Insecticidal Control for the Rice Stink Bug (Hemiptera: Pentatomidae) Complex Found in Florida Rice[1]

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Abstract Currently, the rice stink bug complex (Hemiptera: Pentatomidae) attacking Florida rice is the most diversified and unique stink bug complex in United States rice production. This complex includes the common rice stink bug, *Oebalus pugnax* (F.), and two invasive species, *Oebalus ypsilongriseus* (DeGeer) and *Oebalus insularis* (Stal). Insecticidal efficacy for these two invasive species is not known. Insecticidal evaluations of five insecticides were made on adults of both sexes of the three species. Weights of adults were also determined. In all three species, females weighed more than males of the same species. Also, *O. pugnax* adults were the largest followed by *O. ypsilongriseus*, with *O. insularis* being the smallest adults. All five insecticides gave a high degree of control of 93–100% for both sexes of all three species. These data are currently useful to Florida rice growers and may be useful to rice growers in other states if the two invasive species spread to those states. These data also provide baseline data for future studies on development of insecticide resistance of the stink bugs in Florida rice.

Key Words rice, stink bugs, Pentatomidae

Although many different insects can be found in rice (*Oryza sativa* L.) fields in Florida, stink bugs are currently considered the most important pest. Green et al. (1954) reported finding four species of stink bugs in Florida rice fields but gave no information on their relative abundance. Genung et al. (1979) reported that five species of stink bugs could be found in rice in Florida, but again no information was given on their relative abundance or seasonal occurrence. Jones and Cherry (1986) first reported the relative abundance and seasonal occurrence of stink bugs in Florida rice based on extensive surveys. In the latter study, four species were found with the rice stink bug, *Oebalus pugnax* (F.), the dominant species comprising >95% of the total stink bug population.

The stink bug, *Oebalus ypsilongriseus* (DeGeer), was first observed in Florida rice fields in 1994. An extensive survey was conducted during 1995 and 1996 with sweep nets to determine the relative abundance and population biology of *O. ypsilongriseus* in Florida rice fields. It occurred in 100% of all fields sampled and constituted 10.4% of all stink bugs collected (Cherry et al. 1998). Data from that study showed that *O. ypsilongriseus*, a well-known rice pest in South America, was

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widespread in Florida rice fields (Cherry et al. 1998). This was the first report of this species being found in commercial rice fields in the United States.

The stink bug *Oebalus insularis* (Stal) was first observed in Florida rice fields in 2007. An extensive survey was conducted during 2008 and 2009 to determine the relative abundance and population biology of *O. insularis* in Florida rice fields. It occurred in 100% of all fields sampled and constituted 20% of all stink bugs collected (Cherry and Nuessly 2010). Data from this study showed that *O. insularis*, a well-known rice pest in the Caribbean islands, Central America, and South America, is now widespread in Florida rice fields. This was the first report of this species being found in commercial rice fields in the United States.

Currently, the rice stink bug complex attacking Florida rice is the most diverse and unique stink bug complex in United States rice production. Also, currently Florida rice growers spray almost all rice fields once or more for stink bug control. However, these recommended insecticides are based on control for the widely found rice stink bug, *O. pugnax*. Hence, it is unknown how effective these insecticides are for controlling the two new *Oebalus* species in Florida rice. The objective of this study was to determine the efficacies of five insecticides in controlling the three *Oebalus* species infesting Florida rice. The emphasis was not to compare efficacies between insecticides because these could vary widely depending on test conditions. Rather, our emphasis was to compare the efficacy of an insecticide for each of the three species. These data provide insight into whether the three species are equally susceptible to insecticidal control and will help Florida rice growers to understand how to control the stink bug complex. Also, the data should be useful to other rice-producing states in the event the two new *Oebalus* species are eventually found to spread there. And lastly, the data will provide baseline data should insecticide resistance develop in any of the three rice stink bug species.

Materials and Methods

Insecticidal evaluations were made on adults of both sexes of the three species. Because insect size may affect insecticidal efficacy, weights of adults were measured to determine if the species or sex of the adults had an effect on insecticidal efficacy. Adults were collected with sweep nets in rice fields on different dates and different locations during June to September 2016. Shortly after collection, sweep samples were frozen for later insect identification. At a later date, 25 adults of each sex of each species were weighed after randomly selecting them from thawed samples of the field collections. Only intact adults not missing legs or antennae through collecting and storage were used.

Rice stink bug adults were collected by sweep nets in rice fields and adjacent weeds during June to September 2016 and 2017 to test for insecticidal efficacy. Leskey et al. (2013) reported that overwintered adults of the brown marmorated stink bug, *Halyomorpha halys* (Stal), were more susceptible to insecticides than were new adults of the summer generations. Because all of our testing was conducted within a 4-mo period, seasonality was not a factor to be considered in our efficacy tests. The June–September period is also the time of maximum flight activity of the three *Oebalus* species in southern Florida, with little flight activity the

Table 1. Insecticides tested for control of three species of rice stink bugs.

Trade Name	Active Ingredient	Formulation	Rate of Product/A*	Rate of AI/A*
Carbaryl 4L	43% carbaryl	L	1.5 qts	1.5 lb
Kendo	13.1% lambda-cyhalothrin	EC	5.1 fl oz	0.04 lb
Malathion 57EC	57% malathion	EC	1.5 pt	0.94 lb
Mustang Maxx	9.2% zeta-cypermethrin	EC	4.0 fl oz	0.025 lb
Proaxis	5.9% gamma-cyhalothrin	EC	5.1 fl oz	0.02 lb

* Insecticides applied at maximum allowed AI field rate in 10 gal/A spray mixture.

remainder of the year (Cherry and Wilson 2011). Within 2–4 h after collection, adults were placed into cages for spraying insecticides. These cages were constructed of fine-mesh metal window screen with each cage measuring 15 × 15 × 2 cm in size. New cages were made for each replicate to avoid possible insecticide residue on cages after being sprayed with insecticides. Five females and five males of one species were placed into a cage. A replicate consisted of six cages with the three species in three cages being sprayed and three cages unsprayed (control). Cages were sprayed the same day as field collection. Six replicates were conducted. Being able to conduct a replicate was totally dependent on being able to collect sufficient numbers of each of the three species at one time for testing because often times the species varied in relative abundance at a time or location.

Insecticides were applied using a moving-nozzle spray chamber (Generation II Spray Booth, Devries Manufacturing Corp., Hollandale, MN) equipped with a TeeJet 8001VS nozzle tip (Spraying Systems Co.®, Wheaton, IL) calibrated to deliver 94 L ha^{-1} at 172 kPa. In 2017, five insecticides were registered for stink bug control in Florida rice. However, as noted earlier, efficacies of these insecticides for controlling the two new *Oebalus* species are unknown. These five insecticides (Table 1) were tested for controlling the three *Oebalus* species. All insecticides were applied at the maximum allowed AI (Active Ingredient) field rate in 95.625 liters/ha spray mixtures to keep these two factors constant across the five insecticides. Blackman et al. (2015) assessed *O. pugnax* mortality 4 h after insecticide treatment in acute toxicity tests. Preliminary tests indicated this time period also caused mortality in our tests. Hence, 4 h after insecticidal spraying, adults were placed on a Petri dish and observed for 15 s. If they did not right themselves and remain in an upright position within 15 s, they were considered dead (Blackman et al. 2015). These criteria are consistent with Miller et al. (2010a), who reported that in bioassays for monitoring insecticide resistance, the most commonly used criteria used to classify insects as moribund or dead are a lack of coordinated movement.

Weights of rice stink bugs were analyzed by using the least significant difference (LSD) test. Percent controls of the five insecticides for sexes of the three species

Table 2. Weights of three species of rice stink bug adults collected from Florida rice fields.

Species	Mean*	SD	Range
O. insularis			
Female	0.030 c	0.005	0.017–0.041
Male	0.020 e	0.005	0.013–0.033
O. pugnax			
Female	0.045 a	0.006	0.035–0.055
Male	0.028 c	0.005	0.020–0.037
O. ypsilongriseus			
Female	0.038 b	0.009	0.020–0.057
Male	0.025 d	0.004	0.016–0.032

* Means in grams in the column followed by the same lowercase letter are not significantly different (alpha=0.05) using the LSD test.

were calculated using Abbott's formula (Abbott 1925) to adjust for unsprayed control mortality. Thereafter, percent controls were analyzed using the LSD test.

Results and Discussion

Weights of rice stink bug adults are shown in Table 2. In all three species, females of the species weighed significantly more than did males of the species. This is not unexpected because females being larger than males is common in insects. Consistent with our data, Meneses et al. (1982) reported that adult males of *O. insularis* were slightly smaller than adult females in Cuba. Females of *O. pugnax* were significantly heavier than females of *O. ypsilongriseus*, which in turn were significantly heavier than females of *O. insularis*. Likewise, males of *O. pugnax* were significantly heavier than males of *O. ypsilongriseus*, which in turn were significantly heavier than males of *O. insularis*. To summarize, based on adult weights, *O. pugnax* adults are the biggest followed by *O. ypsilongriseus*, with *O. insularis* being the smallest adults. Also, of the six morph types, female *O. pugnax* weighed the most, as will be noted in later discussion.

There was an average 10% untreated control mortality observed during the 4 h after insecticide exposure. This mortality was probably due to collecting by sweeping and/or putting and holding adults in cages and was used to calculate percent control of insecticides using Abbott's (1925) formula. Percent controls of the three species using five insecticides are shown in Table 3. All five insecticides provided a high degree of control of 93–100% for both sexes of all three species. Interestingly, the only adults not killed by the insecticides 4 h after exposure were a few female *O. pugnax* in the Kendo and Malathion 57EC treatments. This is consistent with these females, being the largest of the six morphological types

Table 3. Percent control* of three species of rice stink bugs using five insecticides.

	O. insularis		*O. pugnax*		*O. ypsilongriseus*	
Insecticide	♀	♂	♀	♂	♀	♂
Carbaryl 4L	100 a	100 a	100 a	100 a	100 a	100 a
Kendo	100 a	100 a	93 b	100 a	100 a	100 a
Malathion 57EC	100 a	100 a	93 b	100 a	100 a	100 a
Mustang Maxx	100 a	100 a	100 a	100 a	100 a	100 a
Proaxis	100 a	100 a	100 a	100 a	100 a	100 a

* Control calculated using Abbott's formula (1925). Insecticide rates are presented in Table 1. Means in a row followed by the same lowercase letter are not significantly different (alpha = 0.05) using the LSD test.

(Table 2), and hence would be expected to be more difficult to kill by insecticide exposure. Similarly, McPherson et al. (1979) reported that females of the stink bug *Nezara viridula* (L.) had a higher lethal dose (LD_{50}) to methyl parathion than did males. However, it should also be noted that increased insecticide tolerance with increased weight cannot be assumed to be a general pattern among all insects (Savin et al. 1982). Although not observed, it is likely that these few females eventually died from the insecticides, just more slowly than the 4-h test criterion.

It might be assumed that closely related insects would be equally susceptible to an insecticide. However, susceptibility of different stink bug species to insecticides occurs in agricultural crops (Takeuchi and Endo 2012). Other studies have shown that variation in susceptibility to insecticides can vary widely across insect species, even within the same genus (Vernon et al. 2008). Moreover, Guedes et al. (2016) noted that insecticide bioassays usually focus on a single species, particularly a single arthropod pest species. The authors report that this is grievously unrealistic because a single-species environment does not exist in nature, not even when only agroecosystems are considered. Multiple species bioassays are receiving increased attention in environmental studies, but not in arthropod pest management and related fields despite their potential importance (Guedes et al. 2016). Our study showed that five insecticides currently recommended for control of *O. pugnax* in Florida rice also have high efficacy at rates tested for control of the other two invasive *Oebalus* species currently infesting Florida rice. These data are useful to Florida rice growers and may be of future use to rice producers in other states if either or both of the two invasive stink bugs spread into other rice producing states.

In addition, surveys of pesticide susceptibility among pest populations are a proactive approach to detect any shift in insecticide performance and provide an early warning to modify chemical control strategies. Thus, by modifying overall integrated pest management strategies, the viability of a given pesticide may be extended (Miller et al. 2010a). More specifically, Snodgrass et al. (2005) have reported that baseline data are needed to detect changes in susceptibility to insecticides that occur in stink bug populations over time and at different locations. Miller et al. (2010b) reported that insecticide resistance had developed in a Texas population of *O. pugnax*, as later confirmed by Blackman et al. (2015). This study provides baseline data for the future measurement of insecticide resistance in the three species of *Oebalus* currently infesting Florida rice fields.

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