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**CHARACTERS, DISTRIBUTION, AND FOOD PLANTS OF
LEAFHOPPER VECTORS OF VIRUS CAUSING
PIERCE'S DISEASE OF GRAPEVINES**

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**LIFE HISTORY OF THE BLUE-GREEN SHARPSHOOTER,
NEOKOLLA CIRCELLATA**

HENRY H. P. SEVERIN

**TRANSMISSION OF THE VIRUS OF
PIERCE'S DISEASE OF GRAPEVINES BY LEAFHOPPERS**

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Distinguishing characters, especially genitalia, are given for the following vectors:

Helochara delta Oman
Carneocephala fulgida Nottingham
Draeculacephala minerva Ball
Neokolla circellata (Baker)
Neokolla confluens var. *pacifica* n. var.
Neokolla severini DeLong
Pagaronia confusa Oman
Pagaronia 13-punctata Ball
Pagaronia triunata Ball
Friscanus friscanus (Ball)

Differences in genitalia distinguish *Neokolla confluens* var. *pacifica* from *N. confluens*. All ten vectors occur in California; several of them have been reported only from this state. The usual food plants of most of them are grasses, though some have been collected on *Vinca* spp., some on various weeds, and *Neokolla circellata* on grapevine and other woody plants.

Life History of the Blue-Green Sharpshooter, *Neokolla circellata* 187

The female deposits a single egg in a slitlike egg chamber cut in the petiole or midrib of grapevine leaves. The egg period varies from 12 to 22 days during the spring in the greenhouse. Nymphs pass through 4 to 6 molts. The average duration of the nymphal stages was 46 to 53 days on grapevines, 58 to 66 days on common alfalfa. Under natural conditions the adults acquire the winged stage during the summer, winter over, and die in the spring. At Berkeley there is usually only one generation a year, but a partial second generation may occur.

Transmission of the Virus of Pierce's Disease of Grapevines by Leafhoppers 190

In single-insect transmission of virus from infected to healthy grapevines, the most efficient vectors tested were *Neokolla circellata* (65 per cent), *Carneocephala fulgida* (33 per cent), and *Helochara delta* (32 per cent). Lower percentages were obtained with *Draeculacephala minerva*, *Friscanus friscanus*, *N. severini*, and *Pagaronia confusa*. No infections were obtained with *P. triunata* or *N. confluens* var. *pacifica*. *N. circellata* was the only one of four species tested that gave a significant transmission of virus from infected grapevines to healthy alfalfa (35 per cent). In single-insect tests, no transmissions from infected to healthy alfalfa were obtained with five species, or from infected alfalfa to healthy grapevines with *P. confusa*. Some of the vectors that proved inefficient were short-lived when confined on grapevines and alfalfa in the greenhouse. Species of leafhoppers of the subfamily Anthysaninae, two species of fulgorids, and unidentified species of cicadas failed to transmit the virus. In transfers from infected to healthy grapevines, the minimum latent period was 2 hours in *Neokolla circellata* and *Carneocephala fulgida*, 7 hours in *Draeculacephala minerva*. In the greenhouse, some adults of the blue-green sharpshooter, reared on infected grapevines, retained the virus throughout adult life, in one case for 122 days.

LIFE HISTORY OF THE BLUE-GREEN SHARPSHOOTER, *NEOKOLLA CIRCELLATA*¹

HENRY H. P. SEVERIN²

THE BLUE-GREEN SHARPSHOOTER, *Neokolla circellata* (Baker), is efficient in transmitting the virus of Pierce's disease of grapevines, as shown in the third paper of this issue (Severin, 1949).³ Its efficiency, its wide distribution (DeLong and Severin, 1949), and its abundance establish it as one of the most important vectors of the virus, especially in north coastal vineyards of California. Since the life history has not previously been reported for this sharpshooter, studies were undertaken on the following aspects: oviposition, egg period, hatching, number of molts, duration of the nymphal stages on grapevines and on alfalfa, and the number of generations under natural conditions at Berkeley in 1943 to 1948. This paper reports the results.

Oviposition. Large populations of adults collected in the field during the spring were allowed to oviposit in grapevine cuttings. In the process of oviposition, the female cuts an incision in the petiole, rarely in the midrib, and a single egg is deposited in the slitlike egg chamber.

Egg Periods. In the greenhouse, eggs deposited in the petioles during March, April, and May hatched from 16 to 22 days after oviposition.

Hatching. Nymphs hatch in the early morning, beginning at 5:00 A.M. during June. During the process of hatching, the nymph, enclosed in the chorion and vitelline membrane, pushes out of the slitlike aperture of the egg chamber. After extrication from the eggshell and embryonic membrane, the nymph remains suspended with the tip of the abdomen in the embryonic envelope, legs sprawled out and the elytra and lower wings held apart. The nymph crawls away after the chitin hardens, and usually settles on the lower surface of the leaf to take its first meal. Sometimes the nymphs experience difficulty in withdrawing the end of the abdomen from the eggshell and membrane. They frequently drop to the ground and then sip moisture from the soil. The dried, shriveled eggshell and vitelline membrane remain in the aperture of the egg chamber.

Mortality during Hatching. Hatching is usually completed successfully when early-morning temperatures are between 54° and 68° F. But above this temperature the nymphs push out of the apertures of the egg chambers, fail to rupture the chorion and vitelline membrane, and die.

Molting. There are certain indications which appear a day or two before the nymph molts. The body becomes distended, the membranous connections between the head and thorax and abdominal segments become greatly stretched, and the abdomen shows a rounding out.

Duration of Nymphal Stages. The interval or periods between molts (stages or stadia) and the total duration of these periods is given in table 1. The average duration of the nymphal stages of this leafhopper is shorter on three varieties of grapevines than on common alfalfa. On grapevines the total dura-

¹ Received for publication May 17, 1948.

² Entomologist in the Experiment Station.

³ See "Literature Cited" for citations, referred to in the text by author and date.

tion of the nymphal stages of the males averaged 47.0 to 52.7 days, females 46.3 to 51.3 days; and on alfalfa, males 57.6 days, females 66.2 days. On the three varieties of grapevines, one nymph molted 4 times, 21 nymphs 5 times, and 6 nymphs 6 times; and on alfalfa 1 nymph molted 4 times, 17 nymphs 5 times, and 7 nymphs 6 times.

TABLE 1
DURATION OF NYMPHAL STADIA OF *NEOKOLLA CIRCELLATA*
REARED ON GRAPEVINES AND ALFALFA

Instar	On Emperor grapevines		On Palomino grapevines		On Ribier grapevines		On California Common alfalfa	
	Males	Females	Males	Females	Males	Females	Males	Females
	<i>days</i>	<i>days</i>	<i>days</i>	<i>days</i>	<i>days</i>	<i>days</i>	<i>days</i>	<i>days</i>
First.....	8-9	7-9	7-10	7-9	7-14	6-10	7-12	7-18
Second.....	6-10	5-7	5-7	5-7	6-9	5-8	3-15	6-13
Third.....	5-27	5-11	5-12	7-12	7-8	5-13	6-26	5-18
Fourth.....	5-7	6-10	7-11	4-12	7-10	4-28	4-16	2-16
Fifth.....	13-27	7-18	11-15	8-19	12-16	10-22	7-26	4-21
Sixth.....	.....	13	13-14	14-17	.....	17	17-21	18-28
Total, range.....	39-77	43-50	45-53	43-56	39-54	42-62	43-74	57-85
Average total.....	52.7	46.3	50.5	50.2	47.0	51.3	57.6	66.2

TABLE 2
AVERAGE MEASUREMENTS OF NYMPHAL INSTARS AND
ADULTS OF *NEOKOLLA CIRCELLATA*

Stage	Diameter of head across compound eyes			Length of head, thorax and abdomen			Length from head to end of wings		
	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean
	<i>mm</i>	<i>mm</i>	<i>mm</i>	<i>mm</i>	<i>mm</i>	<i>mm</i>	<i>mm</i>	<i>mm</i>	<i>mm</i>
Nymphs:									
First instar.....	0.47	0.61	0.52	1.35	1.72	1.63	.....	.....	.....
Second instar.....	0.68	0.76	0.73	2.08	2.56	2.30	.....	.....	.....
Third instar.....	0.89	0.96	0.93	2.37	3.12	2.75	.....	.....	.....
Fourth instar.....	1.08	1.20	1.15	3.60	4.12	3.83	.....	.....	.....
Fifth instar.....	1.40	1.48	1.43	4.72	5.39	4.90	.....	.....	.....
Adults:									
Males.....	1.48	1.50	1.52	5.60	6.00	6.32	6.20	6.50	6.38
Females.....	1.60	1.70	1.64	6.00	6.80	6.45	6.50	7.20	6.91

Measurement of Instars. The diameter of the head across the compound eyes, and the length of head, thorax, and abdomen were measured for each instar. Length from the head to the tip of the wings was also measured for adults. Measurements were made 1 day after hatching and 1 day after each molt. The insects were reared under greenhouse conditions at Berkeley. Table 2 gives the range and mean of the measurements for 10 nymphs of each instar, 10 adult males, and 10 adult females.

Under the conditions used, at least, the ranges for successive instars do not overlap; hence these measurements can be used to determine instars.

Average measurements of the male and female leafhoppers that completed 5 molts show that the males are smaller than the females.

Color of Nymphs and Adults. The nymphs (see plate 4, *A, B, C, D, E* in the third paper of this issue) are white with a yellow tinge along the sides of the abdomen.

In northern California, adult males and females are green or bluish green. In southern California they are often bright blue (Hewitt, Frazier, Jacob, and Freitag, 1942). They are yellowish on the ventral surface and have yellow legs. An occasional dark-blue adult was collected in Napa Valley. Baker (1898) in his description of *Neokolla circellata* gives a detailed description of the color pattern and the black marks on the head and thorax (see plate 4, *F, G* in the third paper of this issue).

Generations. The number of generations was determined under natural conditions. During 1943, 1945, and 1946, 1 generation occurred in Berkeley; nymphs that hatch in the spring become adults during the summer; the adults winter over, and die the next spring. In 1944 a partial second generation developed on Japanese or Boston ivy, *Parthenocissus tricuspidata*, and on *Statice perezii*. An occasional nymph was taken during the winter of 1946-47 and 1947-48.

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