

Sagebrush Defoliator Outbreak in Northern California¹

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ABSTRACT: The sagebrush defoliator was responsible for varying degrees of sagebrush defoliation and mortality over a widespread area in southeastern Oregon, northeastern California, and northwestern Nevada in 1963 and 1964. Severe defoliation sometimes killed sagebrush in a single season. Indications are that the outbreak will continue at least another season. *A. websteri* has a single annual generation. It is attacked by several species of parasites and predators; the most important of these in California was a *Copidosoma*.

The sagebrush defoliator (*Aroga websteri* Clarke /Lepidoptera: Gelechiidae/) is one of the most important insect pests of browse plants in the Western United States. From 1962 to 1964 the sagebrush defoliator, along with several other insect species, caused extensive sagebrush mortality in northeastern California and parts of neighboring States. This infestation is continuing and

extensive sagebrush mortality is expected.

Whether such an infestation is desirable or undesirable depends upon one's viewpoint. Where a perennial grass understory exists, sagebrush mortality improves livestock range conditions by releasing the grass. In this instance the insects causing defoliation serve the same purpose as chemical herbicides. The insects are not selective in killing sagebrush, however, while herbicides generally are.

Because the insects, including *Aroga*, are not selective, they often kill sagebrush on ranges that have no understory of perennial grass. There the plants that replace sagebrush--rabbitbrush and cheat grass are examples--are often less desirable than sagebrush. This is a particularly serious problem on deer winter ranges and antelope ranges because sagebrush is an important food plant for deer and antelope². Sagehens may also suffer from uncontrolled loss of sagebrush.

The sagebrush defoliator has been reported active in California, Oregon, Idaho, Montana, Nevada, Utah, Washington, and probably

¹This note summarizes a more detailed report prepared under terms of a contract with the Pacific Southwest Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture, Berkeley, California. The report is on file at the Station.

²Sampson, A. W., and Jespersion, B. S. California range brushlands and browse plants. Calif. Agr. Expt. Sta. Ext. Serv. Manual 33: 1-162. 1963.

also in Wyoming. In California it has been found in Lassen, Modoc, Nevada, Placer, Plumas, Shasta, Sierra, and Siskiyou Counties. It may also occur in Inyo and Mono Counties. A native insect, it probably is in other areas where sagebrush is abundant.

MEASURING POPULATION DENSITY

This study, carried out mainly during the summer of 1964, attempted to measure the population density of the sagebrush defoliator from field collections made just before adult emergence. Samples of 10 randomly selected sagebrush tips, each 7 inches in length, were collected from 34 locations ranging from Summer Lake, Oregon to Reno, Nevada (fig. 1). The tips were transported to the Pacific Southwest Station's Hat Creek field laboratory for rearing. They were examined at about 2-week intervals. Information was collected on the number of adults of the sagebrush defoliator, parasites, predators, and other insects that had emerged. When emergence had ceased, each tip was examined under a microscope to determine the number of parasitized larvae and pupae.

R. L. Hubbard and D. L. Neal of the Pacific Southwest Station also helped collect data on defoliation damage from sample plots established in Modoc County in 1963. Further information on damage and areas of infestation was obtained from the California Department of Fish and Game, the Oregon State Game Commission, Oregon State University, the U. S. Bureau of Land Management, and the Bureau of Sports Fisheries of the U. S. Fish and Wildlife Service. An earlier report³ was also consulted. Taxonomists at the California State Bureau of Entomology, Sacramento, identified the insects.

THE INSECT

A small gray moth, the adult sagebrush defoliator has a wing expanse of about 14 to 16 mm. The moths vary considerably in color but are generally light gray with black markings on the front wings (fig. 2A). Their eggs are pearly white and about 0.5 mm. long. The mature larva (fig. 2B) is about 12 mm. long, has a dark brown head, a creamy-white body, and a row of black spots on either side of the abdomen. Henry⁴ has described in detail all stages of the insect.

HOSTS

Henry⁴ reported that the sagebrush defoliator infests Artemisia arbuscula, A. tridentata, A. cana, A. nova, A. tripartita, and A. longiloba. I have reared the sagebrush defoliator from the first three

³Hall, Ralph C. Impact on antelope and deer sagebrush ranges by the sagebrush defoliator, *Aroga websteri* Clarke. Trans-Interstate Antelope Conf., pp. 40-45. 1963.

⁴Henry, John E. The biology of the sagebrush defoliator, *Aroga websteri* Clarke, in Idaho. 1961. (Unpub. master's thesis on file Univ. Idaho, Moscow.)

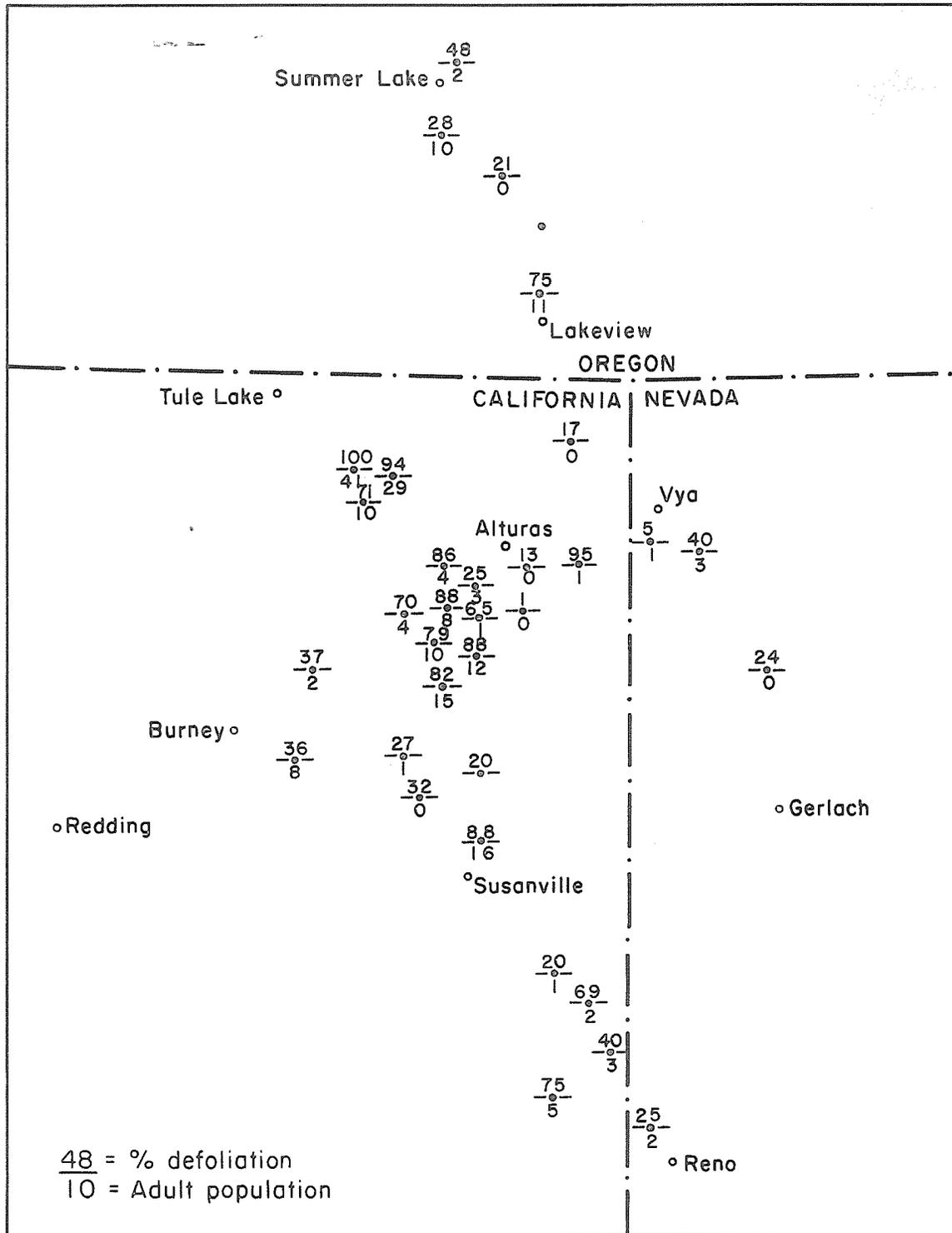
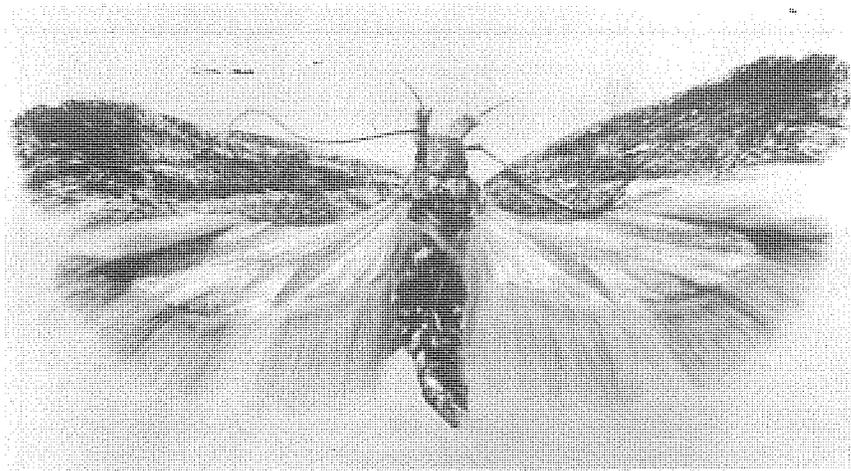


Figure 1.--Location of sagebrush defoliator population samples, 1964.



A

B

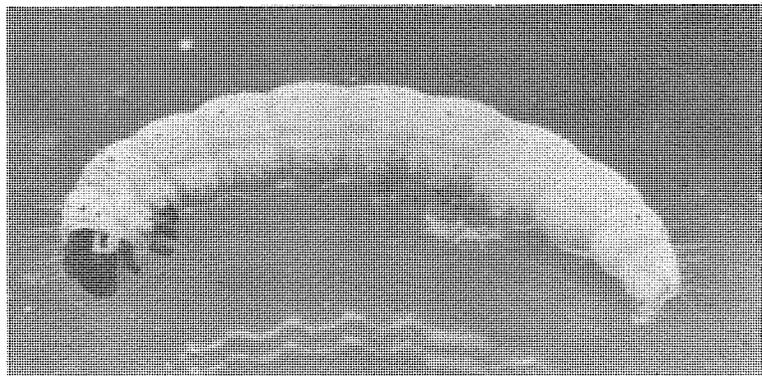


Figure 2.--A, Adult; B, fully developed larva of the sagebrush defoliator.

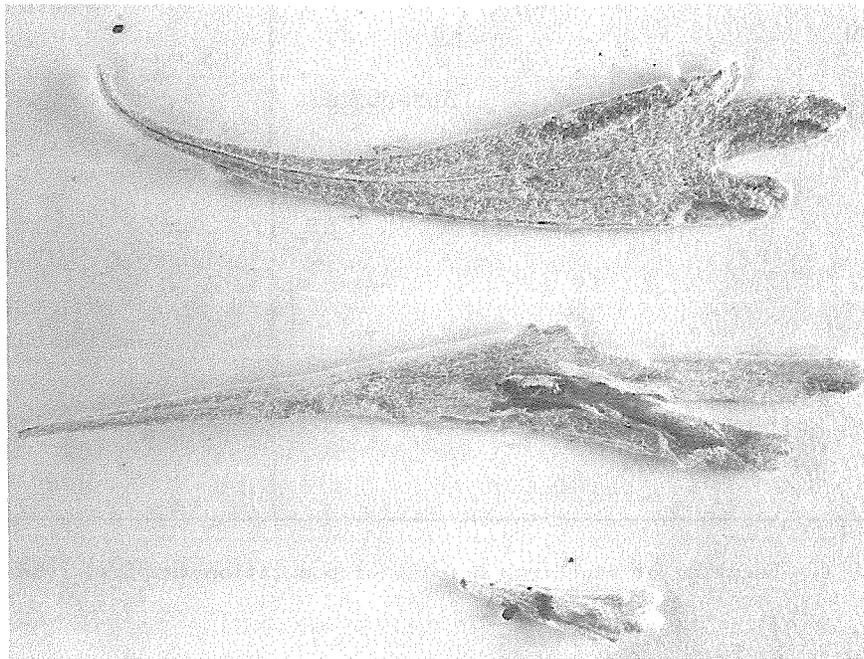


Figure 3.--Sagebrush leaves mined by overwintering larvae of the sagebrush defoliator.

of these species in California, and also from rabbitbrush (Chrysothamnus nauseosus) and bitterbrush (Purshia tridentata). Sagebrush is probably the principal host. The sagebrush defoliator feeds on other species only if the principal host has been completely defoliated and if these other species are associated with sagebrush.

BIOLOGY AND HABITS

The sagebrush defoliator has a 1-year life cycle. The adults are nocturnal and are generally active during July and August. They lay eggs on the stems of the sagebrush plants; eggs hatch in about a month. Henry⁴ reported that the insects overwinter as young larvae, mining in the leaves (fig. 3). They resume activity and complete their larval development in spring, pupating along the leaves or stems.

EVIDENCES OF INFESTATION

Aroga larvae eat the leaves of the host plants. Defoliation is not immediately apparent, however, except on close examination because the larvae eat only the basal part of the leaves, leaving the rest attached to the twigs by webbing; these remain until washed off by the winter rains. At a distance the principal difference in appearance between a defoliated plant and a normal plant during the year of defoliation is the change in color from a sage green to ash gray of the defoliated plants. The webbed leaves are a sure indicator of sagebrush defoliator activity (fig. 4).

RESULTS OF 1964 OBSERVATIONS

POPULATION DENSITIES AND DEFOLIATION

Larval populations averaged 24 larvae per 10-tip sample, and ranged from 0 to 75. Emergence ranged from 0 to 41 moths per sample; the differences from larval populations were accounted for by mortality between the mature larval and adult stages.

The severity of defoliation was closely correlated with larval population density. Eight larvae resulted in about 25 percent defoliation, 25 larvae in 50 percent defoliation, 46 larvae in 75 percent defoliation, and 66 or more larvae in 100 percent defoliation (fig. 5).

EFFECT ON HOST PLANTS

Data were collected in 1963 and 1964 on 17 randomly selected sample plots in Modoc County, California; the plots included 198 tagged sagebrush plants. Results showed that the sagebrush defoliator can cause mortality of sage plants after 1 year of complete defoliation. The extent of mortality observed in 1964 was closely associated with the degree of defoliation the previous year (fig. 6). Of 63 plants completely defoliated in 1963, 50--or about 80 percent--were completely dead in 1964. The amount of dead crown on the 63 completely defoliated plants averaged 96 percent. Indications were strong that young healthy plants

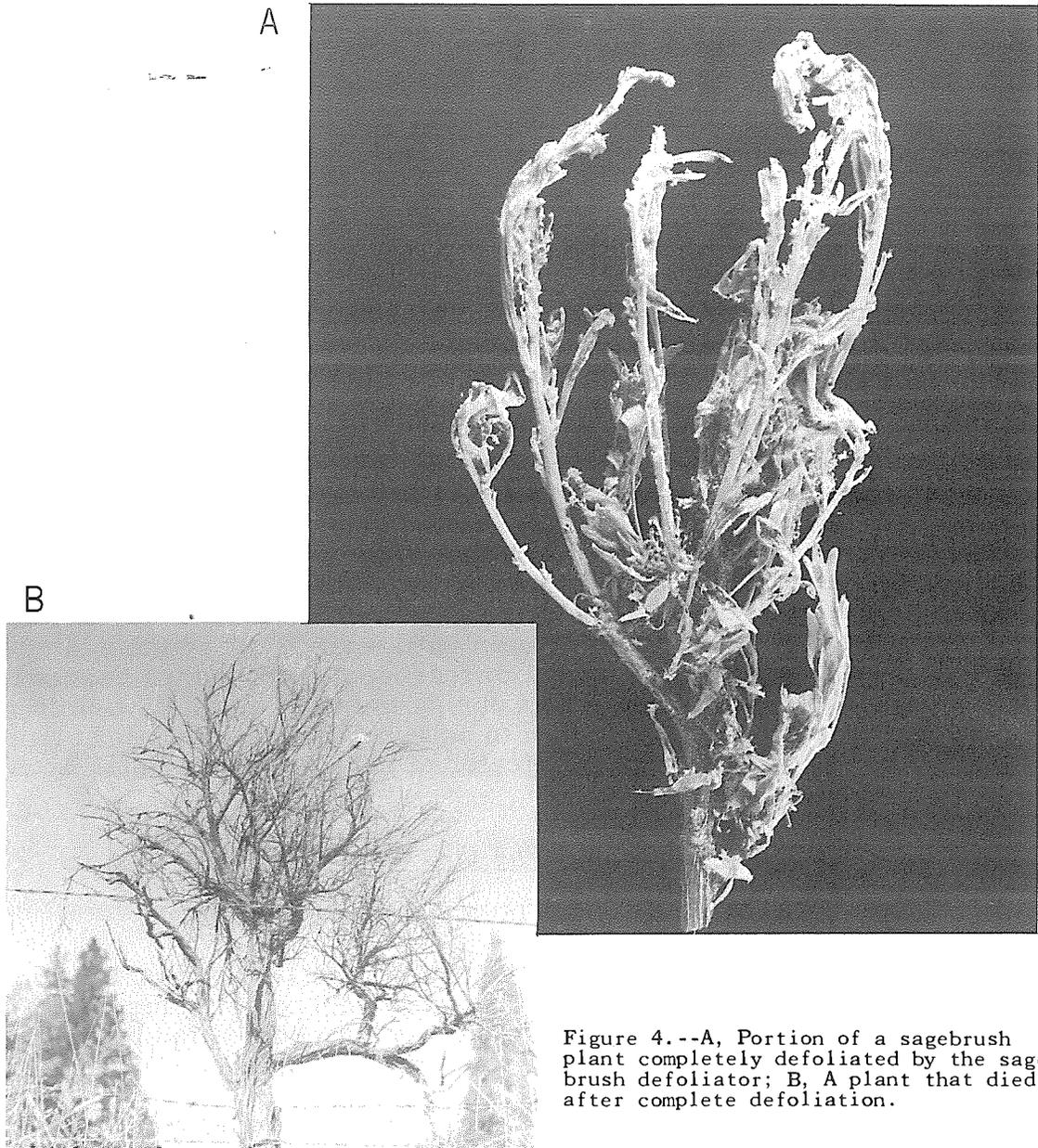


Figure 4.--A, Portion of a sagebrush plant completely defoliated by the sagebrush defoliator; B, A plant that died after complete defoliation.

are better able to recover after defoliation than older plants. Almost without exception the plants that survived complete defoliation were young, thrifty seedlings.

In observations near Lakeview, Oregon, in 1963, McLaury⁵ found the amount of dead crown after complete defoliation averaged only 40 percent, which is much lower than the 96 percent found in California. He also reported that many of the completely defoliated plants grew new leaves in the fall after defoliation. Of 53 plants

⁵McLaury, Eldon L. Larva infestation study on the Sheldon National Antelope Refuge and Range. 1964. (Unpub. rpt. on file Bur. Sport Fisheries and Wildlife, Lakeview, Oreg.)

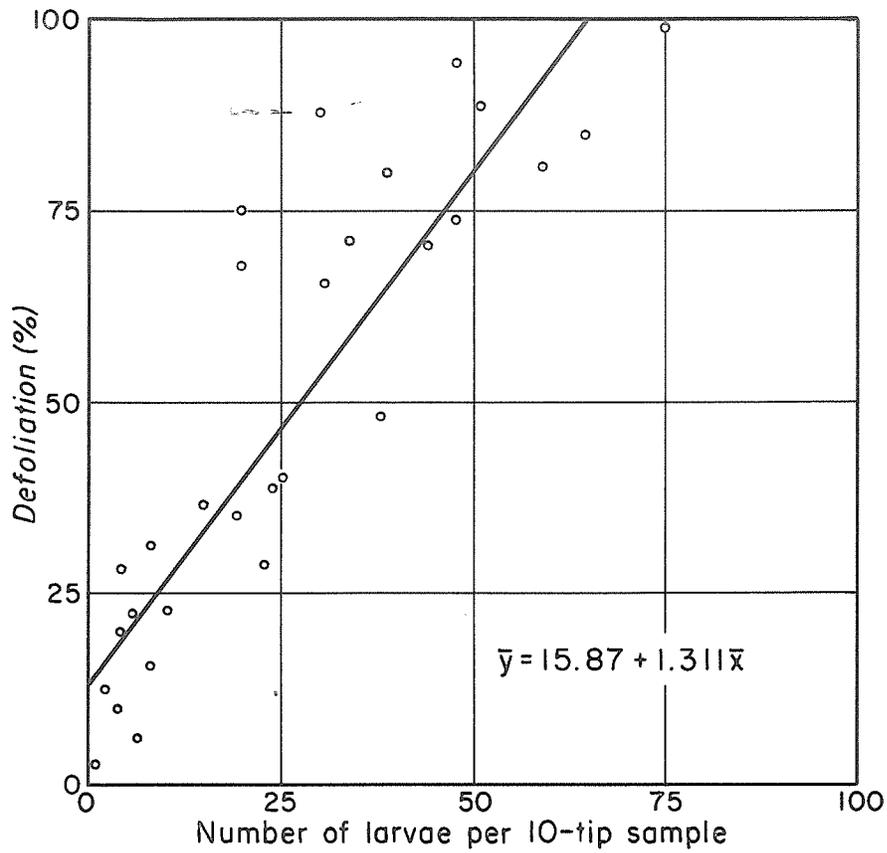
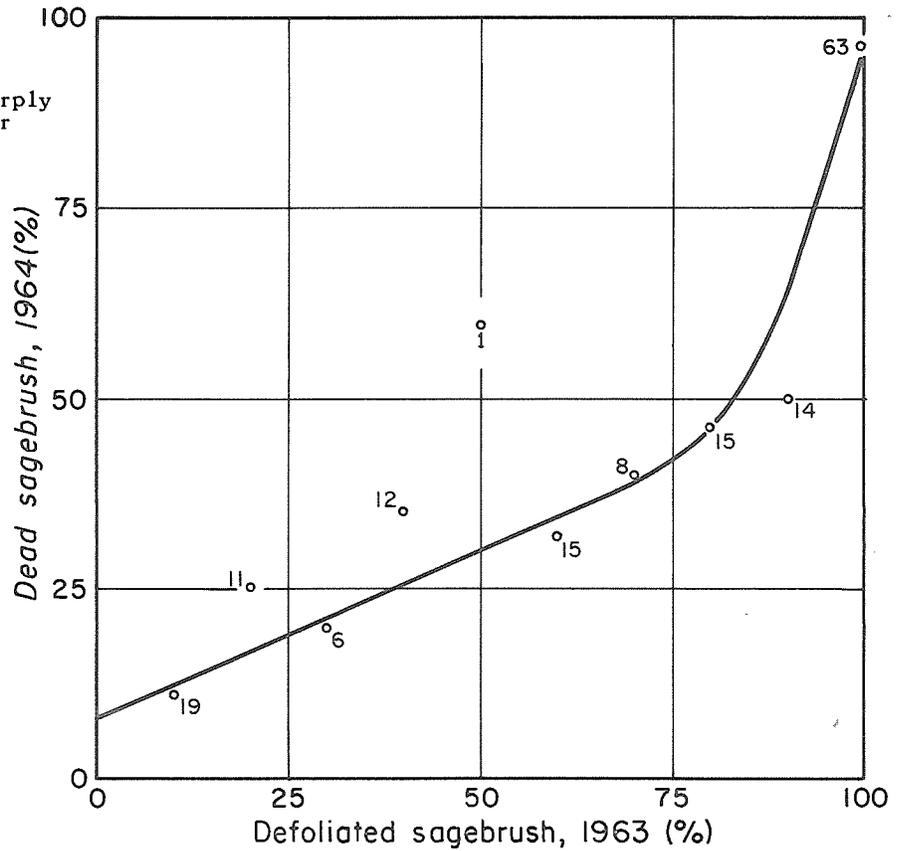


Figure 5.--As population density increased, the amount of defoliation by the sagebrush defoliator increased.

Figure 6.--Mortality rose sharply when plants were 80 percent or more defoliated.



completely defoliated, 46 developed new leaves. Only a few completely defoliated plants in California developed new leaves in the fall after defoliation. Regrowth of defoliated plants has also been reported in Oregon by Drs. Paul O. Ritcher and E. A. Dickason of Oregon State University, and Ira D. Luman of the Oregon State Game Commission. I have no satisfactory explanation for these differences in response of defoliated sagebrush in Oregon and California, but they likely reflect different factors of the physical environment.

PARASITES AND PREDATORS

Parasites and predators greatly reduced sagebrush defoliator populations throughout the area sampled in 1964. Parasitism and predation in the 1964 samples ranged from 25 to 100 percent, and averaged 74 percent. These figures are conservative since they do not include any larvae or eggs which might have been destroyed before midsummer when sampling was started.

Three species of hymenopterous parasites and one predaceous beetle were found in the 1964 rearings. The most common of these parasites was a polyembryonic wasp, presumably Copidosoma (fig. 7). Copidosoma accounted for more than 80 percent of the total parasitism recorded. The predator is believed to be Phyllobaenus subfasciatus. Henry⁴ reported three species of hymenopterous parasites and two species of predaceous beetles in Idaho.

OTHER SAGEBRUSH INSECTS

Other kinds of insects feed on sagebrush. And several were encountered during these observations. In the 1963 rearings a sagebrush leaf miner (Bucculatrix tridenticola) was commonly found with the sagebrush defoliator. In the 1964 rearings, the sagebrush leaf miner was found in 29 out of 33 samples. The leaf miner by itself can cause heavy defoliation.

The sagebrush leaf miner has a 1-year life cycle; the adults emerge well ahead of the sagebrush defoliator. The 1964 rearings started too late to establish the time of initial emergence, but was probably in early July. The last emergence recorded in 1964 was July 31. Populations in the 10-tip samples, from counts of empty pupal cases, ranged from 0 to 455 and averaged 67. The only stages found in 1964 were the pupae and adults. A papery white cocoon attached to the leaves or stems encloses the pupa. The moth is similar in color and markings to the sagebrush defoliator, but has half its wing span (fig. 8). A closely related species, Bucculatrix seorsa, has been reported by H. H. Keifer, California Bureau of Entomology, from sagebrush near Susanville.

Another unidentified moth reared from sagebrush in 1964 was about the size of the sagebrush defoliator but with wings nearly pearly white. Pringle⁶ reported that larvae of a chrysomelid beetle (Trirhabda

⁶Pringle, W. L. A new look at sagebrush control. Rpt. Ann. Mtg., Pac. NW. Sect., Amer. Soc. Range Mangt., pp. 28-29, Nov. 1955.

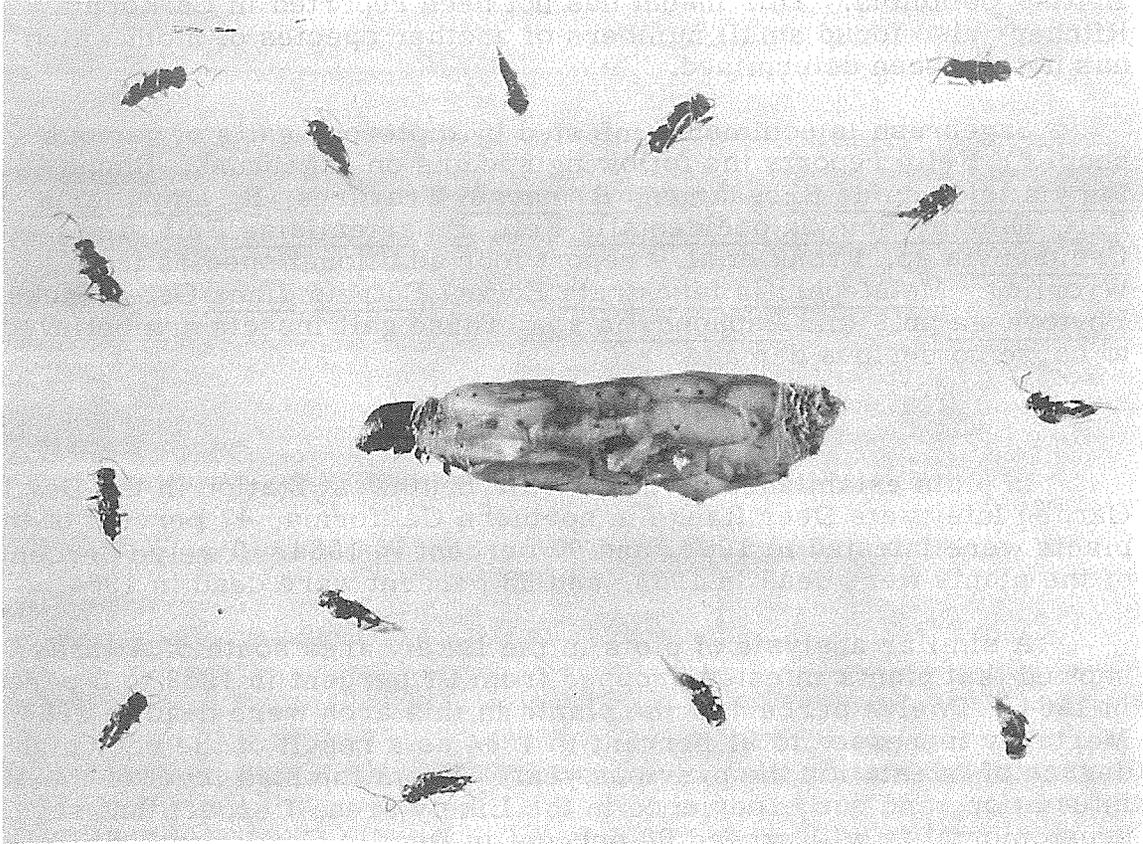


Figure 7.--A mature larva of the sagebrush defoliator killed by *Copidosoma*. Note the numerous capsule-like cocoons, which practically fill the body cavity, and from which the many adults of the parasite have emerged.

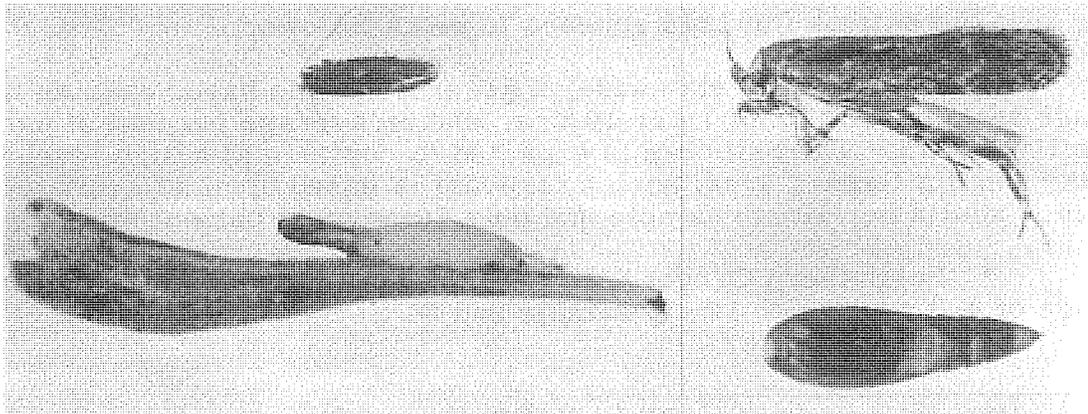


Figure 8.--Adults and pupae of *Bucculatrix tridenticola* (left) and *Aroga websteri* (right). The *B. tridenticola* pupa is attached to its cocoon on a sagebrush leaf.

pilosa) caused serious local damage to big sagebrush near Kamloops, British Columbia. This insect has not been reported in California. Ritcher⁷ also found small numbers of another species of moth which has not yet been determined.

Sagebrush is commonly infested by dipterous galls of various shapes. Felt⁸ reports the following species on sagebrush: Rhopalomyia tridentatae RübSaamen, R. navasi Travares, R. ampullaria Felt, Diarthronomyia occidentalis Felt, D. artemisiae Felt, and Cecidomyia sp. Fronk et al.⁹ report four additional species from Wyoming: Metatephritis fenestrata Foote, Eutreta diana Osten Sacken, Phytophaga sp., and Asphondylia sp. These gall insects are believed to cause no serious damage.

TREND OF INFESTATION

In plots established by the Pacific Southwest Station in the Devil's Garden Interstate Deer Range in northern California, 47 percent of the plants were infested in 1963, and 97 percent in 1964. Twelve percent of the plants were dead in 1963, and 33 percent were dead in 1964.

A similar analysis of plots in the Likely area south of Alturas showed that plants infested dropped from 91 percent in 1963 to 6 percent in 1964. Twelve percent of the plants in this area were dead in 1963. Mortality increased to 91 percent in 1964 as a result of the very high degree of infestation the previous year. From the high level of the 1964 infestation, and our experience in the Likely area, I expect that sagebrush mortality will exceed 90 percent in Devil's Garden in 1965.

In general the population sampling plots showed that the heaviest current defoliation occurred in the Alturas and Devil's Garden areas, in Modoc County, California. The Oregon plots showed light to medium defoliation. And defoliation in the Nevada plots was generally very light.

The outlook for 1965 appears to be as follows:

• In California statewide, a general decline based upon an average adult population of 7 per 10 tips, and an average percent of parasitism of 73. The outbreak is expected to continue at a high level in the Devil's Garden area; such a forecast is based upon an average of 26.7 adults per 10-tip sample and only 50-percent parasitism.

• In southern Oregon, the infestation is expected to decline (average of 4.8 adults per 10-tip sample and 84-percent parasitism).

⁷Personal communication with Dr. Paul O. Ritcher, Oreg. State Univ., Corvallis. Sept. 1963.

⁸Felt, E.P. Plant galls and gall makers. 364 pp. Ithaca, N.Y.: Comstock Pub. Co. 1940.

⁹Fronk, W. D., Beetle, A. A., and Fullerton, D. G. Dipterous galls on the *Artemisia tridentata* complex and insects associated with them. Ann. Ent. Soc. Amer. 57(5): 575-577. 1964.

° In western Nevada, the infestation is expected to continue to decline and should be at a low level; this expectation is based on an average of only 1.5 adults per 10-tip sample, coupled with 90-percent parasitism.

IMPACT ON SAGEBRUSH RANGES

The most serious impact of the sagebrush defoliator on sagebrush ranges will be in deer and antelope wintering areas. The situation may become critical on the Devil's Garden deer range. Already sagebrush has been killed outright over extensive areas, and more is expected to die as the result of the 1964 defoliation. Unfortunately, no information is available on how many acres of sagebrush have been seriously damaged so far. Such information is urgently needed before a proper evaluation of the situation is possible. Even less information is available on the extent of damage on antelope ranges.

Except for winter game ranges, the over-all impact is not believed to be serious. It is unlikely that the sagebrush defoliator will completely eliminate sagebrush over vast areas. Even where defoliation is complete, a few sagebrush plants will survive to aid in revegetation. Even where sagebrush is seriously damaged, sagebrush mortality is usually spotty--with patches ranging from a few hundred acres to several thousand acres. Because of the many acres of land covered by sagebrush in California and the other Western States, the percentage of the area denuded is relatively small.

In discussing the management implications of the current infestation, Dr. Dillard H. Gates, of Oregon State University, stated: "The over-all effects of the moth have tremendous range improvement and management implications. The sagebrush kill (by Aroga) appears to be equivalent to a \$75,000 spray job, but the full effects of the insect cannot be accurately determined as yet. If the 'kill' is permanent, then those concerned with range improvement should be planning to take advantage of a favorable situation."¹⁰ While this may be a favorable situation in so far as the cattlemen are concerned, it may develop into a disastrous situation for the game manager.

NEEDS FOR FURTHER RESEARCH

Henry⁴ has adequately investigated most of the important aspects of the biology of the sagebrush defoliator, but his information is still unpublished. This note generally confirms Henry's findings, except on the overwintering stage of A. websteri; I had extreme difficulty in finding the first-instar larvae in mined leaves during the late fall and winter. Possibly larvae overwinter in places other than mined leaves.

This study established differences in the effects of defoliation in different geographical locations. Questions remain of the effect of available soil moisture, plant vigor, age of plant, species of sagebrush,

¹⁰Anonymous. Science's newest sagebrush removal weapon--the moth. West. Livestock Jour. 41(57): 78-79. 1963.

exposure, elevation, and other ecological factors on mortality or damage resulting from defoliation.

Different degrees of regrowth after defoliation were discovered but not investigated during the current study. The reasons for these differences should be investigated.

An important aspect of mortality in sagebrush caused by the defoliator is the species of plants which replace sagebrush. Limited evidence shows that most of the succeeding plants are species with much lower palatability or utilization than the original sagebrush. Another problem is the length of time that elapses before the sagebrush again returns as a climax type.

The only phases of Aroga population dynamics investigated in the current study were limited population sampling of the insect in the final developmental stages and some of its parasites and predators. Under the conditions of the study, the effect of predation was not identifiable; it may be important. We need to study more closely the earlier developmental stages of both Aroga and the predator. Further research should include a study of all factors expected to influence population trends, and a study of all stages of the insect.

In several instances the insect population was dramatically reduced the year after complete defoliation of sagebrush in local areas. There was evidence that high populations of adults emerged in the year of heavy defoliation, yet practically no defoliation was noted the following year. This phenomenon cannot be explained on the basis of parasites or predators. Possibly not enough live leaves remained in the heavily defoliated areas for the overwintering larvae; this should be investigated in further studies.

This study clearly demonstrated that the associated sagebrush leaf miner (Bucculatrix) contributed to the over-all defoliation in many areas. In a few areas the leaf miner by itself caused more than 90 percent defoliation. Further studies should be made to evaluate the importance of this insect.

Practically nothing is known about the loss in carrying capacity of a range where high sagebrush mortality occurred. This damage occurs suddenly and is expected to have a drastic effect in local areas, particularly on deer and antelope winter ranges. This is one of the most important problems facing the game manager.

Finally the sagebrush defoliator is definitely a sagebrush killer. Under natural conditions, it frequently is as effective as chemical sprays in the elimination of sagebrush. This insect possibly could be substituted for chemical sprays in the biological control of sagebrush, where range management practices call for the elimination of sagebrush. This possibility appears to offer a fruitful area for further study.

The Author
RALPH C. HALL was formerly on the forest insect research staff of the Pacific Southwest Station. A 1925 forestry graduate of the New York State College of Forestry (Syracuse), he also holds a master of forestry degree from Harvard University (1927), and a doctorate from the University of Michigan (1931).