The first, which has been mentioned above in connection with that of the Canvasback, was a mere burrow in the side of the musk-rat house, without any downy lining whatever, and only a few inches above the water level. On May 31 it contained ten eggs, on June 8, eleven, two of which were Canvasback's or Redhead's; and on June 30 all but two Ruddy's and one other egg had hatched, although one duckling had died while hatching.

Meanwhile on June 8, the Canvasback's nest was found on the opposite side of the musk-rat house and about four feet from it; and a new Ruddy's nest containing three fresh eggs was found on top of the house, and about midway between the other two nests and somewhat higher up. This was a mere unlined depression in the litter composing the house, entirely without concealment of any kind, and the great snowy white eggs could be seen from a distance of many yards. On June 22 the nest contained eight eggs, and on June 30 the set had not yet hatched.

The third nest, found June 15, 1907, hardly deserved the dignity of the term. It was merely a depression formed by trampling a tuft of tender marsh grass down to form a flimsy platform just at water level in a dense cat-tail swamp between two small lakes. When found it was over about two inches of water, and the under sides of the eleven fresh eggs were wet. A week later the water in the swamp had risen slightly and the nest was deserted. This was about ten yards from the nest containing thirteen Redhead's eggs mentioned above, and three of the eleven eggs it contained were indistinguishable from eggs in the Redhead's nest.

In all our visits to these three nests we did not see the birds leave a single time, although they sometimes swam about in front of us, some distance out on the lake. The apparent indifference of the brooding Redheads, Ruddys and Canvasbacks was in marked contrast to the devotion of the Teal and Pintails to their nests; and is very difficult to understand when the characteristic timidity of the last named species during the migration period is taken into consideration.

THE RELATION OF BIRDS TO AN INSECT OUTBREAK IN NORTHERN CALIFORNIA DURING THE SPRING AND SUMMER OF 1911*

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WITH FOUR PHOTOS BY THE AUTHOR

AS THE study of the economic relation of birds becomes more and more important, any information as to their use as checks in an outbreak of injurious insects furnishes data of pertinent value. If it can be proved that birds flock to places where insects are abundant or even that the resident birds feed largely on those at any time most obtainable, their service as checks on outbreaks of injurious insects will be established.

Professor S. A. Forbes in 1883 made a study of the relation of birds to an outbreak of cankerworms in an apple orchard in Illinois. The orchard was visited for two successive seasons and a number of the different species of birds present

* This paper is a report of work done in connection with the investigation into the food habits of California birds in their relation to agriculture. This investigation is being carried on by the California State Board of Fish and Game Commissioners, and the present report is published with their permission.

were collected. It was found that "birds of the most varied character and habits, migrant and resident, of all sizes from the tiny wren to the blue jay, birds of the forest, garden, and meadow, those of arboreal and those of terrestrial habits, were certainly either attracted or detained here by the bountiful supply of insect food and were feeding freely upon the species most abundant. That thirty-five percent of the food of the birds congregated here should have consisted of a single species of insect is a fact so extraordinary that its meaning cannot be mistaken." Professor Forbes also found that the same percentage of other caterpillars had been eaten by the birds in the orchard as had been eaten by birds taken in other localities and that the cankerworm ratios had apparently been added to those of other caterpillars.

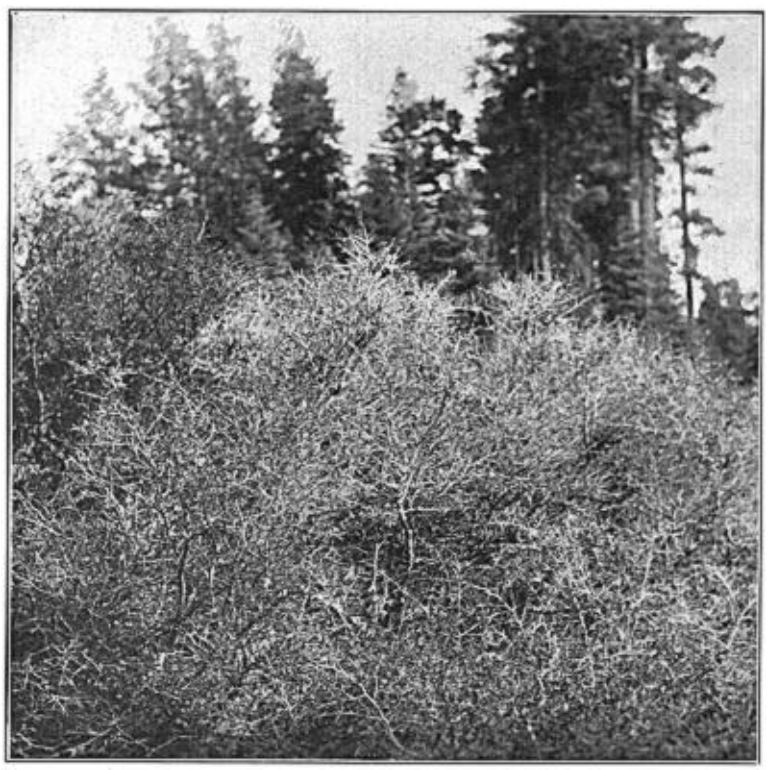

Fig. 67. DEFOLIATED SNOW BRUSH (*Ceanothus cordulatus*), THE RESULT OF THE WORK OF THE LARVAE OF *Eugonia californica*. PHOTOGRAPH TAKEN NEAR SISSON, SISKIYOU COUNTY, CALIFORNIA, AUGUST 24, 1911

The most prolonged series of studies of the relation of birds to insect outbreaks was that by Professor Samuel Aughey, who for thirteen years studied the extent to which birds fed on the Rocky Mountain locust or grasshopper during the periodic outbreaks of that insect. His tabulated results show that birds of every description from the pelican to the tiny hummingbird fed to a very large extent on the grasshoppers.

The relation of birds to the army worm, which is one of the best known of the periodical pests, has received some investigation at the hands of the economic ornithologist. Professor B. H. Warren, the state zoologist of Pennsylvania, mak-

ing a careful investigation, found that a large proportion of the common birds fed upon the pests.

The remarkable plague of caterpillars followed by a pest of butterflies that has existed the past spring and summer (1911) in the northern counties of California, especially in Siskiyou County, has furnished an interesting example of an insect outbreak. The economic importance of the outbreak may not have been as great as in the case of some others, but the numbers of individuals and the extent of the plague mark it as one of the most notable in the history of the state. Reports as to the great numbers of the worms are meagre, but the defoliated brush throughout Siskiyou County, where the plague was most severe, bears mute testimony to their work. When great swarms of butterflies made their appearance, the aspect of the outbreak became so extraordinary that the newspapers published numerous, often exaggerated accounts, of the phenomenon.

From all accounts, the vicinity of Mount Shasta was most affected, both the worm and the butterfly being abundant at Weed, Igerna, and Sisson, three towns on the western base of the mountain. The worms were reported as being very abundant at Marble Mountain in western Siskiyou County and at Weaverville, Trinity County. Although no butterflies in any numbers were noticed at Redding, Shasta County, they were reported as very abundant in the mountains thirty-five miles east of that place.

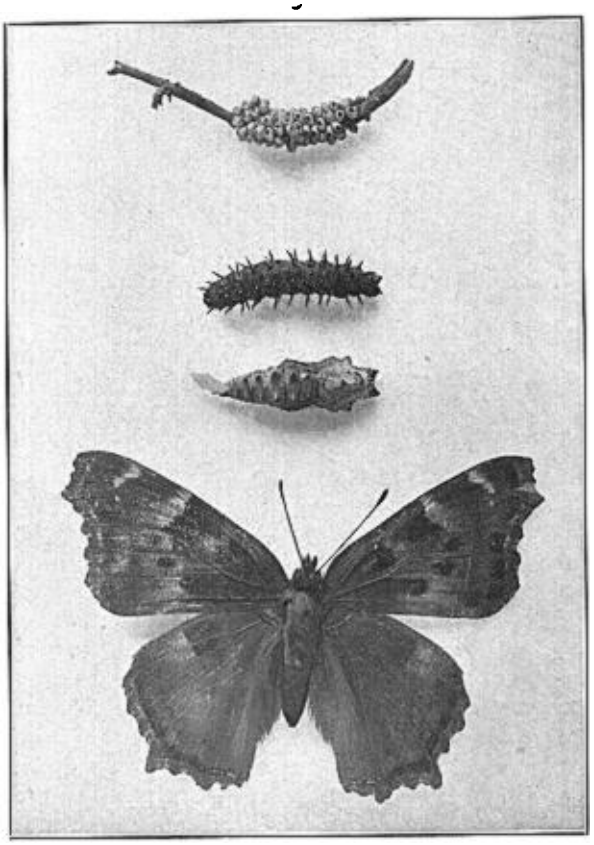

Fig. 68. THE LIFE HISTORY OF *Eugonia californica*. THE EGGS SHOWN ARE NOT THOSE OF *Eugonia californica* BUT THOSE OF A MOTH OF A TENT CATERPILLAR WHICH ALSO LIVES ON SNOW BRUSH. THE EGGS OF *Eugonia* ARE SIMILAR TO THESE AND ARE CLUSTERED ON A SMALL BRANCH IN MUCH THE SAME MANNER. NOTE THE STIFF HAIRS ON THE LARVA; THE SHAPE AND GENERAL CHARACTER OF THE PUPA, AND THE SIZE AND APPEARANCE OF THE ADULT

The following abstract is made from a letter by Honorable J. B. Curtin, dated September 11, describing a similar outbreak, of far less extent, in the Sierras. "Aspen Valley is a part of my cattle range and is at an elevation of six thousand three hundred and fifty feet. For a distance of about a mile each way, that would be east and west, the caterpillars have been traveling, going north. As far as I can learn, they are now in the central part of the county (Tuolumne) and have traveled perhaps thirty miles north from the south fork of the Tuolumne River. They fed only on snow brush, stripping each bush of its leaves."

Although no damage was done to crops, the outbreak furnished a splendid opportunity to study the relations of the birds in checking such a plague of insects. As the Fish and Game Commission is carrying on at the present time an investigation into the food habits of California birds in their relation to agriculture, evidence as to the part played by birds in this particular outbreak seemed to be of importance. Consequently an investigation was instituted under the auspices of the Commission.

The writer spent a week during the latter part of August at Sisson, Siskiyou County, collecting data by field observation and by the collection of birds for analysis of stomach contents. A total of sixty-one specimens, representing twenty-one species of birds, are at hand for stomach examination. A list of the species identified during the stay totals forty-five. It is to be regretted that a larger number of specimens representing a larger number of species is not at hand for examination, for the greater number would, without doubt, have not only augmented the number of species found to feed on the insects, but would also have esta blished points now in doubt.

To insure a complete understanding of the outbreak, a brief account of the life history and habits of the insect in question, follows.

As far as can be ascertained, the butterfly which has been so abundant in the north this year, has no common name. Among scientists it is known as *Eugonia californica*. It is closely allied to the members of the genus *Vanessa*, the tortoise-shell butterflies, species of which are known throughout the United States. *Euvanessa cardui*, a common butterfly of southern California appeared a few years ago in a swarm almost equal in extent to the plague of *Eugonia californica*.

There are four stages in the life of every butterfly and moth, egg, larva, pupa, and imago. From the egg hatches a caterpillar or larva. It is only in the larva stage that a butterfly or moth becomes of economic importance: nearly all of their larvae feed on vegetation. The depredations of the army worm, which is simply the larval form of a moth, are known only too well. The larva lives for some time on vegetation, then either hangs itself head down and is transformed into a chrysalis, spins a cocoon, or buries itself in the ground. This is called the pupa stage. After a week or more in this state there emerges the imago or adult form, a butterfly or moth. The butterfly or moth usually lives for several months or even for a year, then lays its eggs and the cycle is begun over again.

Eugonia californica lays its eggs on a common shrub of the mountains known as thorn brush, deer brush, buck thorn, buck brush, or snow brush (*Ceanothus cordulatus* and *Ceanothus velutinus*). In the early spring the larvae hatch from the eggs, crawl out on the foliage and begin to feed on the leaves. At the present time there are large areas in Siskiyou County where this brush is entirely defoliated as a result of the work of these larvae (see fig.67). By the middle of the summer, they have grown to be an inch or more in length and are ready to pupate. They then hang themselves head down on the under side of the branches and become pupae. In the defoliated areas, great numbers of pupae were found hanging from the under sides of the branches. Most of them were mere shells, as the butterfly had hatched, but large numbers were also found which had apparently been destroyed by birds and by parasites (see fig.69). A large hole picked into the thoracic portion of the pupae evidently showed the work of birds, whereas small round holes for the entrance and departure of some insect, gave evidence of the work of a parasite. Inside of a few weeks the butterfly or imago form emerges. Its food consists of what moisture and sap it can suck up on vegetation. The butterflies may possibly

mate and lay their eggs in the fall, but more often they live through the winter and lay their eggs in the early spring (see fig. 68).

In 1902 this same species of butterfly was abundant in the north. Since that time it has not been seen in any great numbers until this year. In the memory of the oldest inhabitants of Siskiyou County, the numbers of butterflies this year far exceed those of any previous year. The newspaper accounts were often exaggerated, and yet few people who did not see the swarms which filled the air, can have any realization of the great numbers. In order to get some idea of the numbers, counts were made. In damp places or along the banks of streams, where the butterflies had gathered to drink, as many as 150 individuals were counted in one square foot. Often the ground would be blackened by them for many square yards (see fig. 70).

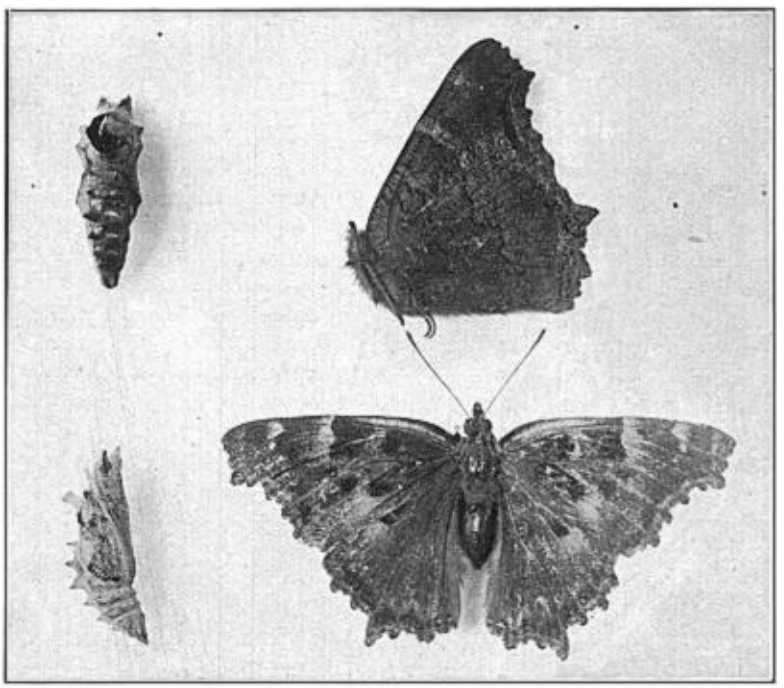

Fig. 69. PUPAE AND ADULTS OF *Eugonia californica*. IN ONE OF THE PUPAE, THE INSECT HAS BEEN DESTROYED BY SOME BIRD; IN THE OTHER BY SOME PARASITE. THE LATERAL VIEW OF AN ADULT SHOWS THE DARK UNDER SURFACE OF THE WING, AND THE DORSAL VIEW, THE COLOR PATTERN OF THE UPPER SURFACE.

In order to estimate the numbers flying, counts were made of the individuals passing between two fir trees about twenty feet high and standing about thirty feet apart. The counts for ten successive minutes between 4:40 and 4:50 P. M. on August 20, were as follows:

1st minute	105	6th minute	100
2nd "	119	7th "	96
3rd "	130	8th "	102
4th "	102	9th "	83
5th "	134	10th "	112
		Average per minute	108

Imagine the same numbers passing across a line a number of miles long, or better, across the breadth of Siskiyou County, and for say eight hours a day for several days; the numbers become incredible.

The butterflies were all migrating southward. In the early morning none were to be seen, but by half past nine they were in full migration. During the night they rested among the leaves on the trees or shrubs, on the sides of buildings or in any other convenient place.

With the life cycle taking but a year, it at first seems hard to explain why the numbers should be so much greater one year than another. One factor governing the phenomenon is the presence or absence of fortunate conditions for hiberna-

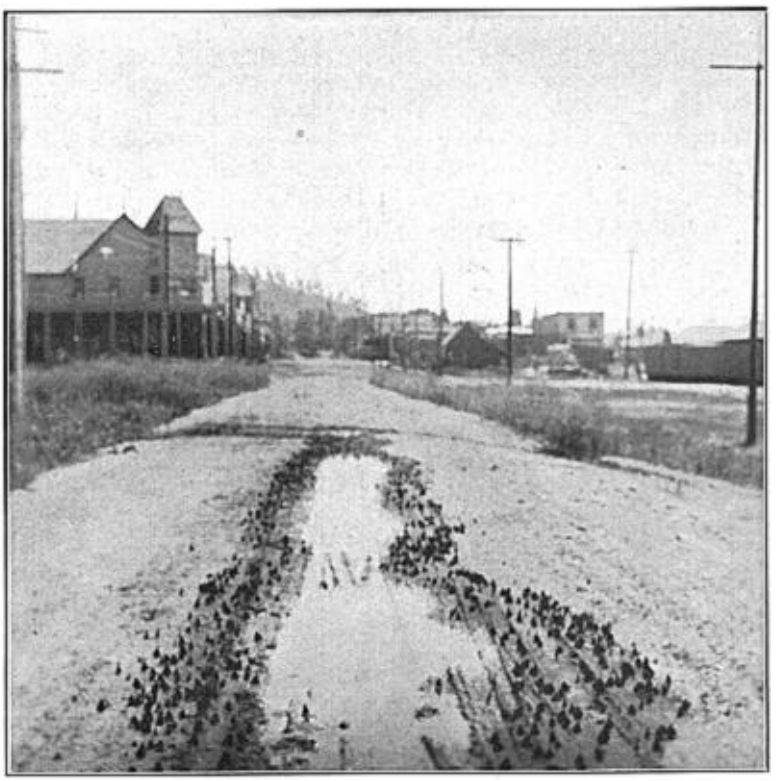

Fig. 70. BUTTERFLIES GATHERED TO DRINK AT A DAMP PLACE IN THE ROAD. PHOTOGRAPH TAKEN AT SISSON, SISKIYOU COUNTY, CALIFORNIA, AUGUST 23, 1911.

tion of the butterfly. As the pupae are parasitized to a large extent, in the neighborhood of 35 percent, and doubtless the larvae are also parasitized, the abundance or scarcity of these parasites must govern the numbers to some extent. A third factor, and without doubt an important one, is the part played by birds in the destruction of larva, pupa, and imago. Many of the pupae, 15 percent or thereabouts, apparently showed the work of birds, and as will be shown birds have an important part to play in the destruction of the butterflies. To what extent birds feed on the larvae is not known. Probably not to as great a degree as on the pupa and imago forms, for the larvae are well protected by stiff hairs. The scarcity or

abundance of food for either the larva or adult also has its influence. It will be seen, therefore, that the numbers of individuals from year to year depend on many factors, and that it is impossible to pick out any one as *the* factor. Probably it was a coincidence of several factors that caused the species to be so abundant this year.

In the investigation two methods were used, observation in the field and examination of stomach contents. Circumstantial evidence that a bird fed on the insects was not considered sufficient, so that unless the bird was actually seen to eat a butterfly or unless remains of butterflies were found in the stomach, the bird was not incorporated in the list of species known to feed on the insect. Doubtless if more time could have been spent in the field and more stomachs collected, the number of species acting as checks would have been found much larger. It is to be regretted that the field investigation was not begun sooner so that the kinds of birds feeding on the larvae and pupae might have been determined. In the vicinity of Sisson, Siskiyou County, where, August 20 to 25, the investigation was carried on, the larvae had all pupated and hatched into butterflies.

The writer is indebted to Professors C. A. Kofoid and C. W. Woodworth for valuable suggestions in the preparation of this paper and to Mr. J. Grinnell of the Museum of Vertebrate Zoology for a critical reading of the manuscript.

Field observation can seldom be depended on to furnish information as to the kind of food taken by a bird. In this investigation, however, the insects concerned were so large that there was no difficulty in determining positively whether the birds were feeding on *Eugonia californica* or on some other insect. The species of birds plainly seen to eat these butterflies were the Brewer blackbird (*Euphagus cyanocephalus*), western kingbird (*Tyrannus verticalis*), and western meadowlark (*Sturnella neglecta*).

By far the most efficient destroyer of the butterflies was the Brewer blackbird, (*Euphagus cyanocephalus*). From early morning till evening on every day during my stay at Sisson, great numbers of Brewer blackbirds could be seen congregated along the damp places in the road or in the meadows where the butterflies gathered, busily engaged in catching these insects. It was only in the near vicinity of the town that these birds were seen, but large flocks, in many cases numbering over a hundred individuals, were scattered about the small valley. Three particular flocks were closely watched.

A flock of some twenty-five individuals could nearly always be found in the near vicinity of the depot. They spent most of their time catching butterflies along the track, or about the damp places in the street just north of the depot. Between 11 and 12 o'clock on August 20, several of these birds, feeding in the road, were seen to take an average of five butterflies each minute. The method of capture was often quite crude. The bird seldom flew after an insect but simply walked along and attempted to pick it up. When a butterfly flew away, the bird either ran after it or attempted to catch another one. Occasionally a bird succeeded in swallowing a butterfly whole, but more often the insect was held with the feet while the body was torn from the wings. In places the ground was strewn with the discarded wings. Several times a bird was seen to catch a butterfly only to have it escape a moment later badly injured. One blackbird, either having had its fill or being attracted by another one of the insects, was seen to crush a butterfly in its bill and then drop it. Doubtless, therefore, these birds killed more than they really consumed.

Another large flock made its headquarters just west of town. On different occasions this flock was seen feeding along the railroad track in a meadow. When

frightened they perched in some nearby fir trees or on the telegraph wires. The third flock could always be found in the near vicinity of some meadow-land south of Sisson. Close observation failed to show them feeding on anything but butterflies.

The stomach examination of the few Brewers taken at this time substantiated the fact that their food was made up almost entirely of the butterflies. The stomach of one bird taken very early in the morning, when examined, was found to contain five *Eugonia californica* and parts of several others. A few grains of oats and parts of beetles were found in the stomach of a bird taken in a meadow near a stubble field. Birds collected the latter part of June and July contained a large percentage of beetles but no larvae or adults of *Eugonia californica*. Considering the comparative numbers of individuals of the different species of birds found to feed on the butterfly, the Brewer blackbird took 95 percent of the butterflies eaten by birds, the meadowlark 2½ percent and the kingbird, blue jay and Say phoebe shared the rest.

Only four western kingbirds (*Tyrannus verticalis*) were seen. Two birds perched on the telegraph wires along a road, were watched for some time. One of them was seen to catch two butterflies in the air. On another occasion two kingbirds were seen in the same general location, probably the same birds. They continually flew out from the wire and caught some insect in the air. As the air was filled with butterflies, it seems probable that these birds were catching them. Two kingbirds seen perched on a fence in a barnyard appeared also to be feeding on butterflies. It is to be regretted that no specimens are at hand for stomach examination, as the supplementary evidence, thus obtainable, would have thrown light on the extent to which the kingbird acts as a check.

Meadowlarks (*Sturnella neglecta*) were so shy that except in one case, it was impossible to determine the kind of food taken. A lone meadowlark feeding with some Brewer blackbirds on the grass plot adjoining the station was seen to run after several butterflies and to catch one. In the examination of seven stomachs, only two showed the remains of butterflies. All of the birds whose stomachs were examined, were taken in meadows or cut fields of wild hay where other insect life was abundant. Beetles and grasshoppers formed the bulk of the food.

A Say phoebe (*Sayornis sayus*) collected August 30, was found to contain a large butterfly of another species and also a *Eugonia californica*, as well as some ants. Since 75 percent of the stomach contents was composed of butterflies of different kinds and since, according to Beal (1910), these insects form more than 10 percent of the food of this bird for the year, it would appear that this flycatcher, as well as the kingbird, can be ranked as one of the checks on *Eugonia californica*. Doubtless another large flycatcher, the ash-throated flycatcher (*Myiarchus cinerascens*), took its share of the butterflies, for it is known to feed to a considerable extent on butterflies and moths. No specimens of this species are available.

If the food of the smaller flycatchers can be judged from that of the western flycatcher(*Empidonax difficilis*) it is doubtful if they bore any relation to the outbreak. The stomachs of the two western flycatchers examined, contained numerous small flies and a few small bees and beetles. A small white moth was found in one of the stomachs. Moreover it seems strange that a bird of its size should take so large an insect as the butterfly under discussion. No specimens of the western wood pewee (*Myiochanes richardsoni*) are at hand. Its food habits are known to be much like those of the western flycatcher.

The red-winged blackbird (*Agelaius phoeniceus*, subspecies ?) was very abund-

ant about Sisson. Flocks containing hundreds of individuals were often seen feeding on the meadow-land or on the stubble fields. They seemingly paid no attention to the hordes of butterflies but busied themselves searching for vegetable food. Stomach examination showed a considerable quantity of oats and other seeds, probably waste picked up in the stubble fields. A very small percentage of the food was made up of small ground beetles and grasshoppers.

Most of the Bullock orioles (*Icterus bullocki*) seen were feeding on huckleberries or other wild fruit. Eighty-two percent of the food in the stomachs examined was made up of wild fruit, mostly huckleberries and elderberries. The only animal food found consisted of wild bees.

The commonest sparrows were English sparrows (*Passer domesticus*) in town, Brewer sparrows (*Spizella breweri*) in the weed patches, and thick-billed fox sparrows (*Passerella iliaca megarhyncha*) in the brush. The English sparrow appeared to be feeding entirely on weed seeds as did also the Brewer sparrows. The stomachs of three Brewer sparrows were filled with weed seed and a few small beetles. The fox sparrow appeared to be largely a vegetarian also, for 96 percent of the food in two stomachs was composed of weed seeds. Parts of two ground beetles formed the only animal food. The stomach of a mountain song sparrow (*Melospiza melodia montana*) contained two cutworms, one unidentified larva, one beetle larva, and one small bee.

A bird of the brush, the green-tailed towhee (*Oreospiza chlorura*), was found to feed largely on small beetles and seeds, for the two stomachs examined were filled with these kinds of food only.

Only two species of woodpeckers were available for examination. As most of the members of this family feed very largely on larvae it seems probable that their use as checks would be most noticeable when the larvae were abundant. The one stomach of the woodpecker most likely to feed on the butterfly, the red-shafted flicker (*Colaptes cafer collaris*), failed to show any *Eugonia californica*. Two flickers, feeding on the ground, were watched for twenty minutes, but they paid no attention to the many butterflies. They walked along searching the ground carefully for some sort of food, in all probability ants. The stomachs of two white-headed woodpeckers (*Xenopicus albolarvatus*) were filled with vegetable matter, doubtfully identified as fungus, and a few beetles.

Blue-fronted jays (*Cyanocitta stelleri frontalis*) were often seen either climbing to the top of a fir or sailing from the tip top of one tall tree to a lower one. Only once was one seen feeding on the ground. Five *Eugonia californica* were found in one of the two stomachs examined. The other contained a number of large green larvae. It seems natural that a bird with the varied diet of the jay should turn to this particular form of insect food when it became available.

A western bluebird (*Sialia mexicana occidentalis*), perched on an old stump in a small grassy pasture, was watched for half an hour. It flew to the ground, caught a white moth, flew back to the stump and proceeded to tear it to pieces and eat it. During the next fifteen minutes it repeated the operation four more times, having within twenty minutes destroyed five moths. Butterflies were very abundant, but the bluebird appeared to prefer the smaller moths to the larger butterflies. Two stomachs were available for examination. One contained a number of small beetles and the other two grasshoppers.

Large flocks of western robins (*Planesticus migratorius propinquus*) could be found wherever wild fruit was abundant. Especially was this true where huckleberries were common. The flocks were made up largely of juveniles. An examination of thirteen stomachs gave evidence that their food at that particular

time of year is largely wild fruit. Over 99 percent of the food contained in the stomachs of six birds taken near the huckleberries, was made up of this fruit.

Cliff swallows (*Petrochelidon lunifrons*) were usually seen circling high in the air although on two occasions a number were seen perched on telegraph wires. These birds were carefully watched, but they did not seem to be feeding on the numerous butterflies about them. They certainly could have been seen to take butterflies if these had been chosen for food. A very few western barn swallows (*Hirundo erythrogastra*) were seen, but these too, seemed to be intent on catching some smaller insect. No stomachs are at hand for examination.

Mountain quail (*Oreortyx picta plumifera*) were very abundant in the brush. A flock was closely watched, but the birds appeared to be searching among the leaves under the brush for their food. As the mountain quail is largely a vegetarian, it probably bore no relation to the butterflies.

The stomachs of three mourning doves (*Zenaidura macroura carolinensis*) contained nothing but weed seeds.

One stomach of each of the following birds was also examined: belted kingfisher (*Ceryle alcyon*), western evening grosbeak (*Hesperiphona vespertina montana*), Cassin purple finch (*Carpodacus cassini*), Sierra junco (*Junco hyemalis thurberi*), and western house wren (*Troglodytes aedon parkmani*). There was no evidence that these birds fed on the butterflies. Judging from its food habits, it seems probable that the wren would be one of the birds to feed on the pupae. The Calaveras warbler (*Vermivora rubricapilla gutturalis*), another common bird of the brush, probably ranks with the western house wren in this regard.

Chickens and ducks seemed to appreciate the unlimited supply of butterflies, for they were seen catching them from early morning till late in the evening. In the vicinity of Sisson, at least, the domestic birds, on account of their capacity and numbers, by destroying butterflies performed a service nearly as great as all the wild species put together.

The following table gives a summary of the contents of the stomachs of birds taken during August, and the number of stomachs of each species examined.

NAME OF SPECIES	Number of Stomachs	Percent of Animal Food	Percent of Vegetable Food	Percent of Butterflies
Mourning dove (*Zenaidura macroura carolinensis*)	3		100.0	
Belted kingfisher (*Ceryle alcyon*)	1	100.0		
White-headed woodpecker (*Xenopicus albolarvatus*)	2	11.5	88.5	
Red-shafted flicker (*Colaptes cafer collaris*)	1	19.0	81.0	
Say phoebe (*Sayornis sayus*)	1	100.0		25.0
Western flycatcher (*Empidonax difficilis*)	2	100.0		
Blue-fronted jay (*Cyanocitta stelleri frontalis*)	2	74.0	26.0	30.0
Red-winged blackbird (*Agelaius phoeniceus*, subsp.?)	13	6.7	93.3	
Western meadowlark (*Sturnella neglecta*)	5	85.4	14.6	15.2
Bullock oriole (*Icterus bullocki*)	4	17.5	82.5	
Brewer blackbird (*Euphagus cyanocephalus*)	3	83.3	16.7	61.0
Western evening grosbeak (*Hesperiphona vespertina montana*)	1	74.0	26.0	
Cassin purple finch (*Carpodacus cassini*)	1		100.0	
Brewer sparrow (*Spizella breweri*)	3	47.7	52.3	
Sierra junco (*Junco hyemalis thurberi*)	1	100.0		
Mountain song sparrow (*Melospiza melodia montana*)	1	100.0		
Thick-billed fox " (*Passerella iliaca megarhyncha*)	2	4.0	96.0	
Green-tailed towhee (*Oreospiza chlorura*)	2	71.0	29.0	
Western house wren (*Troglodytes aedon parkmani*)	1	100.0		
Western robin (*Planesticus migratorius propinquus*)	10	13.7	87.3	
Western bluebird (*Sialia mexicana occidentalis*)	2	86.5	13.5	
Total number of stomachs	61			
Average percent of butterflies taken by four birds				32.8
Average percent of butterflies taken by all birds				6.2

Before taking up a discussion of the influence of birds on the checking of this particular outbreak of insects, it is necessary that there be given some idea as to the bird population of the territory affected. A list of the species recognized with certainty by the writer during his stay at Sisson, August 20 to 25, inclusive, 1911, follows.

1. Mountain quail. *Oreortyx picta plumifera.*
2. Mourning dove. *Zenaidura macroura carolinensis.*
3. Turkey vulture. *Cathartes aura septentrionalis.*
4. Western red-tailed hawk. *Buteo borealis calurus.*
5. Sparrow hawk. *Falco sparverius.*
6. Belted kingfisher. *Ceryle alcyon.*
7. White-headed woodpecker. *Xenopicus albolarvatus.*
8. Lewis woodpecker. *Asyndesmus lewisi.*
9. Red-shafted flicker. *Colaptes cafer collaris.*
10. Pacific nighthawk. *Chordeiles virginianus hesperis.*
11. Hummingbird. Species?
12. Western kingbird. *Tyrannus verticalis.*
13. Say phoebe. *Sayornis sayus.*
14. Western flycatcher. *Empidonax difficilis.*
15. Blue-fronted jay. *Cyanocitta stelleri frontalis.*
16. Red-winged blackbird. *Agelaius phoeniceus*, subspecies?
17. Western meadowlark. *Sturnella neglecta.*
18. Bullock oriole. *Icterus bullocki.*
19. Brewer blackbird. *Euphagus cyanocephalus.*
20. Western evening grosbeak. *Hesperiphona vespertina montana.*
21. Cassin purple finch. *Carpodacus cassini.*
22. Green-backed goldfinch. *Astragalinus psaltria hesperophilus.*
23. English sparrow. *Passer domesticus.*
24. Western Savannah sparrow. *Passerculus sandwichensis alaudinus.*
25. Brewer sparrow. *Spizella breweri.*
26. Sierra junco. *Junco hyemalis thurberi.*
27. Mountain song sparrow. *Melospiza melodia montana.*
28. Thick-billed fox sparrow. *Passerella iliaca megarhyncha.*
29. Spurred towhee. *Pipilo maculatus megalonyx.*
30. Green-tailed towhee. *Oreospiza chlorura.*
31. Lazuli bunting. *Passerina amoena.*
32. Western tanager. *Piranga ludoviciana.*
33. Cliff swallow. *Petrochelidon lunifrons.*
34. Western barn swallow. *Hirundo erythrogastra.*
35. Violet-green swallow. *Tachycineta thalassina lepida.*
36. Western warbling vireo. *Vireosylva gilva swainsoni.*
37. Calaveras warbler. *Vermivora rubricapilla gutturalis.*
38. California yellow warbler. *Dendroica aestiva brewsteri.*
39. Dipper or water-ouzel. *Cinclus mexicanus unicolor.*
40. Western house wren. *Troglodytes aedon parkmani.*
41. Red-breasted nuthatch. *Sitta canadensis.*
42. Mountain chickadee. *Penthestes gambeli.*
43. California bush-tit. *Psaltriparus minimus californicus.*
44. Western robin. *Planesticus migratorius propinquus.*
45. Western bluebird. *Sialia mexicana occidentalis.*

Brewer blackbirds, English sparrows and cliff swallows were the commonest birds found about the streets of the town. In the meadows, red-winged blackbirds, Savannah sparrows and meadowlarks were the only birds seen in any numbers. The red-wings were usually in flocks of several hundred, mostly juveniles. Wherever wild fruit was abundant robins and orioles could be found. In the brush green-tailed towhees were the commonest birds, but Calaveras warblers were also abundant. Only a few spurred towhees were noted. Western house wrens were more often heard than seen. Along the railroad tracks where the brush had been

cleared away and the weeds allowed to grow, Brewer sparrows were exceedingly common.

During an early morning walk through brush and forest the following birds were seen: blue-fronted jay, Brewer sparrow, green-tailed towhee, western house wren, bush-tit, Calaveras warbler, western robin, red-shafted flicker, and Lewis woodpecker. Within the space of three-quarters of an hour, five different species of birds were seen to perch in a dead cedar on a small hill. The tree was first visited by a Bullock oriole, then by a small flock of western bluebirds, four other Bullock orioles, two cliff swallows, which perched on the topmost limb, several purple finches and an evening grosbeak.

In a little meadow west of Sisson, where grass and weeds grew in abundance, a large number of birds were seen. In the weeds green-backed goldfinches and Brewer sparrows were feeding in large flocks. Several flickers were feeding on the ground. A lazuli bunting flew into a fir tree where several Calaveras warblers were at work. A sparrow was heard in a nearby tree. Several robins flew from one tree to another. A western bluebird was perched on a stump.

With the plague-ridden territory inhabited by so large a number of species of birds and by so large a bird population, it may at first seem strange that only five species of birds were found to feed on *Eugonia californica*. The investigation showed that only the larger birds fed on the butterfly. Certainly most of the small birds are ill-adapted for catching insects as large as the butterfly in question. Their most intimate relation to the outbreak was doubtless when the insect was in the larval and pupal stage. If all the birds smaller than the Say phoebe be eliminated from the list as being unable to act as checks on the butterfly, we find that over twenty-two percent of the species of the larger birds fed upon the butterfly. If we eliminate those of the larger birds, which judging from their food habits would not feed upon the butterfly, we find that almost forty percent of the possible species did feed upon the insect.

A striking fact is that the birds acting as checks, with one exception, that of the Say phoebe, are birds about whose depredations there is considerable complaint by the farmers of the state. That the blackbird, meadowlark, jay, and kingbird all do a certain amount of harm is undeniable, but too often only one side of the question is emphasized.

Especial attention is called to the fact that even such a bird as the blackbird, which is often classed as the worst pest of the farmer, may become of value at times and places where it is least expected. The present paper shows that the same birds that are often classed as harmful may be very beneficial in the checking of an insect outbreak.

Even though the brush attacked by the larva of *Eugonia californica* is seldom killed by the defoliation, yet the plants must be weakened to some extent. If the economic value of the brush be measured by its use as forage for deer and sheep, it will be seen that some importance, at least, attaches to this particular insect outbreak in that the defoliation took place during the summer when it was most needed as forage. The economic importance or non-importance of the outbreak, however, in no way affects the value of the principle involved in the relation of the birds to the epidemic; namely, that birds prey upon the insect food most abundant and therefore become factors in the checking of an insect outbreak.

In the life history of such an insect as *Eugonia californica*, we find the maximum number of individuals soon after hatching begins in the spring. From this time on there is normally a rapid decrease in numbers. The decrease is due to, not only the action of birds, which are perhaps the most constant factor in the de-

struction of larva and pupa, but also to parasitism. After the butterfly is hatched there is usually but a slow decrease throughout the winter. From this it will be seen that the butterfly has a far greater chance to survive than the caterpillar or the pupa. With this in view, almost half of the adults of *Eugonia californica* can be counted on to survive until egg-laying time. A much smaller percent of larvae or pupae could be counted on to survive till this stage owing to the greater death-rate. Any destruction of the butterfly, therefore, is an attack on the insect at a critical period in its life history. Consequently the work of five species of birds at this critical point might be more important as a check on the increase of the insect than the work of many more species during the larval and pupal stages. It appears also that in this particular case birds are among the very few natural checks on the butterfly, whereas parasites as well as birds probably play an important part as checks on the insect in its larval and pupal stages.

If we consider the work of one Brewer blackbird, its value as a check becomes apparent. Suppose that one of these birds having fourteen hours a day in which to feed, takes an average of one butterfly a minute for eight hours out of the fourteen. Judging from observations made, this would not be extraordinary. By the end of the day it would have consumed 480 butterflies, by the end of the week, 3360, and by the end of a month, over 100,000. If, say, a third of the butterflies destroyed were females, probably a larger percent are females, the numbers of eggs so destroyed would number near 336,000. Such computations as this are of somewhat doubtful value for they often seem so exaggerated that in the mind of the reader, the real facts are discounted. Its use here is simply to give some idea of the extent to which a bird might act as a check and probably did act as a check in this instance.

One of the most striking things brought out in the investigation was the great difference in the food habits of the red-winged and the Brewer blackbirds. Whereas the Brewer was found to feed almost entirely on the pests, the red-wing apparently paid no attention to the extraordinary abundance of insect food.

The results of investigation show that a good percentage of the birds larger than the Say phoebe fed on the butterfly, *Eugonia californica*, and this was without doubt a factor in the reduction of the insects. A comparison of birds taken at Sisson before the butterflies became abundant with those taken at the time of the investigation proved the fact that the birds varied their food ratios and took advantage of the abundant supply of this particular insect food.

SUMMARY OF RESULTS

The investigation instituted by the State Fish and Game Commission into the relation of birds to an insect outbreak in northern California during the spring and summer of 1911, showed the following results:

1. The insect which became a pest was a butterfly, *Eugonia californica*, the larval form of which feeds upon snow brush or buck brush (*Ceanothus cordulatus*, *Ceanothus velutinus*).

2. The great number of caterpillars and butterflies and the large amount of territory covered by the plague furnished an interesting example of an insect outbreak. Since the relation of birds to any insect outbreak furnishes important information as to their economic value as checks, the value of an investigation into the relation of birds to this particular outbreak was evident.

3. Five species of birds were found to feed on the butterfly, *Eugonia californica*, the Brewer blackbird (*Euphagus cyanocephalus*), western meadowlark

(*Sturnella neglecta*), western kingbird (*Tyrannus verticalis*), blue-fronted jay (*Cyanocitta stelleri frontalis*), and Say phoebe (*Sayornis sayus*).

4. Four out of five species found to feed on the butterfly are numbered among the birds whose usual food habits justly subject them to severe criticism from the farmer.

5. The Brewer blackbird (*Euphagus cyanocephalus*) was found to be the most efficient check both on account of numbers and food habits. When the comparative number of individuals of the different species of birds were considered, it was found that the Brewer blackbird took 95 percent of all the butterflies eaten by birds. In this particular outbreak, therefore, one species of bird rather than birds in general, played the greatest part in the destruction of the insect.

6. The examination of thirteen stomachs of the red-winged blackbird (*Agelaius phoeniceus*, subspecies?) showed over 93 percent of its food to be vegetable matter, thus bringing out the vast difference in food habits between this bird and the Brewer blackbird (*Euphagus cyanocephalus*), 83 percent of whose food was animal matter.

7. *Eugonia californica* in the butterfly stage, probably on account of its large size, was not eaten by any species of bird smaller than the Say phoebe. The smaller birds probably had a more intimate relation to the outbreak when the insect was in the larval and pupal stage.

8. The birds in feeding on the butterfly attacked the insect at a critical point in its life history and were therefore of more value as a check than they would have been had they fed on the larva or pupa.

9. A comparison of the food of birds taken before the plague with that of birds taken while the plague was at its height, showed that birds had varied their food habits and had taken advantage of the abundant supply of insect food in the form of butterflies. Their value as checks in this particular insect outbreak, therefore, was real.

10. The data collected shows of what value birds may be in the checking of an insect outbreak rather than their value in the prevention of an outbreak.

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FURTHER NOTES FROM SANTA CRUZ ISLAND

By ALFRED B. HOWELL and A. VAN ROSSEM

THE topography of Santa Cruz Island is more varied than that of any other of the islands comprising the Santa Barbara group, and it has a corresponding diversity of bird life. Its greatest altitude is nearly three thousand feet; for the most part it is grass land with extensive barren stretches, and canyons filled