PENTATOMIDAE (HEMIPTERA) ASSOCIATED WITH RICE CROPS IN SOUTHEASTERN AUSTRALIA

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Summary

In response to reports of blemished grain in export shipments of Australian rice a sweep-net survey of stink bugs (Hemiptera: Pentatomidae) was conducted across 38 rice crops in the Murrumbidgee and Murray Valleys during the 2005/6 and 2006/7 rice seasons. Seven stink bug species were recorded, however three species, represented in the samples by both adults and nymphs, accounted for approximately 97% of the 257 stink bugs collected. *Anaxilaus vesiculosus* (Herrich-Schaeffer) dominated the fauna (84%), whilst *Eysarcoris trimaculatus* (Distant) and *Nezara viridula* (L.) constituted 9% and 4% of captures respectively. Although stink bug densities were very low and unlikely to cause significant damage to the crops examined, there was a high level of variability between crops and also between seasons, with a six-fold increase in the average number of bugs collected per crop in the second year of the study. Field-collected *A.vesiculosus* adults placed on a caged rice plant survived for up to 20 days. Nymphs that emerged from eggs laid on the plant were reared through to adulthood without any alternative food sources being supplied. Hulled grain from the exposed plant showed the characteristic blemishes associated with stink bug feeding. This is the first record of *A.vesiculosus* feeding and developing on rice.

Keywords: Pentatomidae, rice, *Eysarcoris trimaculatus*, *Anaxilaus vesiculosus*, grain quality

INTRODUCTION

Stink bugs (Pentatomidae) are serious pests of rice (*Oryza sativa* L.) throughout the world. Although nymphs and adults may feed on various parts of the rice plant, they tend to prefer the developing grain, particularly as it passes through the 'milk' and 'dough' stages. The symptoms of damage depend on when feeding occurs. Grains attacked at the milk stage do not fill properly, and the panicles often remain erect as the crop matures. Stink bugs inject enzymes into the grain whilst feeding, and when grain is at the dough stage, this results in discoloration and structural weaknesses that frequently cause the grain to shatter during milling (Pathak and Khan 1994, Dale 1994, Panizzi 1997). Damaged grains that survive the milling process often have small black or brown spots that mark the points of stylet entry. Grain damaged in this way, combined with grain showing superficially similar blemishes arising from other causes, is broadly defined as 'pecky' rice, and represents a serious quality issue, particularly for industries seeking to export rice to discerning overseas markets. In Australia limits for pecky rice contamination are generally determined by individual customer specifications, however for defined grades of US rice allowable limits for total damaged grains may be as low as 0.5% (USDA 2005).

Commercial rice production in Australia is currently confined to the Murrumbidgee and Murray Valleys of southern New South Wales (NSW), however rice has previously been grown commercially in the Northern Territory (Humpty Doo), Queensland (Mareeba and Lower Burdekin districts), and in the Ord River Irrigation Area of Western Australia. The rice stink bug *Eysarcoris trimaculatus* (Distant) was a serious pest both in Western Australia (Learmonth 1980) and Queensland (Halfpapp 1982, Halfpapp *et al.* 1992), prompting studies on its chemical management (Kay *et al.* 1993) and natural enemies (Kay 2002). Other species of *Eysarcoris*, notably *E. lewisi* (Distant), *E. aeneus* (Scopoli), and *E. ventralis* (Westwood), are considered serious pests of rice in Japan (Kisimoto 1983, Kiritani 2006), however these species do not occur in Australia (Wood and McDonald 1984). Although *E. trimaculatus* is known to occur in the NSW rice area and is considered to have pest potential (Stevens *et al.* 2004), it is not currently regarded as a significant pest of rice in NSW. The failure of *E. trimaculatus* to reach economically significant densities in NSW may relate to the relatively cooler and less humid conditions in southeastern Australia.

The green vegetable bug (*Nezara viridula* (L.)) has also been recorded from NSW rice crops (Stevens *et al.* 2004), although it has never been found in sufficient numbers to be considered a pest. *N. viridula* has become a significant pest of rice in Japan since the introduction of early transplanting (Kisimoto 1983), which effectively synchronized flowering of the rice crop with the emergence of first generation adults that had developed on alternate hosts (Dale 1994).

In 2005 a shipment of milled Australian rice (cv. *Langi*) was rejected by an overseas customer because of over-specification levels of pecky grain. Retention samples of milled grain from the 2005 harvest showed peck levels of 4-6% (Group Technical Manager, Sunrice, *pers. comm.*), and this led us to conduct the current survey to obtain baseline data on the stink bug fauna associated with rice in southern NSW.

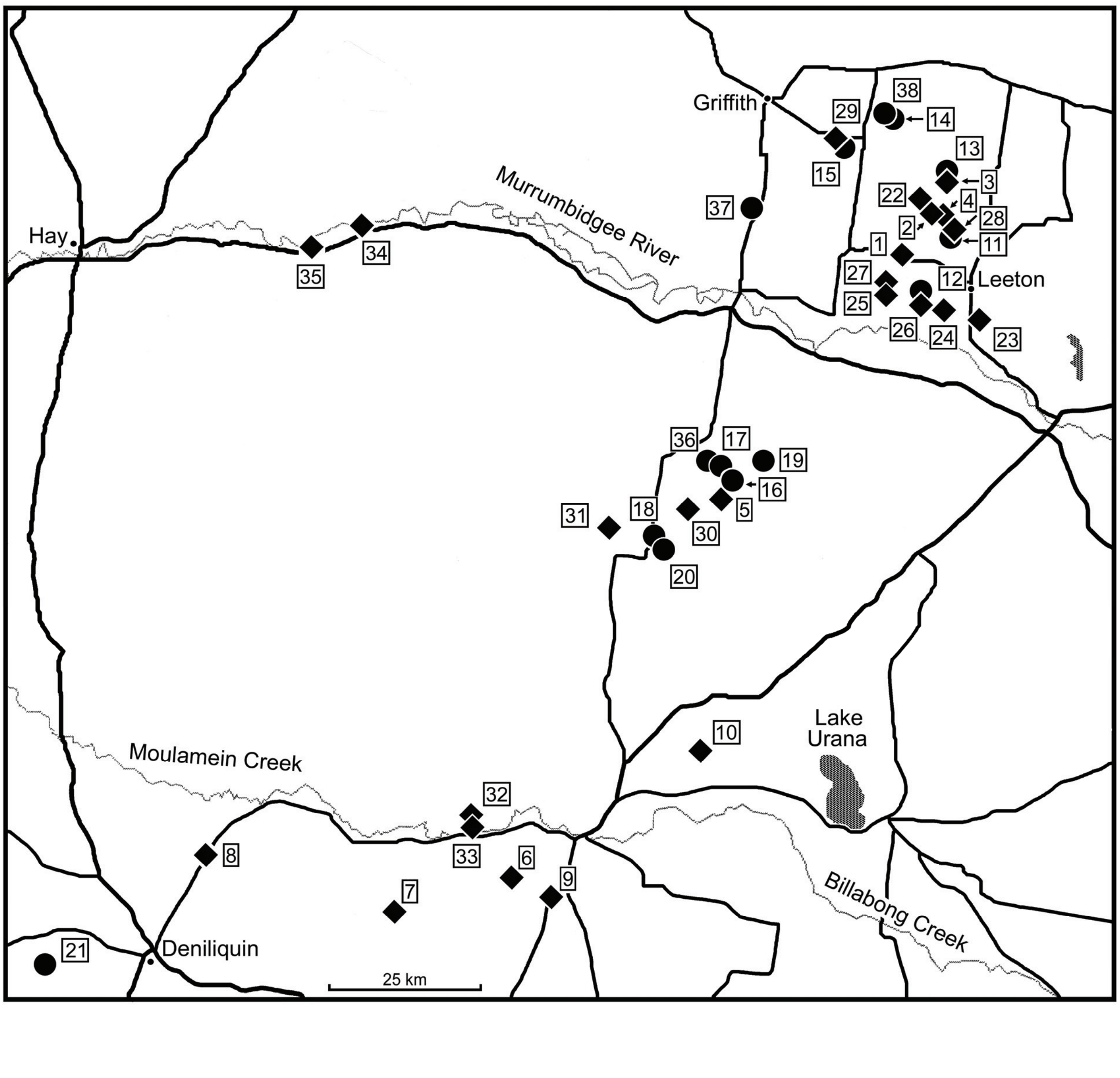
MATERIALS AND METHODS

Crop survey

A total of 38 commercial and experimental rice crops in the Murrumbidgee and Murray Valleys of southern NSW were surveyed for stink bugs - 21 during February 2006 and a further 17 in February/March 2007. Crop locations are shown in Figure 1. Sampling was timed to coincide with the grain-filling period in each season, when stink bug activity was anticipated to be at peak levels. In 2006 cv. *Langi* rice crops were deliberately targeted for sampling. In 2007, when relatively little rice was grown due to limited water availability, crops were sampled at random without regard to the cultivar being grown.

Sampling was done with sweep-nets (39 cm diameter, 120 cm handle), which were swung through the upper section of the plant canopy whilst walking along a random transect through each crop. Each sweep covered a swath approximately 2.8 m in width. Two people sampled independently in each crop for 40 minutes, each completing transects approximately 120 m long using contiguous sweeps and giving a combined sampling area of approximately 670 m^2. Nets were checked every few minutes and any bugs collected were transferred to specimen tubes for subsequent identification. Voucher specimens are lodged in the School of Integrative Biology Insect Collections, University of Queensland, and in the

Figure 1. Stink bug survey site map. Sites 1- 21, 2006; sites 22- 38, 2007. ♦, sites where stink bugs were collected; ●, sites where no stink bugs were found. Reference localities: Leeton 34º 32'S 146º 24'E; Griffith 34º 16'S 146º 02'E; Hay 34º 29'S 144º 50'E; Deniliquin 35º 31'S 144º 56'E.



Scientific Collections Unit, Orange Agricultural Institute, NSW Department of Primary Industries. The position of each crop was recorded using a Garmin® GPS 60 global positioning unit.

Screenhouse rearing study

Higher numbers of stink bugs encountered during the second season of the survey provided an opportunity to conduct a preliminary unreplicated study on the ability of *Anaxilaus vesiculosus* (Herrich-Schaeffer) (see survey results) to feed and develop on rice. Two rice plants (cv. *Doongara*) with grain at the early 'milk' stage were transplanted from a rice trial site at Yanco Agricultural Institute (34°37'S, 146°26'E) into separate pots, each 30 cm square and 30 cm in depth. There was no evidence of stink bug activity at the trial site from which the plants were taken. The pots were flooded on 20 February 2007 and placed within separate fine mesh insect cages (1.2 x 1.2 x 1.0 m (height)) in a screenhouse, where they were exposed to ambient temperatures and photoperiods. Twenty adult *A. vesiculosus* collected from crops in the Yanco area were placed on one of the plants, while the other plant was maintained as an unexposed control. The exposed plant was examined every few days for egg masses, and also to determine how long the field-collected adults survived. After 20 days surviving adults were removed, and nymphs arising from egg masses laid by the field-collected adults were monitored to determine if they could fully develop without alternative food sources. Fifty days after initiation of the experiment the grain was removed from both the exposed and control plants, dehulled, and examined under a stereomicroscope. Pecky grains were separated manually and the numbers of grains in both the clean and pecky fractions of each sample were counted. The pecky grain was then milled to industry standards using a laboratory brush mill.

RESULTS

A total of 257 stink bugs were collected during the survey, 44 in 2006 (27 adults and 17 nymphs) and 213 in 2007 (149 adults and 64 nymphs) (Table 1). Stink bugs were recovered from 48% of crops sampled in 2006 and 82% of crops sampled in 2007. Average stink bug recoveries were only 2.1 bugs per crop in 2006, however in 2007 recoveries were approximately six-fold higher at 12.5 bugs per crop. These recoveries equate to average estimated densities of only 0.003 and 0.02 bugs m^{-2} in 2006 and 2007, respectively. The highest estimated stink bug density recorded from a single farm was 0.06 bugs m^{-2}. Three species were represented by both nymphs and adults: *A. vesiculosus, E. trimaculatus* and *N. viridula*. Together these three species accounted for approximately 97% of stink bugs collected, and constituted 84%, 9%, and 4% of captures, respectively. Other species recovered included *Dictyotus caenosus* (Westwood), *Cuspicona simplex* Walker, and the predatory species *Oechalia schellenbergii* (Guérin-Méneville) and *Cermatulus nasalis* (Westwood). No rice bugs (Alydidae) were found during the survey.

Of the 20 adult *A. vesiculosus* of unknown age transferred to the caged rice plant, three remained alive after 20 days, and were removed from the cage. Females had oviposited on the plants, and early instar first generation nymphs were observed actively feeding on the panicles. The first adults arising from these nymphs were found on 6 April 2007, 45 days after the field-collected adults were placed in the cage. A total of seven adults were recovered prior to the conclusion of the experiment five days later. Average daily temperatures during this period ranged from 15.0 to 29.9°C.

Of the 2478 rice grains recovered from the plant exposed to *A. vesiculosus*, 174 (7%) showed peck damage consistent with stink bug feeding. In contrast, the control plant had less than 0.2% pecky grains (3 of 1814 grains recovered). Many of the pecky grains shattered during milling.

DISCUSSION

The dominance of *A. vesiculosus* in sweep-net captures was an unexpected result of our survey. This native pentatomid has not previously been recorded from Australian rice crops, and little is known about its biology. It is widely distributed across Australia, and has been collected from variable groundsel (*Senecio lautus* G.Forst. ex Willd. (Asteraceae)), coastal wattle (*Acacia longifolia sophorae* (Labill.) Court (Mimosaceae)), and also from tomatoes (*Lycopersicon esculentum* Mill. (Solanaceae)) (Gross 1976), however it is not regarded as a tomato pest.

Only three species of stink bugs were represented by both nymphs and adults in the field survey. As nymphs cannot fly, and cannot readily disperse into flooded rice crops from surrounding vegetation due to the open water along the field margins, their presence strongly suggests they have developed from eggs laid within the crop. Both *N. viridula* and *E. trimaculatus* are recognized rice pests elsewhere, and reproduction within the crop by these species was anticipated. Our screenhouse study demonstrates that *A. vesiculosus* is also capable of completing its entire life-cycle on rice plants, and that this species causes similar grain damage to stink bug species previously recognized as rice pests both in Australia and overseas. Substantial further work is required to accurately quantify the relationship between *A. vesiculosus* densities and grain damage levels.

Although sweep-netting is widely recommended for sampling stink bugs in rice crops, it is known to

Table 1. Stink bug recoveries from rice crops sampled in February 2006 and February/March 2007. Captures are given as the number of adults followed by the number of nymphs in parentheses (zero where no value is given). Sites at which no stink bugs were found (see Figure 1) are not listed.

Site (see Figure 1)	Cultivar	Date	*Anaxilaus vesiculosus*	*Eysarcoris trimaculatus*	*Nezara viridula*	*Dictyotus caenosus*
1	Langi	8/02/06	3	1	0	0
2	Langi	24/02/06	0	0	2	0
3	Langi	1/02/06	2 (10)	2	0	0
4	Langi	6/02/06[1]	1	1	2	0
5	Langi	10/02/06	1 (1)	0	0 (1)	0
6	Langi	14/02/06	2 (2)	1	0	0
7	Langi	14/02/06[2]	1 (2)	1	0	0
8	Langi	14/02/06[3]	1	0	0	0
9	Langi	14/02/06	0	2	0 (1)	0
10	Langi	15/02/06	0	0	0	1
		Total	**26**	**8**	**6**	**1**
22	Langi	2/03/07	3	0	0	0
23	Jarrah	20/02/07	0	3	0	0
24	Mixed	20/02/07	24 (1)	0	0	0
25	Langi	23/02/07	11 (1)	0	3	0
26	Reiziq	23/02/07	7 (1)	0	0	0
27	Reiziq	12/03/07	14 (7)	1	0 (1)	0
28	Langi	23/02/07	17 (3)	2 (2)	0	0
29	Reiziq	28/02/07	0	0	0	1
30	Amaroo	6/03/07	7 (11)	0	0	0
31	Reiziq	6/03/07	12 (15)	1	1	1
32	Koshihikari	13/03/07	24 (14)	1	0	0
33	YRM68	13/03/07	9 (6)	0 (1)	0	0
34	Reiziq	22/03/07	3	4	0	0
35	Reiziq	22/03/07	0	0 (1)	0	0
		Total	**190**	**16**	**5**	**2**

Additional taxa recorded: [1]*Cermatulus nasalis* (1 adult)
[2]*Oechalia schellenbergii* (1 adult)
[3]*Cuspicona simplex* (1 adult).

underestimate total bug densities (Bowling 1969), and is affected by a range of variables including temperature, time of day, and variations in net technique (Bowling 1969, Rashid *et al.* 2006). In a study on the American species *Oebalus pugnax* (F.), Rashid *et al.* (2006) concluded that bugs moved to lower parts of the plants during the heat of the day, reducing the effectiveness of sweeping as a monitoring tool. In our rearing study it was noted that *A. vesiculosus* nymphs (but not adults) responded to any disturbance of the plant foliage by rapidly moving down the plant tillers, only stopping when they were within 2 to 3 cm of the water surface. This behaviour may lead to sweep net sampling underestimating the population densities of immature *A. vesiculosus* relative to adults of the same species, particularly if sampling is undertaken in windy conditions.

Economic thresholds (ETs) for *O. pugnax* vary between five and ten bugs per ten sweeps, depending on crop development stage. This equates to between 2.8 and 5.6 bugs m^{-2} (Rashid *et al.* 2006). Halfpapp *et al.* (1992) proposed an ET of four bugs m^{-2} for *E. trimaculatus* in Queensland rice crops, however the maximum estimated stink bug density at any of our survey sites (for all species combined) was only 0.06 bugs m^{-2}. This suggests that stink bugs were probably not a serious problem in the 2006 and 2007 rice crops. Despite extremely low stink bug recoveries (mean 0.003 bugs m^{-2}) in 2006, pecky rice occurred sporadically in crop samples and reached levels of 2-4% (Group Technical Manager, Sunrice, *pers. comm.*). This level of damage cannot be accounted for by such low estimated bug densities, and suggests that other factors may also be involved. Rice bugs (Alydidae) are known to cause similar grain damage to that caused by stink bugs (Kisimoto 1983, Pathak and Khan 1994) however no rice bugs were found during the survey. Although stink bug feeding is a major contributor to the incidence of pecky rice, other factors such as fungal infection may also be involved (Patel *et al.* 2006). In particular, a disorder known as 'speckback' may produce lesions on milled grain that are very similar to those caused by stink bug feeding. Speckback is apparently unrelated to insect attack, and appears to arise during grain-filling as a consequence of physiological anomalies peculiar to semi-dwarf long-grain rice varieties (Cogburn and Way 1991). Further research is needed to determine the relative importance of stink bugs, fungal diseases, and crop physiological traits as causal agents of pecky rice in southeastern Australia.

Although only very low numbers of stink bugs were collected in our survey, it is clear that stink bug populations in Australian rice show high spatial and seasonal variability. In comparison to the 2006 results, average stink bug captures per crop were almost six times higher in 2007, possibly reflecting differences in seasonal conditions. Stink bugs were seldom recovered from crops with low weed densities and clean banks that were remote from other areas of vegetation, and this observation agrees with the known behavior of polyphagous stink bugs elsewhere, which frequently shift between native or uncultivated hosts and temporally restricted crops (Panizzi 1997). *E. trimaculatus* is known to breed on grasses adjacent to rice crops and move onto the crop at flowering (Halfpapp 1982), and weed management around the crop has been recommended as a means of cultural control (Halfpapp *et al.* 1992). Identification of the alternate hosts of *A. vesiculosus* will be important for the non-chemical management of this species should its pest status increase, as limiting access to alternate hosts has the potential to significantly reduce pest populations.

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