✓ Symposium on

The Major Insect Pests of the Rice Plant

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29 Insect Pests of Rice in the United States

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Rice is grown on approximately 1,792,000 acres in the United States each year. The acreage is concentrated in two major producing areas. The southern area is located primarily in parts of Arkansas, Louisiana, and Texas. Rice is grown each year on approximately 1,468,000 acres in the southern area and on 323,630 acres in the western area, which is located in California. Rice is subject to insect damage wherever it is grown in the United States. Problems associated with insect pests of rice in the southern area differ only slightly among the various states. Rice insect problems in the western area are, with one exception, entirely different from those in the southern area.

The following are the major insect pests of rice in the United States.

THE RICE WATER WEEVIL

The rice water weevil, *Lissorhoptrus oryzophilus* Kuschel, is the most common and probably the most destructive insect pest of rice in the United States. The insect apparently has been associated with rice since the crop was introduced into the United States.

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History

Early references to a rice pest believed to have been the rice water weevil were recorded by Riley (1881a). In a letter addressed to Dr. J. L. LeConte, John Screven of Savannah, Georgia, mentioned a species of maggot attacking rice roots. Screven mentioned an adult insect which he called the water weevil. Riley (1881b) published another letter in which Screven explained why he believed the water weevil to be the adult stage of the root maggot, which had previously been sent to him for identification. Adult insects sent by Screven were identified as *Lissorhoptrus simplex* Say (Riley, 1881b). Dr. L. O. Howard observed the rice water weevil in fields near Savannah, Georgia, in 1883, and his observations were recorded by Riley (1883).

Taxonomy

Riley (1883) stated that "this insect was originally described by Say (Curcul., 29; ed., LeConte, I, p. 197) as *Bagous simplex*, and Dr. LeConte founded in 1876 the genus *Lissorhoptrus* upon this and a second species, the *Notiodes apiculatus* Gyllh." Early references to the rice water weevil used the name *Lissorhoptrus simplex*. Kuschel (1951) revised the species in the genus *Lissorhoptrus* and described *L. oryzophilus* as a new species. Both *L. simplex* and *L. oryzophilus* are now known to exist in the southern rice-growing area. Previous work with the rice water weevil could have been concerned with either species or a combination of both. However, *L. oryzophilus* is believed to be the more prevalent.

Biology

The rice water weevil passes through four stages of development: egg, larva, pupa, and adult.

Adult. The adult weevil is small, approximately one-eighth of an inch long. The female is slightly larger than the male. It is grayish with a darker area on the dorsal aspect (Isely and Schwardt, 1924). A technical description of the adult was given by Kuschel (1951). The semi-aquatic adults move into fields by flight, and they move from plant to plant by swimming just beneath the water surface (Newell, 1913). Adults feed, rest, and copulate on leaves and stems of host plants.

Egg. Webb (1914) described the egg and the process of oviposition as follows: "When ready to deposit an egg, the adult female crawls down the rice stem beneath the water and surface dirt to one of the principal roots. Here she inserts the ovipositor, apparently by merely forcing the tip of this organ through the epidermis of the root. The egg is then placed longitudinally just inside the epidermis. The egg is cylindrical, pearly white, and about one thirty-second of an inch in length. It is three or four times as long as broad and is barely visible to the naked eye." The present author and others currently studying the rice water weevil have not found eggs in rice roots.

Larva. The newly hatched larva feeds within the rice roots. As the larva grows, it moves to and feeds within other roots (Webb, 1914). Movement of the larva through the soil, as far as six inches, was demonstrated by Rolston and Rouse (1965): Isely and Schwardt (1934) gave the head capsule measurements for the three larval instars as follows: first instar, .20 to .22 mm; second instar, .33 to .35 mm; third instar, .44 to .45 mm. Detailed descriptions and the suggested duration of the immature stages also were given by Isely and Schwardt (1930, 1934).

Pupa. The pupa is distinct and readily recognized. It is enclosed in the cocoon, which is attached to a rice root. The pupa is similar to the adult in size and form, but is white (Webb, 1914).

Distribution. The original distribution of the rice water weevil in the United States was from the New England states and Canada westward to Michigan and Iowa and south to Texas and Florida (Blatchley and Leng, 1916). The presence of this insect in the rice-growing area of California was first reported by Lange (1959).

Host Plants. Webb (1914) noted that *Paspalum larranagae* Arech. and *Paspalum plicatulum* Michx. were the hosts for the rice water weevil. The insect, when confined, also developed on the following species: *Echinochloa zelayensis* H. B. K., *Paspalum dissectum* L., *Paspalum boscianum* Flugg, *Syntherisma sanguinalis* (L.) Dulac, *Capriola dactylon* (L.) Ktze, *Axonopus compressus* (S. W.) Beauv., *Panicum hians* Ell., *Panicum dichotomiflorum* Michx., *Jussioea suffruticosa* L., and *Eleocharis obtusa* Schult. Barnyard grass, *Echinochloa crusgalli* Beauv., was noted by Isely and Schwardt (1934) as the most common host in Arkansas besides rice.

Seasonal History. The rice water weevil overwinters in the adult stage in Spanish moss and in fine-matted grass (Tucker, 1912). In Arkansas, it emerges from hibernation in late April (Isely and Schwardt, 1934). Webb (1914) gives the emergence period in Louisiana as March 25 to June 26. In Texas, early emergence was noted on March 29, 1961, and on March 12, 1963. These were only incidental, and the main emergence in 1961 started April 26 and continued until mid-May, according to the author's light-trap records. The generations apparently overlap, as adults can be found in rice fields throughout the summer months. The seasonal history in a given field starts when adults from the overwintering generation move into fields of young rice and feed upon the leaves (Tucker, 1912). If the field has not been flooded, adults hide in the soil during the day and feed at night. After the field is flooded, the adults feed both day and night (Ingram, 1927). Oviposition usually begins after flooding; however, in some instances, it is suspected to occur before flooding. Larvae may be found within eight days after flooding. The larvae pass to the second instar in about three days, and three to four days are required for the third instar. The pupal period requires approximately seven days (Isely and Schwardt, 1934). Newly emerged adults may feed on the rice leaves in the field in which they develop, but ordinarily they do not reinfest the same field. The adults fly at night to fields of younger rice and start another generation.

Factors Affecting Larval Abundance

Population levels of the larval stage of the rice water weevil have been found to vary considerably.

The date of planting can obviously influence the level of infestation. Rice that is seeded early in relation to emergence and oviposition is likely to escape heavy infestation (Isely and Schwardt, 1934). Rice seeded in June in Texas had more larvae than rice seeded in May or July (Bowling, 1958).

The possibility that rice varieties differ in susceptibility to infestation or in yield loss resulting from an infestation has been investigated. Isely and Schwardt (1934) found that the variety Caloro was infested with more larvae than other varieties observed. In a series of tests by Bowling (1963a), the larval populations were not significantly different on eight commercial varieties. However, since not all varieties were included in all tests, there could have been undetected differences in susceptibility among some of the varieties used in the experiments. In the same tests, yield response from controlling the rice water weevil was greater for some varieties. Rolston and Rouse (1964a) reported that larval populations on Bluebonnet-50 were lower than on three other varieties tested.

Factors that affect the physiology of the rice plant may indirectly affect larval abundance. Tucker (1912) found that larvae were more numerous in plots receiving fertilizer. Bowling (1963b) noted a linear increase in larval populations with increased increments of nitrogen fertilizer. Plots fertilized with 80 lbs. of nitrogen per acre had more larvae than the unfertilized plots when sampled 58 days after seeding (Rolston and Rouse, 1964a). Other factors involving plant physiology suggested by Rolston and Rouse (1964a) are plant age, alkalinity, chemical injury, and plant density.

Description of Damage and Economic Importance

The rice water weevil attacks the rice plant in both its adult and larval stages. The adult feeds on the leaves of young rice plants. This activity leaves a longitudinal scar or strip where the leaf surface has been removed (Tucker, 1912). This damage is generally believed to be of no economic importance; however, accurate information on leaf-feeding damage by adults is not available.

The larvae of the rice water weevil feed within and upon rice roots. Where larval populations are dense, the root system is reduced to the extent that wind may cause the plant to lean, or, in extreme cases, to become dislodged and float (Tucker, 1912). It also has been noted in some instances that the reduced root system appears blackened and decayed. This damage to the root system of the rice plant causes a reduction in plant height, a slight delay in maturity, and a reduction in yield (Bowling, 1957b). Early reports associated dense larval populations in rice plants with yellow color (Tucker, 1912; Newell, 1913). Observations in various tests where rice water weevil larvae were present in large numbers in untreated plots and absent in treated plots in the same test indicate that yellowing in plants is not a symptom of rice water weevil infestation.

Early estimates of economic damage by the rice water weevil vary. Tucker (1912) estimated damage to vary from 1 to 75 per cent. Cage tests by Ingram and Douglas (1930) in Louisiana suggest that damage by the rice water weevil is negligible. Tests by Isely and Schwardt (1934) in Arkansas show that rice caged in order to exclude the rice water weevil yielded 28.85 per cent more than surrounding rice subjected to normal infestation. In other tests by Isely and Schwardt (1934), where rice fields were drained at the proper time for optimum control of the rice water weevil, yields increased approximately 18 per cent over undrained plots. The use of insecticides that effectively control the rice water weevil has helped to estimate the economic damage caused by this rice pest. In tests conducted by the author in Texas from 1956 to 1962, yield increases resulting from the control of the rice water weevil ranged from 0 to 756 lbs. per acre. The average for all tests was 340 lbs. per acre. The rice water weevil population in untreated plots ranged from 24 to 76 per foot of drill row. The average for all tests was approximately 40 larvae per foot of drill row (Bowling, 1958, 1959, 1960a, 1961a, 1963a,b). The average yield increase in tests conducted by Rolston and Rouse (1960) in Arkansas to control the rice water weevil and grape colaspis was approximately 206 lbs. per acre.

Expected yield decreases because of the rice water weevil cannot always be accurately predicted from larval populations (Bowling, 1963a,b). In some tests, larval populations as high as 31 per foot of drill row did not significantly reduce yield (Bowling, 1961a). Unknown soil conditions or biological factors, in conjunction with rice water weevil infestations, are believed to cause yield losses.

Methods of Control

Cultural. Draining and drying the rice field to control the rice water weevil has been practiced since the insect was first observed (Riley, 1883). Isely and Schwardt (1932, 1934) confirmed the value of this practice, provided the timing is accurate. Rolston and Rouse (1964b) reported that intermittent flooding and draining reduces larval infestations. Draining and drying the field specifically to control the rice water weevil has generally been discontinued.

Chemical. Relatively small amounts of various insecticides effectively control the rice water weevil larvae. Dieldrin, lindane, aldrin, chlordane, DDT, heptachlor, toxaphene, and endosulfan have been found effective to some degree when applied at rates of 4 to 15 oz active insecticide per acre (Whitehead, 1954; Bowling, 1957a; Mathis and Schoof, 1959). Aldrin is presently the most generally used insecticide for rice water weevil control. Tests by Whitehead (1954) in Arkansas showed best results when insecticides were applied to the soil and young rice plants (two to four weeks after planting) just prior to the first flood. Insecticides applied as sprays, as granules, or mixed with fertilizers usually are equally effective (Whitehead, 1954; Bowling, 1959).

Bowling (1957b) found that certain insecticides applied to seed rice prior to planting effectively controlled the larval stage of the rice water weevil. Seed treatment has become the most widely used method of controlling the rice water weevil; consequently, problems associated with this method have prompted considerable research. Insecticides, rates and formulations of insecticides, and insecticides in combination with fungicides have been investigated relative to their effect on rice seed germination (Rolston, Rouse, and Hall, 1960; Bowling, 1965). Problems of phytotoxicity are restricted to certain insecticides or formulations and have not limited the use of seed treatment as a method of rice water weevil control.

Seed treated with aldrin at 4 oz. active ingredient per 100 lbs. of seed was found to be equally effective when seeded at the rates of

40, 60, and 80 lbs. of rice seed per acre (Bowling, 1958). Rolston and Rouse (1964b) concluded that the rate of seeding had little or no effect on rice water weevil control by seed treatment. Seed treated with aldrin was found to be equally effective in controlling rice water weevil larvae when the rice was water seeded or drill seeded (Bowling, 1960a; Rolston and Rouse, 1964b). Rolston and Rouse (1964b) found that neither soil type nor storage of treated seed for five months reduced the effectiveness of seed treatment as a method of rice water weevil control. In the same test, the effectiveness of seed treatment was reduced as the ratio of aquatic grass plants to rice plants increased.

Seed treatment, besides being as effective as other methods of controlling the rice water weevil, has several other advantages. The insecticides, applied by seed processors several months before planting, protect rice in storage against insects and rodents. Since the insecticide is on the seed when planted, the time-of-application factor is automatically eliminated. The insecticides are applied to the seed simultaneously with fungicides, thereby reducing the cost of application. The insecticide is localized in a small soil area and is less likely to injure other forms of life found in rice fields. These advantages have led to the general acceptance of seed treatment in areas where the rice water weevil is a problem.

THE RICE STINK BUG

The rice stink bug *Oebalus pugnax* (F.) is an injurious insect commonly found in North America, east of the Rocky Mountains, and as far north as Minnesota and New York (Sailer, 1944). This insect also is a pest of rice in the southern rice-producing area.

Taxonomy

Sailer (1944) gives the following names applied to the rice stink bug *Oebalus pugnax* (F.) family (*Pentatomidae*, order *Hemiptera*): *Cimex pugnax* Fabricius, 1775; *Cimex typhoeus* Fabricius, 1803; *Pentatoma orthocantha* Palisot de Beauvois, 1805; *Pentatoma augur* Say, 1831; *Cimex vitripennis* Burmeister, 1835; *Moridea typhoeus* (Fabricius), Dallas, 1851; *Pentatoma typhoeus* (Fabricius) Guerin Meneville, Sagra, 1857; *Oebalus typhoeus* (Fabricius) Stal, 1862; *Oebalus pugnax* (Fabricius) Stal, 1868; *Oebalus typhaeus* (Fabricius) Glover, 1876; *Pentatoma (Mormidea) typhaeus* (Fabricius) Stal, 1883; *Solubea pugnax* (Fabricius) Bergroth, 1891.

Sailer (1944) stated that, "The generic name *Solubea* was established by Bergroth in 1891 to replace *Oebalus* Stal, 1862, which he found preoccupied by *Oebalus* Rafinesque, 1815, in the Mollusca. Kirkaldy (1909) subsequently designated (*Cimex typhoeus* F.) = *Solubea pugnax* (F.) as genotype." However, Sailer (1957) reported that, "Dr. W. E. China of the British Museum has brought to attention the fact that *Oebalus* Rafinesque, 1815, was and still is a *nomen nudum*. Hence, Bergroth's 1891 proposal of *Solubea* as a new name for *Oebalus* Stal, 1862, was without justification and *Solubea* Bergroth must be treated as a synonym of *Oebalus* Stal."

Biology

Various workers have studied and described the different stages of the rice stink bug.

Egg. The egg is about 0.86 mm long and 0.65 mm in diameter. It is cylindrical in form and rounded off at the base. The full diameter is carried to the edge of the operculum, forming a decided corner, from which small white processes arise. There are from 67 to 72 of these processes in an egg (Esselbaugh, 1946). Newly deposited eggs are apple green, becoming darker and developing a reddish tinge prior to hatching. The eggs are deposited in masses numbering from 10 to 47. They are arranged in two rows, the eggs of one row alternating in position with those of the other row. They may be deposited on stems, leaves, or panicles of different grasses (Ingram, 1927).

The incubation period recorded by Esselbaugh (1948) ranged from 4 to 8 days, with an average of 5.2 days. Odglen and Warren (1962) recorded a range of from 4 to 6 days, with an average of 5.1.

Nymph. Newly hatched nymphs are ovate-oblong. The head, thorax, legs, and antennae are black, and the abdomen is red, marked with two elongated black spots running crosswise. These markings fade into a light tan during the successive molts of the young bug until the last nymphal stage, when the nymph resembles the adult (Ingram, 1927). A detailed technical description of the nymphal stages is given by DeCoursey and Esselbaugh (1962).

The duration of the five nymphal instars reported by Esselbaugh (1948) were: first instar, 2.7 days; second, 6.0 days; third, 5.4 days; fourth, 6.3 days; and fifth, 9.9 days. The average for the entire nymphal period was 30.3 days. The nymphal periods reported by Odglen and Warren (1962) were considerably shorter, with the entire period ranging from 16 to 20 days.

Adult. The adult is a straw-colored, shield-shaped bug that gives off a strong, disagreeable odor when disturbed. It ranges from three-eighths to one-half inch long and is slightly less than half as broad (Ingram, 1927). The head, pronotum, and scutellum are straw-yellow and frequently have a reddish cast. The antenna is pale red, with the first segment lighter than the others. The legs are yellow with scattered black punctures. The hind wings are iridescent and frequently appear green (Sailer, 1944). The rice stink bug can be distinguished from its near relatives by its elongated shape and the sharp shoulder spines which project forward. A complete technical description of the adult is given by Sailer (1944).

Oviposition data by Odglen and Warren (1962) show an average of 72.5 eggs in an average oviposition period of 16.3 days. Females lived an average of 38.2 days and males, 28.3 days. Hibernation is primarily in wood trash and bunch grass (Odglen and Warren, 1962).

Host Plants. Wild host plants listed by Douglas and Ingram (1942) are as follows: *Echinochloa crusgalli* (L.) Beauv., *E. colonum* (L.) Link, *Digitaria sanguinalis* (L.) Scop., *Panicum dichotomiflorum* Michx., and *Paspalum urvillei*, *Phalaris minor* Retz. Odglen and Warren (1962) list these additional wild hosts: *Paspalum dilatatum* Poir., *Corex* spp., *Echinochloa crusgalli* var. *mitis* (Pursh) Peterm., *Echinochloa crusgalli* (L.) Beauv. var. *crusgalli*, *Rhynchospora inexpansa* (Michx.) Vhal., *Panicum hians* Ell., *Glyceria septentrionalis* Hitchc., *Juncus effusus* L., *Paspalum distichum* L., *Sorghum halepense* (L.) Pers., and *Digitaria* spp. Recorded cultivated hosts are rice, *Oryza sativa* L.; corn, *Zea maize* L.; wheat, *Triticum aestivum* L.; barley, *Hordeum vulgare* L.; rye, *Secale cereale* L.; oats, *Avena sativa* L.; and sorghum, *Sorghum vulgare* Pers. (Odglen and Warren, 1962).

Seasonal History. Overwintering rice stink bugs emerge in early spring. Ingram (1927) gives the emergence period as late April and early May. First emergence noted by the author in Texas in 1961–63 fell within these dates. Since the insects feed almost exclusively on developing seeds of grasses, the adults can usually be found on grasses heading out at the time for stink bug emergence. The rice stink bug reproduces on favorable host plants in or adjacent to rice fields or in pasture lands until rice begins to develop panicles. Factors responsible for initiating movement of the adults from other hosts to rice is not fully understood. Douglas (1939) reported that stink bugs forsake the grasses as the rice panicles emerge. He also noted that when an early field of rice is cut, the population in adjoining fields may increase. Observations by the author suggest that movement to rice is initiated primarily when other hosts have diminished or have become unfavorable for food.

Damage and Economic Importance

Damage. The association of this insect with rice was first noted by Howard and recorded by Riley (1882). Various observers have described the feeding activity of the insect (Webb, 1920; Ingram, 1927). Both the adult and nymphal stages of the rice stink bug feed on the individual grains of rice as the panicle develops. The insect uses its long stylets to puncture the grains in the early stages of development and extracts the fluids present. Grains of rice fed upon in the early milk stage fail to continue normal development, resulting in an empty glume or an atrophied grain. The insects also feed upon grain in the later dough stage of development, and if infected with certain fungi, develop a grain with a black spot, which is commonly termed "pecky" rice (Ingram, 1927; Douglas and Tullis, 1950). Grains that are pecky and do not break during the milling process appear in the head rice and can cause the grade to be reduced. Grains reduced structurally by rice stink bug feeding may break during the milling process and thereby lower the percentage of whole grains or head rice.

Economic Importance. Economic losses caused by the rice stink bug vary. Early estimates of losses in a given field vary from a negligible amount to 25 per cent (Ingram, 1927). The estimated annual loss from pecky rice alone in Louisiana, Texas, and Arkansas in 1930–37 was estimated by Douglas and Ingram (1942) at $473,595. Helm (1954) reported that infestation levels of a bug per sweep of a 15-inch insect net would justify the cost of control.

More recent attempts to evaluate damage from rice stink bugs have been with cage tests, with varying results and conclusions. The work by Odglen (1960) in Arkansas suggested no losses in yields, milling quality, or grade from several population levels of rice stink bugs. The possible absence of micro-organism capable of causing pecky rice was believed to have influenced these results. Cage tests in Louisiana by Swanson and Newsom (1962) show that quality was affected to the extent that federal support prices for each of the four varieties used were reduced even at the lowest infestation level, which averaged between seven and eight bugs per 1,000 panicles. Consistent and severe losses in rough rice yields were reported for infestation levels which averaged 230 or more bugs per 1,000 panicles. Tests by the author in Texas in 1960–61 showed that increased population levels resulted in slight decreases in rough rice yield and milling yield, accompanied by increased percentages of pecky rice. Total loss per acre was $6.53, $12.75, and $19. 93 for population levels of 1, 2, and 4 rice stink bugs per square foot, respectively. Total loss per acre was separated into loss from yield, milling yield, and grade (Bowling, 1962a). Factors believed to have had a minimizing effect on results from these tests were adult stink bug mortality and parasitization of the eggs.

Obviously, many factors need to be considered in predicting economic losses caused by the rice stink bug in a given field. The ratio of insects to grains of rice, the stability of the population, the effect of parasites on the eggs, the presence or absence of various fungi, and the shape of the grain are all factors that may influence losses caused by this insect.

Methods of Control

Climatic and Biological. Ingram (1927) mentioned low winter temperatures on the adults and high summer temperatures on the nymphs as the climatic conditions instrumental in keeping rice stink bug populations at low levels. He listed the red-winged blackbird as an important predator on the adult stage. In Louisiana, Swanson (1960) noted the parasitization of the adult stink bug by the larvae of a tachinid fly, *Beskia Aelops* (Walker). The author has since colstubble of the host plants (Ingram, 1927). The larvae pupate and emerge in spring. The insects breed on other host plants until rice plants are large enough to feed upon. Eggs are laid in clusters on the leaves of rice plants. After the eggs hatch, the larvae move about and feed on the rice plant 24 to 48 hours before boring into the plant. The larvae usually crawl into the space between the leaf sheath and the plant stem to make the entry hole. The young developing larvae feed, attain full growth, and pupate within the plant.

The adult moth emerges through a hole prepared by the larvae before pupation. Detailed studies on the biology of *Diatraea saccharalis* under controlled conditions have been recorded by Pan and Long (1961) and by Wongsiri and Randolph (1962).

Host Plants. Holloway *et al.* (1928) listed the following as host plants of the sugar cane borer: sugar cane, corn, broomcorn, kafir, Johnson grass (*Sorghum halepense* [L.] Pers.), milo maize, sorghum, Egyptian wheat, Sudan grass (*Andropogon sorghum* var. *sudanense* [Piper] Hitchc.), Para grass (*Panicum purpurascens* Raddi), vetiver (*Vetiveria zizanioides* [L.] Nash), red sprangletop (*Leptochloa filiformis* [Lam.] Beauv.), giant broomsedge, and rice. Jones and Bradley (1924) also record *Panicum purpurascens*, Vasey grass (*Paspalum urvillei* Steud.), *Panicum gymnocarpon* Ell., *P. dichotomiflorum* Michx., *Sorghum halepense* (L.) Pers., and *Andropogon glomeratus* (Walt.) BSP as food plants. Douglas and Ingram (1942) observed the sugar cane borer feeding on pearl or cattail millet and shallu. The same writers recorded rice, *Zizania aquatica* L., *Zizaniopsis milacea* (Michx.) Doell and Aschers, and *Spartina cynosuroides* (L.) Roth, as hosts of the rice stalk borer.

Damage and Economic Importance

Damage. The larvae feed on the inner portion of the rice stems, removing the contents until only the outside portion of the stem remains. If the attack occurs early, the head fails to emerge. Plants attacked in the later stages of development produce a white panicle with unfilled grains. Newly hatched larvae have been known to attack the rice plant at the uppermost node after the head has emerged and partially developed. These panicles may break at the injured point and be lost.

Economic Importance. Surveys conducted in 1927–31 by Douglas and Ingram (1942) in Louisiana showed that the number of injured stalks varied from 2.25 to 16.45 per cent. Yield losses were estimated at 124 lb. per acre. Infestations on rice near Edna, Texas, in 1956 varied from 3.4 to 8.6 per cent infested stems (Bowling, unpublished). In general, infestations in Texas have been much lower than observed in this field. The sugar cane borer is usually more numerous in Texas than the rice stalk borer.

Methods of Control

Douglas and Ingram (1942) suggested such cultural practices as pasturing, burning, plowing, or flooding the rice stubble to reduce the overwintering population of rice stem borers.

Two species of egg parasites, *Trichogramma minutum* Riley and an undescribed *Microbracon*, were listed by Ingram (1927). Several insecticides are known to be effective in controlling the larvae of sugar cane borers on sugar cane in Louisiana. Due to the sporadic nature of the infestations of rice, no control measures are presently recommended.

THE RICE DELPHACID

The rice delphacid *Sogata orizicola* Muir is a vector of the virus disease of rice, hoja blanca. The occurrence of the vector and disease in the United States has been reported by Atkins and Adair (1957), Atkins, Kramer, and Hensley (1958), and by Atkins *et al.* (1960). Although neither the vector nor the disease is now known to be present in the field in the United States, both have been the object of research in recent years.

Biology

The various stages of development of the rice delphacid as described by McGuire, McMillian, and Lamey (1960) are as follows:

Egg.

When freshly laid the *Sogata* egg is slightly curved, about 0.7 mm in length, white, and has a very indistinct reticulation on its chorion. The micropyle end is pointed, whereas the caudal end is well rounded. The eggs are laid in the spongy tissues of the midrib of the rice leaf in varying numbers, but with a tendency toward multiples of seven. The sharp micropyle end of the egg usually protrudes from the plant tissues at the oviposition site. When the egg is four days old two lateral red eyespots are visible at the cephalic end, and the color has changed to a very light yellowish-brown. At about eight days the color has deepened and there are vacuolated areas at each end, above and below the now-visible embryo. At hatching the first-stage nymph pushes out of the chorion and onto the leaf surface.

Nymphal Stage.

The first-stage nymph is about 0.5 mm long. Its color is white to light testaceous with two faint brown stripes on the dorsum.

The second-stage nymph is about 1 mm long and has two faint brown stripes on the dorsum. Its color is also white to light testaceous.

The third-stage nymph is somewhat darker in body color, and the two dorsal stripes are broader and dark brown. The insect is about 1.5 mm long.

The fourth-stage nymph is very similar in color to the third-stage and reaches an average length of about 2.5 mm. At this stage the wing pads are now noticeable.

The fifth-stage nymph is almost identical with the fourth but has well-developed wing pads and in general is more robust.

Adult.

The adult male is about 3.0 to 4.0 mm long, is fuscous in ground color, and has a light median stripe on the dorsum. The clypeus has two dark areas laterally leaving a light median stripe which widens toward the white vertex. The pronotum is fuscous with two lateral dark spots and a mediodorsal white stripe. The mesonotum is fuscous with lighter tegulae and a mediodorsal white stripe. The metanotum is fuscous with a lighter and a mediodorsal white stripe. The metanotum is fuscous with a lighter triangle dorsally. The abdomen is generally dark brown; the first abdominal tergum is brownish yellow; all others are dark with light margins and a very faint and narrow middorsal line. The anal segments are black.

The legs are very light testaceous, almost white. The forewings are light testaceous with veins yellow except for R-m, apical part of R4, M1-2, M3, M4, Cu1-2, and associated crossveins. Cell 4R is usually darkened, but at times the basicostal area is hyaline. Cells 2M, 3M, and 4M are darkened as is cell 2Cu, except for a small marginal area in the form of a crescent. The costa goes all the way around the wing, and the section of it on the vannal part is white so that when the wings are folded over the abdomen, the two white dorsal veins cause the white dorsal stripe to extend almost the entire length of the insect.

The alate female is light testaceous with the same white dorsal stripe. The abdominal tergites are of the same general color as the rest of the insect except for a series of lateral marginal dark areas on each tergum which are homologous with the lateral dark stripes on the later nymphal stages (Acuna and Ledon 1957 a,b; Anonymous, 1958). The wing is light testaceous with a small darkened area at the point of anastomosing of the cubital and medial veins. The vannal portion of the costal vein is white, as in the male.

The brachypterous female is light testaceous throughout without any special markings. The wings reach only the hind margin of the third abdominal tergite. The medial white stripe is faintly present on the vertex and thorax. There is no clouding on the wings.

The forms described are the light phase of two color phases found in a *S. orizicola* population. A darker phase in which the melanism is about twice that of the normal insect is also present.

Ecology and Habits. McGuire, McMillian, and Lamey (1960) made the following observations on the ecology and habits of the rice delphacid in Cuba:

S. orizicola is of sedentary habits. The male is the most active of the three adult forms and will fly readily to another plant when disturbed. The alate female has a habit of flying to the ground or water rather than to other plants. All three forms prefer to move around the stem or to the other side of the leaf rather than to fly or jump. The newly hatched nymphs can be found principally on the leaf blade where the eggs are laid. As they get older, and if the population is not too large, they have a tendency to go to the emerging leaf where some may be found even within the roll-up portion. If the plants are young, many may be found on the leaf sheaths. The eggs are usually laid in the midrib on the upper side of the leaf, but when the population is large they are laid on both sides of the leaf. At times the oviposition is so heavy that the midrib will be killed almost completely.

At Camaguey, there is a period of maximum activity at twilight. At this time practically all winged adults were found on the walls of the screenhouse where the main colony was kept. This may be the time of maximum dispersal in the field under natural conditions. In a series of releases made at Jobabo, in the Arrozal Bartes, where the insect population was light, the areas of dispersal, as indicated by the diseased plants, were definite and not too large in diameter.

Heavy winds and flowing water will help in the spread of the insect by actually blowing the insects away or forcing the adults or nymphs onto the flowing water on which they will float to other parts of the field. The insects prefer young plants to older ones and in areas where a heavy infestation is present on older plantings there will be a slow but certain migration to younger plantings.

The insects require high humidity and moderately high temperatures. Temperatures of about 107 F were lethal to the adults and nymphs on two occasions. There has been no mortality observed at 100 F; therefore, the lethal temperatures may be somewhere between these two temperatures. Insects subjected to low temperatures for 24 hours were able to survive at 21 F. The relative humidity in an irrigated rice field usually is high. Insects kept in glass tubes under low humidities have a high mortality; however, the emerging nymphs cannot withstand a saturated atmosphere. Attempts to breed *Sogatas* in tall plastic cages were not successful until ventilation windows were made at the base of the cylinders.

In Cuba there are two peaks in the abundance of *Sogatas*, one in late spring and early summer and another in early fall. The first peak coincides with the population build-up on young rice, up to 50 days old, and the second with the drying up of the old rice and the subsequent migration of the insects to younger rice. The two peaks are probably the result of the weather and the build-up of predators, although the availability of young rice late in the growing season will be a strong factor in the fall peak. The winter season in Camaguey is cool and dry, and even susceptible varieties of rice seeded at this time will usually escape severe injury. Rice seeded at any other time is likely to be heavily infested.

The reproductive systems and mating habits were studied by McMillian (1963). The description of mating habits as summarized is as follows:

> Neither the male nor the female mates until the adult is three days old. Preliminary to mating, the male signals the female when in her vicinity with abdominal vibrations, approximately four per second; a receptive female responds with similar abdominal vibrations. The male then approaches the female and copulation is accomplished. Females need mate only once in order to produce fertile eggs throughout their lifetimes. Mated females usually begin to oviposit several minutes after copulating, and their average total production was 161 eggs each. Virgin females usually laid eggs only in the latter part of their life span and averaged 56 eggs each.

Studies of hoja blanca transmission by the rice delphacid were reported by McMillian, McGuire, and Lamey (1962).

Economic Importance

The economic importance of the rice delphacid and the disease hoja blanca in other countries is great. Since the insect has not become established in the United States, its importance exists only as a serious threat. However, Cordero and Newsom (1962) pointed out that since this insect depends on *O. sativa* or its close relatives as a host, it is unlikely that it can become established in the major rice-growing areas in the United States. McGuire, McMillian, and Lamey (1960) have compiled a comprehensive bibliography on the hoja blanca disease.

Methods of Control

Biological. McGuire, McMillian, and Lamey (1960) suggested that predators and parasites were effective in reducing rice delphacid populations in Cuba. Noted as important among these were two coccinellids, *Coleomegilla maculata cubensis* Csy. and *Cycloneda sanguinea limbifer* Csy., a myrarid, *Anagrus* species, and an undetermined species of *Dryinidae*. Pierce (1961) reported *Sogatelenchus mexicanus* Pierce as a parasite on the rice delphacid in Mexico.

Resistant Varieties. Considerable work has been directed toward developing rice varieties resistant to hoja blanca, but little information is available on resistance to the insect vector. Cordero and Newsom (1962), after a study of the development of the rice delphacid on species of *Oryza*, concluded that the possibility of developing a variety through interspecific crosses resistant to this insect was remote because of the difficulty of crossing species.

Chemical. Experimental information with insecticides for controlling the rice delphacid is limited. McGuire, McMillian, and Lamey (1960) found repeated applications of DDT, methyl dimeton, chlordane, dieldrin, BHC, and malathion effective in reducing the number of diseased plants and increasing yields. Phorate has been effective in reducing populations in greenhouse tests (Newsom, unpublished). The limited information available suggests that an effective insecticidal control program could be developed if the need arises.

THE GRAPE COLASPIS

The grape colaspis *Colaspis flavida* Say is a rice pest in portions of the southern rice-producing area where lespedeza is grown in rotation with rice.

Biology

The grape colaspis is an economic pest of several crops other than rice. Lindsay (1943) has reviewed the early history of this insect on other crops and has also presented the most extensive work on its biology. (This paper was not immediately available to the writer.)

Host Plants. Rolston and Rouse (1965) reviewed the recorded hosts of the grape colaspis and also conducted host-preference studies. They reported that lespedeza and soy beans were both important hosts of adults and larvae in the rice area. Crabgrass, *Digitaria sanguinalis* (L.) Scop., was noted as a preferred larval host.

Seasonal History. Rolston and Rouse (1965) describe the seasonal activity of the grape colaspis in Arkansas as follows:

> These observations indicate that the grape colaspis has one complete generation a year in this region and in favorable situations, a partial second generation. The overwintering larvae spend nearly seven months in cucumiform cells pressed into the earth above or slightly into the subsoil. Since the topsoils in this region are generally shallow and underlaid with heavy clays, nearly all of these larvae are at depths of two to seven inches. Most of the overwintering larvae range from the third to the seventh or eighth instar according to head capsule widths given by Lindsay (1943) for the various instars. Even the largest larvae are not fully grown, although a few are apparently in the tenth and last instar. Movement of overwintering larvae toward the soil surface begins about the first of May and by the middle of June, at the latest, all have entered the top three inches of soil. The larvae resume feeding and complete their growth as they move upward in the soil. Larvae overwintering in lespedeza fields pupate over a period of three to five weeks. Pupae of this brood were found in the field as early as May 20 and as late as June 26. The pupal stage, which is passed in vertical cells that are usually in the top one-half inch of soil, require from three to seven days and averaged 5.4 days in the insectary. The adults leave the pupal cell within a day if the soil is friable. Overwintering brood adults appear in the field about the first of June and are abundant in June and early July. The adults are able to mate upon emergence and may mate several times during their relative short life span. Fertile eggs are deposited in rather large numbers throughout the summer. These are placed in the soil near the surface, unless the female descends into a crack in the soil before ovipositing, or occasionally, in turf.

Damage and Economic Importance

Rice is damaged when planted on land infested by overwintering larvae that developed on the previous crop. The larvae feed upon the germinating seeds and seedlings, reducing the stand of rice. Damage is confined to dry-seeded rice and levees in fields of water-seeded rice. The problem is most acute in the Grande Prairie of Arkansas and the Coastal Prairie of Louisiana, where large acreages of rice are grown following a lespedeza crop. Monetary loss is in the form of yield reduction or replanting expenses. Yield loss occurs where stands are reduced to the extent that tillering cannot compensate for stand reduction (Rolston and Rouse, 1965). Yield increase from controlling grape colaspis and the rice water weevil was 206 lb. per acre in tests in Arkansas (Rolston and Rouse, 1960).

Control

Damaging infestations by larvae can usually be avoided if lespedeza is omitted from the crop rotation, or if rice follows another crop. Soil applications or seed treatment with aldrin are effective in controlling grape colaspis larvae. Phorate as a seed treatment also is effective in controlling this insect (Rouse and Whitcomb, 1947; Rolston and Rouse, 1960). The 1964 Insecticide Recommendations of the Entomology Research Division, U.S. Department of Agriculture (Agriculture Handbook No. 120), mention aldrin or heptachlor as effective against the grape colaspis at the rate of ½ lb. active ingredient per 100 lbs. of seed.

THE RICE LEAF MINER

The rice leaf miner *Hydrellia griseola* (Fallen), a widely distributed insect, is a sporadic rice pest in the western rice-growing area of the United States. DeOng (1922) described an infestation occurring on rice in parts of the rice-growing areas in California. Only minor infestations occurred between 1922 and 1953, when Lange, Ingebretsen, and Davis (1953) reported a serious outbreak.

Biology

The rice leaf miner *Hydrellia griseola* (Fallen) is a member of the tribe *Hydrellini*, subfamily *Notiphilinae*, family *Ephydridae*, order *Diptera*.

Grigarick (1959) described the various stages of the insect as follows:

Adults.

Females—Head: antennae dark, third segment with a slight greenish tinge, arista with five to six branching hairs; frontal lunule and frontoclypeal region finely punctate, most commonly golden but varying from shining white to yellow, to gold, to golden brown, bordered with five facials; palpi clubshaped, sericeous, yellow except dark base, with four setae on distal edge; eye finely and densely pilose; vertex olivaceous brown, lesser ocellars and verticals strong, greater ocellars weak.

Thorax: dorsum olivaceous brown dissipating laterally to metallic blue-green to gray ventral regions; anterior and posterior dorsocentral bristles forming a dorsocentral rectangle with long dimension transverse. Legs: femora metallic blue-green, tibiae dark gray, tarsal segments black except the inner side of the first which is covered with dense golden setae. Halteres lemon yellow. Wings: length 2.5–3.2 mm, hyaline, oval, coastal vein extends up to the extremity of the median, cross veins well separated from one another, costa II nearly twice the length of costa III.

Abdomen: dorsal area of tergites olivaceous brown dissipating laterally to metallic blue-green, with numerous setae; sternites and terminal tergites which are in an extended position. Total body length 2.0–2.8 mm, width 7–0.8 mm.

Male: Under similar rearing conditions, male usually slightly smaller than female, otherwise similar to female except abdominal tergite V is broadly rounded apically. Total body length 1.8–2.7 mm, width 5–0.8 mm.

Larva—First instar: Color nearly transparent to light cream when first hatched, but takes on a yellow to greenish tinge after feeding; length 0.33–1.33 mm; width 10–0.17 mm; pharyngeal skeleton 0.16–0.20 mm long; mean length of mouth hook 0.03 mm; dorsal region of postanal segment bearing two asteriform sclerotized structures which may have two to five projections surrounding a seta.

Second larval instar: Color unchanged; length, 0.82–2.17 mm; width 0.13–0.30 mm; pharyngeal skeleton 0.28–0.33 mm long, mean length of mouth hook 0.05 mm; asteriform structures on postanal region present and somewhat darker and larger than first instar.

Third larval instar: Color unchanged, internal organs and tracheae clearly visible; cylindrical and tapering at both ends; consisting of 13 segments: a pseudocephalon, three thoracic, eight abdominal and one postanal; length 1.67–0.53 mm. Mouth hook and pharyngeal skeleton black with slightly less pigment in area of cheliform spot and tips of dorsal ventral rods; mouth hook of one piece, ventral rods fused, dorsal rods free; length of pharyngeal skeleton 0.43–0.50 mm; mean length of mouth hook 0.06 mm; mouth hook extends exteriorly through several lightly sclerotized processes or paraclypeal phragma surrounding the oral opening. Antennae two-segmented, set on a small enlargement which may be a third segment; minute inferior tubercles ventral to antennae and just dorsal to tip of mouth hook. Anterior spiracles lacking; posterior spiracles terminal on postanal segment. Anus opens ventrally through a slit in the anal plate which is ovoid, slightly concave anteriorly and convex posteriorly, nearly three times as wide as long.

Anterior and posterior margins of dorsal segments bearing numerous spiculi, irregularly arranged in transverse rows and confined to intersegmental furrows; ventrally, these spiculi form distinct, transverse, oval bands or creeping welts on all except the pseudocephalon, anal and postanal segments. First two segments liberally covered with minute spiculi, anal segment bearing only a dorsal group of spiculi; postanal segment circled posteriorly with prominent spiculi, but no asteriform structure as in first and second instars. Anterior to and paralleling each creeping welt is a ring of ten setae, six confined to width of creeping welt and two on each side; postanal segment bearing six setae.

Puparium. Measurement of 25 puparia gave the following size: average length 3.67 mm, range in length 3.10–4.25 mm; average width 1.01 mm, range in width 0.90–1.25 mm. Color, transparent light-to-dark golden brown. Ovoid, subcylindrical; posterior and tapering gradually to last segment which bears two terminal respiratory spines, curvature of posterior and quite variable. Anal plate ovoid, anterior margin convex, posterior margin only slightly concave. Anterior end of puparium gradually tapering on sides to blunt tip, venter straight, dorsum sharply angled downward from fourth segment to tip, forming a dorsocephalo-thoracic cap. Pharyngeal skeleton of third instar larva remains in puparium; setal pattern as shown and described for larva.

Distribution. Grigarick (1959) reports that the rice leaf miner is believed to be widely distributed throughout the Holarctic region. The insect has been collected from 34 states. All states have at least one bordering state with a record of this insect.

Hosts. Grigarick (1959) gives an extensive list of known hosts. He also points out that the *Graminae* is the most important family of plants serving as hosts for the rice leaf miner.

Grigarick (1959) gave the following summary of field and laboratory observations on the biology and ecology of the leaf miner on rice in California.

> *H. griseola* adult activity was noted as early as the latter part of January or the first part of February at rain pools bordered with grasses. Oviposition and mining steadily increased in these areas until the latter part of March when the pools began to dry up. The first generation is usually completed during the first half of April.
>
> The second generation usually occurs on grasses in association with rice field irrigation practices and generally reaches completion in mid-May when the rice is emerging. Adult population and oviposition indices were consistently near their peak at this time. Oviposition starts on rice as soon as it emerges from the water and mining soon follows. A maximum of three generations was found on rice, but each generation was progressively smaller in extent due to adverse maximum temperatures, parasitism, and rapid rice growth.
>
> Adult population and oviposition indices were quite low by the first part of July and leaf-miner activity was almost entirely restricted to the cooler inlet areas associated with wells where water temperatures remained close to 67 F. Observations and existing temperatures indicated the probable completion of four generations, mainly on beardgrass, prior to drainage of the rice fields in September.
>
> Decreasing fall temperatures permit a dispersal to more permanent aquatic areas and a generation is usually completed on grasses in these areas by the latter half of November. Adult flies were observed from November through January and presumably are the main stage of winter carry-over.
>
> Twelve species of parasites were found in California with representatives in four families. The most abundant parasitic species were *Chorebus aquaticus* Muesebeck, *Opius hydrelliae* Muesebeck, and *Halticoptera* sp.
>
> Laboratory studies of the adult showed a

decided preference for cool temperatures and high moisture conditions. Adults remained alive as long as 42 days at 28 F, but thermal death began at 108 F at 4- to 5-minute exposure. Maximum longevity of 146 days occurred at room temperature (49–75 F).

Time-temperature development curves were obtained for the egg, larval, and pupal stages at 5 to 6 constant temperatures. The sum of developmental times of all immature stages ranged from 92.7 days at 50 F to 13.8 days at 90 F.

Damage and Economic Importance

The damage to rice by the rice leaf miner occurs as the maggots feed within the leaves. The maggots feed on the green cells, causing the leaf blades to turn transparent, leaving only the leaf epidermis. The leaves subsequently shrivel and lie prostrate on the surface of the water. The maggots also may mine the leaf sheaths (Lange, Ingebretsen, and Davis, 1953).

In the 1953 outbreak, the loss was estimated at 10 to 20 per cent of the total crop of a probable value of $16 million. In addition, $1,200,000 was expended for insecticides to control this insect (Lange, Ingebretsen, and Davis, 1953).

Method of Control

Spray applications of dieldrin or heptachlor (4 oz active insecticide per acre) effectively control the rice leaf miner. Insecticide application should be made after the plants emerge from the water. Water in the rice field should be lowered prior to making the application and raised again 24 hours after spraying (Lange, Ingebretsen, and Davis, 1953). Grigarick (1959) compiled a comprehensive bibliography of world literature on the rice leaf miner.

THE TADPOLE SHRIMP

The tadpole shrimp *Triops longicaudatus* (LeConte) is a rice pest in the northern counties of California, the western rice-growing area. Rosenberg (1947) described the damage to rice by tadpole shrimp under the names of *Apus oryzaphagus* and *Apus biggsi*.

Biology

T. longicaudatus is commonly called the tadpole shrimp by California rice growers because of its similarity to the true tadpole in color, size, and swimming activity. It is olive-gray, the anterior portion of the body is covered with a shield-like carapace, and the nearly cylindrical abdomen extends from beneath this carapace and terminates in two cercopods. Over-all length may reach 2 to 2½ inches. The crustacean has two large compound eyes and a median ocellus. The first and second pairs of appendages are respectively the antennules and antennae, and the third pair forms two strong-toothed structures called the mandibles, which may be compared to those of a chewing insect. Numerous appendages bearing leaf-like gills attach to the abdomen (Grigarick, Lange, and Finfrock, 1961).

Seasonal History. Dried eggs from the previous year hatch 72 hours after water submergence. The mentanauplii and succeeding stages pass through a series of moults until they become adults. Reddish-orange egg sacks appear along the sides of the abdomen near the carapace in about 8 to 10 days. The number of generations is not known, but it is believed to be more than one (Rosenberg, 1947).

Damage and Economic Importance

The larvae feed on the organic content of the mud and on diatoms, protozoa, and various other small organisms (Grigarick, Lange, and Finfrock, 1961). The digging activity of the shrimp stirs the loose silt and causes muddy water in local areas of rice fields (Rosenberg, 1947). As the shrimp mature, their food and foraging habits change. They feed upon leaves and roots of the rice plants, dislodging the loosely rooted seedlings. Dislodged plants drift with wind and wave action, and the result is uneven stand establishment (Grigarick, Lange, and Finfrock, 1961).

Methods of Control

Rosenberg (1947) found that either DDT or copper sulfate effectively controlled the tadpole shrimp. Portman and Williams

(1952) found DDT to be effective against the tadpole shrimp when applied to the soil before planting, applied with seed at seeding, or applied as a spray to flooded fields. Grigarick, Lange, and Finfrock (1961) found DDT effective when applied as granules with the seed or as granules or sprays after seeding. Diazinon, malathion, and carbaryl (sevin) also were found to be effective when applied at the rate of 2 lb. actual toxicant per acre as postflooding sprays.

OTHER INSECTS OF RICE

In addition to the insects previously discussed, numerous other insects have been reported as rice pests, but are of unknown or of minor importance.

Southern Rice-Growing Areas

The sugar cane beetle *Eutheola rugiceps* LeConte (Douglas and Ingram, 1942).

The chinch bug *Blissus leucopterus* (Say) (Ingram, 1927; Isely and Horsfall, 1931).

A flea beetle, *Systena frontalis* (Fabricius) (Ingram, 1927).

A bill bug, *Sphenophorus oblitus* LeConte (Webb, 1920).

The southern corn rootworm *Diabrotica duodecimpunctata* Olvieri (Webb, 1920).

A grasshopper, *Melanoplus differentialis* (Thomas).

A grasshopper, *Conocephalus fasciatus* (DeGeer) (Bowling, 1962b).

A hemipteron, *Paromius longulus* (Dall) (Douglas and Ingram, 1942).

A hemipteron, *Leptocorixa tipuloides* (DeGeer) (observed by author).

A leafhopper, *Draeculacephala portola* Ball (Bowling, 1961b).

A leafroller, *Ancyloxrpha numitor* (Flanders) (observed by author).

A leafroller, *Hylephila phyleus* (Drury) (observed by author).

Western Rice-Growing Areas

The western 12-spotted cucumber beetle, *Diabrotica soror* LeConte (Ingram, 1929).

A pentatomid, *Thyanta custator* (Fabricius) (Douglas and Ingram, 1942).

A grasshopper, *Melanoplus differentialis* (Thomas) (Douglas and Ingram, 1942).

A grasshopper, *Conocephalus fasciatus vicinus* Morse (Douglas and Ingram, 1942).

A chironomid, *Cricotopus sylvestric* Fabricius (Darby, 1962).

The giant scavenger water beetle, *Hydrous triangularis* (Say) (Portman and Williams, 1952).

DISCUSSION

C. C. Bowling, *United States*

Questions

S. Iwao (*Japan*): The color of the armyworm larvae, *Leucania* (*Pendalethia*) *separata,* which attack rice, corn, and other grasses in Japan, is green to brown to velvety black. Black larvae appear under outbreak conditions. It has been verified experimentally that when the population density is high the larvae become black, and when it is low, they become pale. Black larvae are very mobile, voracious in feeding habits, and tolerant to less suitable host plants and starvation. Such density-related variation is called "phase variation," which is famous in migratory locusts. Has such a phenomenon occurred in *Laphygma frugiperda* or in *Spodoptera mauritia*?

Answer: No, what we have observed is that the young larvae of *Laphygma frugiperda* are green; they become darker, sometimes brown, as they grow older.

A. S. Srivastava (*India*): Is there any precise method for assessing the population of the rice water weevil and its larvae under field conditions?

Answer: The larval population is assessed by separating larvae from samples of plants and soil. The most commonly used sample is one foot of drill row. It is a foot long, four inches wide, and four inches deep. Other sampling procedures are being tested.

H. ISHIKURA (*Japan*): Does cooked hot rice mixed with stink bug-infested grain smell bad? (In case of the attack of Nezara, the cooked rice is hardly edible while it is hot because of the bad smell.)

Answer: The odor from the rice stink bug does not persist in the mature grain and has not been detected in cooked rice.

M. Q. KHAN (*India*): In areas where paddy is grown under swamp conditions, will treating seed with insecticide be effective in the control of the rice root weevil *Echinocnemus oryzae*, which is found in limited areas in southern India? You found this method to be effective in the control of the rice water weevil in the United States.

Answer: Rice seed treatment has been very successful in controlling the rice water weevil in the United States. This method of insect control has several definite advantages: (1) since small quantities of insecticides are used, the cost is nominal; (2) application is simple and inexpensive; and (3) the insecticide is localized in the soil. It would also be advisable to investigate this method of control for other insects.

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