Suitability of *Oryza* and Other Grasses as Hosts of *Sogata orizicola* Muir[1]

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Abstract

Young adults of *Sogata orizicola* Muir survived and oviposited as well on the wild diploid forms *Oryza perennis* var. *cubensis* (Moench), *O. perennis* var. *barthii* (Chevalier), and *O. balunga* Yeh and Henderson (=*O. perennis* var. *balunga* (Sampath and Govindaswami)) as on the cultivated variety, *O. sativa* L. var. Nato. Newly emerged nymphs caged on these wild forms completed their development normally. The other eight species of *Oryza* and five species of grasses tested did not prove to be suitable hosts for *S. orizicola* in these greenhouse studies.

Hoja blanca, an insect-transmitted disease of rice, is a serious threat to the rice industry in the Western Hemisphere. Origin of the disease is obscure. It is believed to have appeared in rice during the early 1950's, but received little attention until its discovery in Panama (Cralley 1957). However, the disease was probably observed and described in Colombia as early as 1935 (Garces-Orejuela et al. 1958).

The disease and its vector, the rice delphacid (*Sogata orizicola* Muir), were discovered in Florida in 1957 (Atkins & Adair 1957), in Mississippi in 1958 (Atkins et al. 1958) and was found to be widely distributed in Louisiana in 1959 (Atkins et al. 1960). Neither the disease nor the vector has been found in the field in the United States since.

The objectives of this investigation were to determine if resistance to the insect which could be used for breeding purposes might occur among species of *Oryza*, and if some of the common grasses found in Louisiana rice fields could serve as hosts of *S. orizicola*.

Materials and Methods.—Suitability of the various species of rice and grasses as hosts of *S. orizicola* was determined by comparing longevity, oviposition and viability of eggs on each of them with that on the cultivated rice variety Nato. Nine diploid and three tetraploid species of *Oryza* and five species of wild grasses were studied. Diploid species were *O. perennis* var. *cubensis* (Moench), *O. perennis* (Moench) var. *barthii* (Chevalier), *O. balunga* Yeh & Henderson (=*O. perennis* (Moench) var. *balunga* (Sampath & Govindaswami)), *O. grandiglumis* (Doell) Prodoehl, *O. stapfii* Roschevicz, *O. granulata* Nees, *O. australiensis* Domin, *O. breviligulata* Chevalier & Roehrich, and *O. glaberrima* Steudel. Tetraploid species were *O. minuta* Presl, *O. latifolia* Desvaux, and *O. alta* Swallen. The wild grasses were *Digitaria sanguinalis* (L.) Scopoli, *Echinochloa colonum* (L.) Link, *Paspalum urvillei* Steudel, *Zizaniopsis miliacea* (Michaux) Doell & Ascherson and *Leersia lenticularis* Michaux. The cultivated variety *O. sativa* L. var. Nato was included as a control.

Experiments were conducted in a greenhouse where the temperature usually varied from 70° to 100° F. and relative humidity from 30% to 95%. Plants were grown in Olivier loam soil in 1-gallon tin cans. Vigorous growth was maintained by adding 8-8-8 fertilizer and water as needed. A stock colony of *S. orizicola* was established with 23 adults and 16 nymphs collected from rice at Paulina, Louisiana, in October 1959. Insects were maintained on plants of the variety Nato grown in cages 36×18×18 inches screened with 32-mesh saran plastic and provided with a cloth sleeve for transferring the insects and plants. Spiders of several species were a problem requiring frequent transfer of the planthoppers to clean cages. Since insecticides could not be used to control the spiders, they were destroyed by washing them out of the cages with water under strong pressure. Spider mites were controlled by spraying the plants with water.

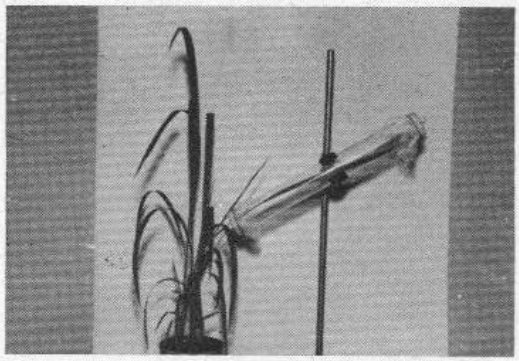

Fig. 1.—Technique used to cage *S. orizicola* on leaves of plants.

Forty 2- to 3-day-old adult insects were caged on each species according to the method developed by McGuire & McMillian (personal communication). Cages consisted of 12-inch sections of glass tubes, 1½ inches in diameter, cut from fluorescent lamps. The ends of the tubes were closed with tobacco cloth provided with ¼-inch holes in the center through which plants and insects were introduced. When cages were in use, holes in the cloth were closed with cotton or corks to prevent the insects from escaping. The method of caging insects on the plants is shown in figure 1.

Insects of known age were obtained by collecting fifth-instar nymphs every 2 days and transferring them to uninfested plants. On the following day all that had become adult were collected and transferred to uninfested plants in a different cage. After 2 days on these plants, 4 replications of 5 males and 5 females were established on each of the test species. Each cage enclosed a single leaf. The insects were transferred to cages enclosing uninfested leaves every 2 days in order to prevent excessive damage to the leaves and excessive development of mold on honeydew excreted by the in-

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sects. Newly hatched nymphs were removed each day.

The number of eggs laid and the percentage which hatched were determined by examining leaves under a dissecting microscope. Although the incubation period was 6 to 8 days under the conditions prevailing during the course of the study, counts were not made earlier than 20 days from the time the adults were removed from the leaves in order to be sure that ample time had been allowed for all eggs to hatch.

One full-grown leaf each of *O. perennis* var. *cubensis*, *O. perennis* var. *barthii*, *O. balunga*, and *O. sativa* var. Nato was caged with three gravid females. Five full-grown leaves were used for each of the other species in order to assure that enough nymphs to conduct the test would be obtained. Leaves were examined every 3 to 4 hours during the day to determine the approximate time of oviposition. When egg deposition was observed, leaves were removed from the cages and observed regularly after the fifth day to determine when hatching occurred. As soon as they hatched, 40 of the newly emerged nymphs were collected and caged on plants of the same species in 4 replications of 10 nymphs each. They were transferred to new leaves in clean cages every 2 days in order to prevent excessive mortality resulting from accumulation of moisture and growth of mold on the inner surfaces of the cages. Mortality was checked each day.

RESULTS.—*Longevity of Adults on the Various Hosts.*—Differences in longevity of adult insects on the various hosts allowed the rice species studied to be separated into two clearly defined groups. The first group was composed of *O. perennis* var. *cubensis*, *O. perennis* var. *barthii*, *O. balunga* and *O. sativa* var. Nato. Longevity of the adults on these species did not differ significantly. Males lived about 1 week and females about 2 weeks on the average on all of them. This was considerably less than reported by McMillian et al. (1961). However, many of the insects included in this study were killed by being trapped in water of condensation which collected on the walls of the cages.

The second group was composed of the other *Oryza* species. The majority of insects caged on these died within 1 or 2 days. None lived longer than 5 days on any of this group, but two each survived on both *O. grandiglumis* and *O. granulata* until the fifth day. Survival on all species of the wild grasses did not differ significantly from the second group of *Oryza* species. Data on longevity are summarized in table 1.

Oviposition and Hatching Percentage.—The number of eggs deposited per female and the percentage of these which hatched could be used as a basis for separating the *Oryza* species studied into three groups. The first group was composed of *O. perennis* var. *cubensis*, *O. perennis* var. *barthii*, *O. balunga*, and *O. sativa* var. Nato. The number of eggs laid per female was practically the same for all of these except *O. sativa* var. Nato, on which heavy infestations of an unidentified mite apparently destroyed many of the eggs, making accurate counts impossible. This mite was not observed on any of the other species. The average number of eggs per female on these hosts compares favorably with 161 obtained by McMillian et al. (1961) in spite of the fact that the insects lived a shorter time.

The second group was formed by *O. grandiglumis*, *O. granulata*, *O. stapfii*, *O. glaberrima*, *O. australiensis* and *O. breviligulata*, in which about one-fourth as many eggs per female was deposited as in the first group. A third group was composed of the tetraploid species *O. minuta*, *O. alta* and *O. latifolia*, in which about one-fourth as many eggs were deposited per female as in the second group.

The wild grass species *E. colonum*, *P. urvillei*, *D. sanguinalis* and *Z. miliacea* received practically the same number of eggs per female as the third group of *Oryza* species. No eggs were deposited in *L. lenticularis*.

The manner in which eggs were deposited was abnormal on all of the tetraploids and all of the wild grasses except *Z. miliacea*. Some of the eggs were laid in the edges of the leaves of the tetraploids in groups of two or three instead of being inserted in the tissues along the midrib in the normal manner, figure 2. On *O. alta* and *O. latifolia* the majority of the eggs were laid singly in the midrib tissues parallel to the leaf surface. Eggs were deposited in tissues of *E. colonum* and *D. sanguinalis*

Table 1.—Average longevity in days of 20 adults of *S. orizicola* on several species of rice and other grasses grown in a greenhouse at Baton Rouge, Louisiana, during 1960.

SPECIES	LONGEVITY IN DAYS	
	Females	Males
O. sativa var. Nato	13.30±8.08	8.30±5.18
O. perennis var. *cubensis*	13.90±6.99	7.35±3.77
O. perennis var. *barthii*	12.60±7.68	9.85±6.02
O. balunga	15.75±6.99	8.25±4.54
O. grandiglumis	2.10±1.59	2.10±1.55
O. granulata	2.45±1.43	2.50±1.31
O. stapfii	1.50±1.25	1.95±0.88
O. breviligulata	2.20±1.05	2.50±1.31
O. glaberrima	2.20±1.55	1.55±1.59
O. australiensis	2.00±0.55	1.80±0.76
O. minuta	2.15±1.27	2.10±1.01
O. latifolia	1.55±0.83	1.50±0.51
O. alta	2.05±0.88	1.60±0.74
E. colonum	1.20±1.23	1.55±0.68
P. urvillei	1.40±0.64	1.70±0.80
D. sanguinalis	1.55±0.83	1.75±0.84
Z. miliacea	1.40±0.59	1.80±0.94
L. lenticularis	1.35±0.74	1.35±0.63

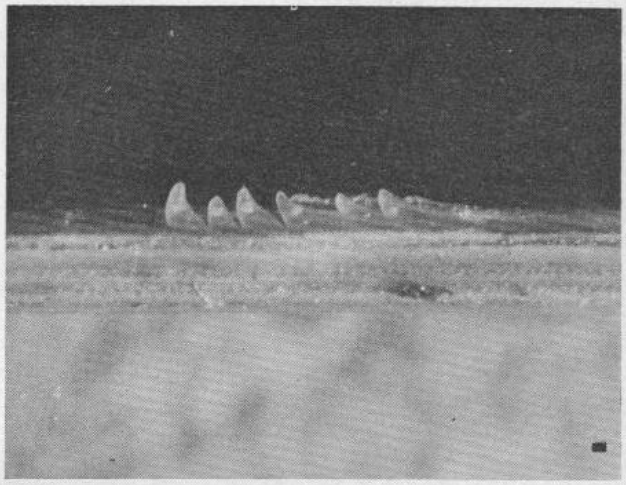

FIG. 2.—Eggs of *S. orizicola* deposited in the normal manner in leaf midrib of *O. sativa*.

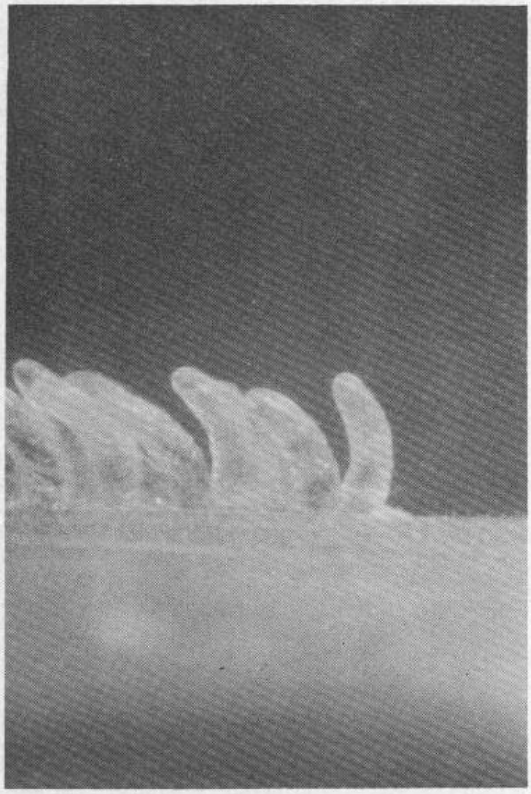

FIG. 3.—Eggs of *S. orizicola* deposited in an abnormal manner in leaf of *E. colonum*.

in such a manner that most of the eggs were left protruding from the leaf, figure 3, or they were laid just beneath the epidermis along the midrib.

The eggs were always laid in the leaf midrib in *P. urvillei*. In some cases they were inserted very shallowly into the tissues, leaving them half or more exposed. These never hatched. However, the majority of the eggs deposited in this species were so placed in the midrib that they could not be seen without tearing away the tissues. The majority of these eggs did not hatch even after 20 days, more than three times the normal incubation period. They seemed to be normal otherwise. When treated with tetrazolium (Colbry et al. 1961) 75 of 85 eggs developed the reddish color characteristic of tissues having active oxidative enzymes. Inhibition of hatching by any of the other species tested was not observed.

Table 2.—Egg deposition of *S. orizicola* and percentage of hatching on several species of rice and other grasses grown in a greenhouse at Baton Rouge, Louisiana, during 1960.

SPECIES	AVERAGE NUMBER OF EGGS LAID PER FEMALE[a]	HATCHING (%)
O. sativa var. Nato	102	—
O. perennis var. *cubensis*	148	93
O. perennis var. *barthii*	145	99
O. balunga	150	94
O. grandiglumis	32	96
O. granulata	28	93
O. stapfii	31	94
O. breviligulata	16	95
O. glaberrima	38	94
O. australiensis	33	96
O. minuta	10	68
O. latifolia	7	69
O. alta	5	61
E. colonum	5	49
P. urvillei	11	48
D. sanguinalis	5	57
Z. miliacea	7	80
L. lenticularis	0	—

[a] Based on 20 females per plant.

The percentage of eggs which hatched was the same for all the *Oryza* diploids. It was not determined for eggs deposited in *O. sativa* var. Nato because of the mite damage mentioned previously. It was considerably less in the tetraploid species than in the diploids and about the same as in the wild grasses. Data summarizing oviposition and per cent hatch of eggs are given in table 2.

Ability of S. orizicola to Complete Development on Rice and Other Grasses.—The incubation period for those eggs which hatched varied from 6 to 8 days on all hosts on which oviposition occurred. The ability of nymphs to complete their development could be used as a criterion for separating the *Oryza* species into three groups. Nymphs caged on *O. perennis* var. *cubensis*, *O. perennis* var. *barthii* and *O. balunga* completed their development in the same time and essentially as successfully as on *O. sativa* var. Nato. A small percentage was able to complete development on the second group, which was composed of *O. stapfii*, *O. grandiglumis*, *O. granulata* and *O. australiensis*. However, the time required was extended considerably and these individuals never reproduced. The third group composed of *O. breviligulata*, *O. glaberrima* and the tetraploids *O. minuta*, *O. alta* and *O. latifolia* did not support nymphal development. Nymphs did not develop beyond the third instar on the two diploids of this group and the second instar on the tetraploids. Newly hatched nymphs caged on the wild grasses lived less than 24 hours except on *Z. miliacea* on which some lived as long as 48 hours. Data showing the ability of *S. orizicola* to complete nymphal development on the various hosts are summarized in table 3.

DISCUSSION OF RESULTS.—Response of *S. orizicola* to the *Oryza* species groups showed remarkable similarity to such groups arranged according to their cytogenetic relationships (Yeh & Henderson 1961). *O. perennis* var. *cubensis*, *O. perennis* var. *barthii* and *O. balunga* were equal to *O. sativa* var. Nato as hosts for *S. orizicola*. The insect could not complete its development satisfactorily on any of the other species of *Oryza* or wild grasses studied.

According to Yeh & Henderson (1961), *O. sativa* and *O. balunga* possess the same genome and their hybrids are completely fertile. Their work showed the genome of *O. perennis* var. *cubensis* and *O. perennis* var. *barthii* to be basically the same, but they found that all hybrids of these two forms with *O. sativa* were almost completely sterile. They considered that *O. glaberrima*, *O. breviligulata* and *O. stapfii* possessed the same genome. This differed from that of the groups named above. Their work showed *O. sativa*×*O. glaberrima* hybrids to be completely sterile. The reactions of *S. orizicola* to these species also indicated that they were distantly related to *Oryza sativa* just as the cytogenetic studies showed them to be. The more closely related to *O. sativa* the better suited the species proved to be as a host of the insect.

Table 3.—A comparison of the percentage of nymphs[a] of *S. orizicola* completing nymphal development and average number of days needed to complete development on various species of *Oryza* and wild grasses grown in the greenhouse at Baton Rouge, Louisiana, during 1960.

SPECIES	AVERAGE NUMBER OF DAYS IN NYMPHAL STAGE	PERCENTAGE COMPLETING NYMPHAL DEVELOPMENT
O. sativa var. Nato	14.0	67.5
O. perennis var. *cubensis*	16.5	62.5
O. perennis var. *barthii*	13.5	82.5
O. balunga	14.5	57.5
O. stapfii	21.0	2.5
O. grandiglumis	23.5	5.0
O. granulata	18.0	2.5
O. australiensis	26.5	5.0
O. breviligulata	4.8[b]	0.0
O. glaberrima	4.5[b]	0.0
O. minuta	2.5[b]	0.0
O. latifolia	2.3[b]	0.0
O. alta	2.1[b]	0.0
Z. miliacea	1.6[b]	0.0
E. colonum	1.0[b]	0.0
P. urvillei	1.0[b]	0.0
D. sanguinalis	1.0[b]	0.0
L. lenticularis	1.0[b]	0.0

[a] Based on 40 nymphs per plant.
[b] Number of days nymphs survived.

Several of the diploid and all three of the tetraploid species studied were either highly resistant or virtually immune to *S. orizicola*. However, none of them offers any good possibility of being utilized successfully in developing forms resistant to the insect because of their genetic incompatibility with *O. sativa*. This suggests that efforts to develop varieties with effective resistance to the insect are likely to be extremely difficult.

None of the wild grasses studied proved to be suitable hosts for *S. orizicola*. If this pest should become established in the United States, it appears that these grasses could not serve as alternate hosts for it. The obvious dependence of *S. orizicola* upon *O. sativa*, or its close relatives, makes it unlikely that this pest can become permanently established in the major rice growing areas of the United States. Rice does not grow in these areas during the winter months, and all evidence available indicates that this species is unable to survive such an extended host-free period.

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