the surrounding earth was filled in with a frothy matter. When freshly deposited the egg-mass is of a pale bluish color.

On several succeeding days I saw many females of this species deposit their eggs, and in nearly every instance the situation chosen for this purpose was the edge of one of the basin-like hollows at the base of a tree.

I saw several of the females make numerous attempts to sink their abdomens into the earth upon a hard beaten walk, but always without meeting with success. They do not appear to have the power to penetrate hard substances that is possessed by some locusts. Upon one occasion I saw a female *Chloëaltis conspersa* (Harris), that had excavated a hole in the bark of a burr-oak log by means of the horny plates at the tip of her abdomen; when found by me she had reached a depth equal to about one-half the length of her abdomen. This occurred in Northern Illinois.

The Differential Locust is not so easily startled as the Devastating Locust is, and its flight is heavier and sustained for only a short distance, seldom flying more than 12 or 14 feet at a time. It does not perform those migrations indulged in by the Devastating and Ash-colored Locusts, seldom taking to its wings except when disturbed.

It was principally found in trees, being especially partial to the leaves of poplar trees. I did not find it in the grain fields, and it occurred only in limited numbers in the low, waste places, overgrown with weeds. It was very numerous in alfalfa fields, where it probably breeds, as young ones of all sizes were very numerous in these fields.

THE YELLOW LOCUST.

The only species of Spineless-breasted Locusts (*Edipodinae*) that appeared in destructive numbers in the San Joaquin Valley the present season was the Yellow Locust (*Trimerotropis pseudofasciata* Scudder), which was only about one-twentieth as abundant as the Devastating Locust. When I first came to the valley early in June, this species was most numerous in grain fields, but after these had been harvested it migrated to new pastures. In many places it was very destructive to the leaves of grape-vines and low trees, but it was very seldom found in large trees.

The flight of the Yellow Locust is more undulating than that of the Devastating Locust, and is sometimes continued for long distances at a time. They do not always fly in one direction, against the wind, as the last-named species almost invariably does, but fly in almost every direction. They do not all start at once, but one will start up here, another there, and so on, each apparently going entirely independent of the others.

Their flight is sometimes accompanied by a crackling sound, but they appear to produce this sound at their pleasure while on the wing. Several other species of Spineless-breasted Locusts (*Edipodinae*) can also produce this sound while on the wing, but I am not acquainted with a single species of Spine-breasted Locust (*Aceridinae*) that ever produces a similar sound.

The Yellow Locusts are more frequently found resting upon the bare ground than in any other situation, but during the hottest part of the day they seek the shade of low weeds, grape-vines, small trees, &c., which they usually ascend, but never, or very seldom, go very high. I have frequently seen them feed upon dry leaves, and they seem to prefer feeding upon these on the ground to climbing after the green ones.

I have also seen them feed upon a locust that had but recently died; they would usually begin upon the side of the thorax next to the head,

and eat away the whole side and internal parts of the thorax, sometimes also devouring the greater part of the abdomen. This cannibalistic habit seems to be indulged in by all the different species of locusts that inhabit this valley.

I saw several pairs of Yellow Locusts united in coition in the latter part of June, but did not succeed in obtaining any eggs, although I frequently saw a female that had her abdomen sunken its whole length into the loose sand in the grain fields; after she had withdrawn her abdomen and walked away, I carefully dug up the earth in the place where her abdomen had been thrust into the sand, but never succeeded in obtaining the eggs. As the situation chosen by these females was in the open fields where it was impossible to watch their movements unobserved by them, it is quite likely that my presence frightened or otherwise disturbed them to such an extent that they would not deposit their eggs so long as I was within view of them. So long as I remained hidden from view, the female Differential Locust would continue depositing her eggs, that is, when I discovered her in the act of depositing eggs some distance off, and my presence was unknown to her; but, when I came upon her unawares and she saw me, it mattered not how quickly and carefully I withdrew myself from her sight, she always refused to deposit any eggs, after a certain time withdrawing her abdomen and walking away. Hence I believe that no female locust will deposit her eggs when she is aware of the presence of any person.

OTHER SPECIES OF LOCUSTS.

I captured eighteen different species of locusts in the San Joaquin Valley during the two months that I remained in that valley. In order to show the comparative abundance of each of these species, I subjoin herewith a list of those determined, with numbers attached showing the numbers in which the locusts of each species appeared as compared with those of any of the other species. Thus, the first species is represented by the number 1 and the second species by the number 4, indicating that there were four specimens of the latter species to every one of the former, and so on throughout the list:

<i>Psoloessa texana</i> Scudder	1
<i>Hesperotettix viridis</i> Thomas	4
<i>Conozoa wallula</i> Scudder	6
<i>Camnula pellucida</i> Scudder	8
<i>Acridium shoshone</i> Thomas	10
<i>Dissosteira venusta</i> Stål	10
<i>Trimerotropis vinctulata</i> Scudder	20
<i>Trimerotropis</i> sp. ?	40
<i>Trimerotropis</i> sp. ?	50
<i>Melanoplus</i> probable var. of <i>devastator</i>	50
<i>Paroxya near atlantica</i>	50
<i>Trimerotropis</i> sp. ?	75
<i>Dissosteira spurcata</i> Saussure	100
<i>Caloptenus differentialis</i> Thomas	750
<i>Melanoplus cinereus</i> Scudder	1,000
<i>Trimerotropis pseudofasciata</i> Scudder	1,000
<i>Melanoplus devastator</i> Scudder	20,000

INJURY COMMITTED BY THE LOCUSTS.

It is very difficult to give any idea of the injury committed by the locusts in the San Joaquin Valley the present season. A majority of the trees and grape-vines that had been defoliated by them, put forth a new growth of leaves in the course of three or four weeks from the

buds that ordinarily would not have developed until the following season; in these cases the only injury sustained through the attacks of the locusts was a partial arrest of the growth of the trees and vines, and in many cases a loss of the fruit upon fruit-trees and grape-vines in bearing.

Grape-vines that had been stripped of their leaves, buds, and much of their bark, sent out new shoots from the base of the vines, the denuded part dying back as far as the buds and bark had been removed. In cases where the bark had been removed but the buds had not been injured, these buds developed a new set of leaves, and a new bark seemed to be forming in those places where the old bark had been removed.

Several vineyardists plowed under their young vines to save them from receiving further injury from the attacks of the locusts, and also to prevent them from drying out, and the majority of the vines treated in this manner, in the course of three or four weeks, sent up a new growth through the thin covering of earth that had been thrown upon them by the plow.

The devastations committed by the locusts in the grain fields and vegetable gardens were in most cases irreparable. Alfalfa fields were in most cases kept eaten down so closely by the locusts that not a single crop of hay was gathered from them.

NATURAL ENEMIES.

Besides several kinds of domestic animals, such as hogs, dogs, cats, chickens, ducks, turkeys, &c., I have also seen several kinds of wild animals, birds, and insects preying upon the locusts. Among these is a large, ground-lizard, or *swift*, as it is commonly called, which I have twice seen catch a locust in its mouth, springing upon it somewhat as a cat would spring upon a mouse. I have also seen the following birds feeding upon locusts: Bullock's oriole (*Icterus bullockii*), a sparrow resembling the Eastern Song sparrow (*Melospiza melodia*), and a larger sparrow having a patch of red feathers on the head.

Among insects I saw two different species of wasps preying upon the locusts. The most common species is the *Priononyx atrata*. When a locust takes to its wings one of these wasps will pounce upon it, seize it in her legs and bear it to the ground, after which she thrusts her sting into it; the part of the locust into which the sting is thrust is the under side of the thorax, between the insertion of the first two pairs of legs. Soon after being stung the locust becomes motionless, when the wasp gets astride of it, seizes its antennæ with her jaws, and drags the locust to her burrow, the body of the locust being under and directed in the same direction as that of its captor, three of the wasp's legs being on one side of the locust and three on the other. The wasp leaves the locust at short intervals for the purpose of finding her burrow, after which she returns to it again and drags it a short distance farther in the direction of her burrow.

I have seen upwards of two dozen of these wasps thus dragging locusts to their burrows, which are always made in loose, sandy soil, and in every instance the victim was a Devastating Locust. How and why they always select this species for their victims is a mystery, since there were always three or four other species of locusts of the same size and nearly of the same color—among which may be mentioned the Ash-colored Locust—always associated with them; still I never saw them attacking any other species than the Devastating Locust.

After dragging the locust into her burrow the wasp stations herself

in front of the latter, her head directed from it, and then with her front feet she throws the dirt into her burrow, occasionally going into the latter apparently for the purpose of scratching the dirt into the farthest end of it, soon to return and resume the filling-up process; in this way she continues until the burrow is filled up and not a trace of its existence is to be seen.

In digging her burrow the wasp frequently uses her strong jaws, but in filling it up she uses her feet almost altogether, standing upon her two hind pairs of feet and scratching with her front ones somewhat as a dog would; all of her movements are very rapid.

I saw a single specimen of another species of wasp dragging a Devastating Locust to her burrow; she dragged the locust into her burrow in the same manner that the *Priononyx atrata* did, as described above.

I also saw a single specimen of the *Sphex rufiventris* dragging a wingless cricket (*Anabrus* sp.) to her burrow in a similar manner. During the fore part of July I saw several pairs of these *Sphex* wasps united in coition in the dooryard of the Buhach plantation, while many of them were lying upon the ground dead; these latter I judged were males which had died after coition had taken place.

On the 20th of July I found three red mites attached to the under side of the breast of a *Trimerotropis* sp., a Spineless-breasted Locust having the hind wings bluish at the base. These mites were in shape like an inverted tea-cup, and were doubtless the young *Trombidium locustarum*; but unfortunately they escaped before a careful examination of them could be made, and I did not succeed in obtaining any additional specimens.

On the 6th of July a dipterous larva, about 9 millimeters long, issued from an oval hole in the side of the thorax next the head of a *Dissosteira spurcata* which I had inclosed in my cyanide bottle; this larva died before pupating, having been killed by the cyanide, as it was not discovered by me until an hour or more had elapsed after I placed the locust in the bottle.

This was the only specimen of this parasite that I obtained, although I dissected many hundred locusts in search of additional specimens, but without meeting with success.

In a paper on the North American *Conopidae*, which appeared in the Transactions of the Connecticut Academy of Natural Sciences, for the month of March, 1885 (vol. vi, p. 389), Dr. S. W. Williston, quoting from Brauer, states that *Conops* is sometimes parasitic upon *Ædipoda* (a genus of Spineless-breasted Locusts). The only species of *Conops* that I have taken in the San Joaquin Valley is the *Physocephala affinis*, Williston; and the Dipterous larva mentioned above may have belonged to this species.

REMEDIES.

As soon as the locusts began to appear in destructive numbers upon the Buhach plantation, the superintendent, Mr. G. E. Ladd, tried a great many means of destroying them.

Adjoining this plantation on the west is an alfalfa field that literally swarmed with locusts; many of them found their way to the adjacent trees upon the Buhach plantation, and to intercept them Mr. Ladd placed a windrow of dry pyrethrum stems between this alfalfa field and the nearest row of trees upon the plantation. In the evening many of the locusts would crawl into this windrow for the purpose of spending the night therein, and late at night the windrow was set on fire; in this

way a great many of the locusts were destroyed, but a great many more passed over the windrow into the adjacent trees.

This alfalfa field was rolled late in the evening with a heavy wooden roller, but this did not kill very many of the locusts, although the ground was quite level, but sandy. I have repeatedly stepped squarely upon a locust on loose, sandy soil, without injuring the locust in the slightest degree, so far as I could discover.

A small patch of alfalfa that was thickly infested with locusts was sprayed with a solution composed of 1 part of the kerosene emulsion (2 gallons kerosene, 1 gallon water, and one-half pound of soap) diluted with 4 parts of water, but the locusts were not killed by it. Locusts immersed in the undiluted emulsion died a few minutes afterwards.

Mr. G. N. Milco, one of the proprietors of the Buhach plantation, tried the experiment of driving the locusts out of a small vegetable garden by burning some flowers of sulphur on the windward side of the garden, but the locusts were not visibly affected by it. Several other persons also tried this remedy, but always with a like result.

This remedy might prove effectual in localities where the air is so damp and heavy as to keep the smoke near the ground, but in a climate where the air is so light as it is in the San Joaquin Valley in the summer time it will avail nothing, as the smoke rises rapidly in the air and thus is not brought in contact with the locusts upon the surrounding vegetation.

A. R. Frank Smith, whose farm adjoins the Buhach plantation on the west, had a trough of zinc constructed, the dimensions of which were about as follows: Length, 6 feet; width, 2 feet; depth, 18 inches. This was mounted on runners, and late in the evening it was drawn by a horse through the orchard; the bottom of the trough was covered to the depth of 5 or 6 inches with strong soap-suds.

In operating it, the trough was drawn beneath a tree infested with locusts; the tree was then struck with a heavy stick that had been wrapped in several thicknesses of cloth to prevent bruising the tree; by this operation many of the locusts were dislodged from the tree and fell into the soap-suds in the trough, and after a certain quantity of them had been thus collected they were transferred into grain-sacks and afterwards beaten to death with a heavy club. In this manner a great many of the locusts were destroyed.

This plan would have been more effectual had there been two troughs instead of only one, so that there could have been a trough placed on each side of the tree. The best results were obtained when it was operated very late at night, when the locusts were somewhat stupefied by the cold.

A remedy that has been very successful in destroying locusts consists of a certain proportion of bran, arsenic, sugar, and water; these have been used in different proportions, but the one that appears to give the best results consists of 1 part by weight of arsenic, 1 of sugar, and 6 of bran, to which is added a sufficient quantity of water to make a wet mash.

This preparation is usually prepared in wash-tubs or half-barrels. One of these is filled about three-fourths full of dry bran, and to this is added about 5 pounds of arsenic, which is thoroughly stirred through the bran with a spade or shovel. Five pounds of sugar is next thrown into a pail, which is then filled with water and the sugar stirred until it is dissolved, when this sugar-water is added to the bran and arsenic and the three well stirred; more water is added and the stirring continued until every portion of the mash becomes thoroughly saturated.

About a teaspoonful of this mash is placed at the root of each tree, shrub, or plant infested with locusts, dropping it in the shade when this can be done. In the case of low shrubs or plants nothing more need be done, as the locusts will find their way to the poison, but when large trees are treated the locusts should be jarred out of them, or be driven out with long poles.

I have known locusts to be killed by eating some of this mash that had been put out over a week previously. The poison works very slowly, and when put out early in the morning will show but little effect upon the locusts until quite late in the day. A Devastating Locust that I saw eating the mash at 9 o'clock in the forenoon was still alive at 6 in the evening, but was dead when next examined early the next morning.

Allowing a teaspoonful of this mash to each grape-vine in the vineyard—the vines being 7 or 8 feet apart—this will require about 10 pounds of the dry bran (and arsenic and sugar in proportion) to each acre. The cost of the material will vary, but should not exceed 50 cents for each acre of grape-vines, including cost of labor for mixing and applying it. For orchards the cost will be much less than this.

The addition of sugar to this mash is merely for the purpose of causing the arsenic to adhere to the particles of bran, and not for the purpose of increasing its attractiveness, since bran is more attractive to the locusts than sugar. This I have demonstrated to my own satisfaction. A quantity of sugar was placed upon the ground contiguous to an equal quantity of bran mash; when a locust came to the sugar he would eat a little of it, move on a short distance and again take a few bites of the sugar, and continue in this manner until he reached the mash, when he would settle down, eat his fill, and then move off. The locusts which came to the mash before reaching the sugar would, almost without exception, eat their fill of the mash and then walk away, but occasionally one would leave the mash and take a few bites of the sugar, only to return to the mash again. None of them ate their fill of the sugar, but always manifested an evident preference for the mash.

This mash was used upon about 300 acres of orchard and vineyard on the Buhach plantation, and about two weeks later scarcely a living locust was to be seen where they could have been counted by the hundred or even thousands before the poison had been applied, the ground in many places being literally covered with the dead bodies of the slain.

Several other parties also used this poisonous mash, and so far as I was able to learn, it gave entire satisfaction in every instance.

By exercising only ordinary precautions there need be no fear of endangering the lives of either man or any of the domestic animals in using this poisonous preparation. It should be mixed in a close room to prevent the arsenic from being blown about by the wind. There is no need of touching the arsenic or the mixture with the hands, as the mixing and distributing is accomplished by means of spades, shovels, wooden paddles, &c.

Of course this mixture should not be put out in places where poultry or any of the domestic animals can gain access to it. Upon the Buhach plantation were four greyhounds and several cats that were allowed to roam about the plantation where this mixture had been put out for the locusts; still at the time that I left the plantation—about four weeks after the poisonous mixture had been put out—not one of them had been killed either by eating of the mixture itself, or of the locusts that had been poisoned by it.

There were also several barnyard fowls upon this plantation, but not one of them was poisoned from having eaten locusts that may have

found their way to the poultry range after having eaten of the poisonous mixture. Mr. Boynton, whose farm adjoins the Buhach plantation on the west, stated to me that many of the locusts which had eaten of the poisonous mixture would fall into an irrigating ditch that flowed through his poultry yard, and many of the locusts were thus carried within the reach of his fowls; still he was not aware that any of the latter had died from the effects of having eaten of the poisoned locusts.

In fact, I did not learn of a single instance where this mixture had caused the death of any person, nor of any domestic animal, although it was used very extensively in many parts of the San Joaquin Valley. Neither were the birds killed in any considerable numbers from having eaten either of the mixture itself or of the locusts that had been poisoned by it. During the four weeks following the putting out of this mixture upon about 300 acres of the Buhach plantation, I found only about half a dozen dead birds that had evidently met their death through the agency of this mixture; these consisted of three or four meadow larks, a bee-bird, and a field sparrow.

Rabbits and hares, or "jack-rabbits," as they are commonly called, were destroyed in large numbers by this mixture. After the greater numbers of locusts upon the Buhach plantation had been destroyed the work of extermination was carried into a large patch of wild sunflowers adjoining the plantation on the north, and as one of the results, at least two dozen hares paid the penalty with their lives.

The four greyhounds belonging to the plantation were among these poisoned hares almost every day; still I never saw one of them attempt to feed upon the poisoned hares; certain it is that not one of them met his death from this cause.

As the mixture is saturated with water before it is put among the plants infested with locusts, there is no danger of its being blown about by the wind; and there is also very little danger of its being deposited upon the fruit by the feet of birds and insects that may have alighted upon the mixture and afterwards flown to and alighted upon the fruit. As the mixture becomes dry its particles adhere together, forming a solid mass which could not be blown about by the wind.

I have never seen this poisonous mixture used in grain fields, but know of no reason why it would not prove very effectual in such fields. Great care should be exercised in using it in alfalfa fields, but if it were placed upon small pieces of boards it could doubtless be used with entire safety in such fields; but of course it would not be safe to pasture any animal in such fields, even after the poison had been removed.

Where it is desired to destroy locusts infesting trees or shrubs in places where it would not be safe to use the poisonous mixture described above, this can be accomplished by placing blankets upon the ground beneath the tree or shrub and spraying the latter with a solution composed of 1 pound of buhach thoroughly stirred in 10 gallons of water. This solution will be more effectual if 2 or 3 pounds of glucose is added to it, first dissolving the glucose in hot water; the addition of the glucose is for the purpose of causing the solution to adhere more firmly to the bodies of the locusts, while its presence does not appear to have an injurious effect upon the leaves of such trees as the Carolina Poplar.

The best time for applying this solution is late at night, and the stiller the night the more effect the solution will have upon the locusts. In a few minutes after it is applied the locusts will begin to drop down upon the blanket placed under the tree, and in the course of half an hour all of the locusts that have been touched by the solution will be lying upon the blanket in a perfectly helpless condition, when they can easily be

destroyed. One way of accomplishing this is to gather the locusts in a pile, cover the latter with straw and then set fire to it; or they may be collected in grain sacks and immersed in scalding-hot water until life is extinct, after which they may be fed to hogs or to poultry.

One of the best nozzles that I have ever used for spraying this solution is the "Cyclone" nozzle, originally introduced by the Department of Agriculture. It throws a very fine spray, and by its use the upper as well as the under surface of the leaves can be directly sprayed—an object that could not be attained in using the old "San José" nozzle, which threw a spray from its *end* instead of from one of its *sides*.

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