Biology, Ecology, and Management of Rice Black Bugs in Some Asian Countries

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Abstract

The rice black bug (RBB) is a widely distributed insect pest of rice. The insect has a long life cycle, up to 7 mo, and attacks the rice plant at every growth stage, causing economic losses. Although not frequent, epidemics of RBB have been reported in many countries. Control measures include application of insecticides; cultural practices such as maintaining a clean field, irrigation and water management; and use of light traps. As RBB is a significant pest in some countries and a minor pest in some other countries, its management could be achieved by promoting biological diversity of natural enemies and by curtailing the use of insecticides.

Key words: rice black bug, critical stages of rice, biological management

Introduction

The rice black bug (RBB) (*Scotinophara coarctata*) is known as "turtle bug" and "negro bug" but is commonly and widely known as "black rice bug," "black paddy bug," or "Malayan rice black bug" (Brands 2006). It belongs to order Hemiptera and family Pentatomidae. The RBB is a serious invasive pest of rice in some parts of the world such as Asia (Cuaterno 2007), while it is regarded a minor pest in others. RBB infestations have also been observed in such Asian countries as south China, Vietnam, Brunei, Indonesia, Malaysia, Cambodia, Sri Lanka, Thailand, Myanmar, India, Bangladesh, and Pakistan (Catindig and Heong 2007). It has been a pest of rice in Malaysia for so many years (Catindig and Heong 2007). In the Philippines, the insect was observed in 1979, invading 12 regions (Cuaterno 2007). In Thailand, this pest entered the southern region and gradually spread to the central region. RBB is one of the rice pests that collectively reduce about 10–20% of the annual rice production in Sri Lanka (Feakin 1970). The spread of the pest depends on many factors. RBB goes along with the light of the trading vessels plying from island to island.

RBB prefers poorly drained and densely cultivated rice fields as its habitat (IRRI 2003). Usually, it attacks irrigated rice from early vegetative to maturity stage (Cuaterno 2007). The most susceptible are maximum tillering to ripening stages. The insect uses piercing and sucking methods of feeding, directly sucking the plant sap, which leads to stunted growth and formation of whitehead, half-filled, or empty grains (IRRI 2003, Morrill et al. 1995).

The RBB is not easy to manage. Although control of rice bugs is urgently required, it may also cause environmental problems. But, in some countries like the Philippines, farmers are knowledgeable in managing RBB. Enhancing the population of natural enemies and adopting appropriate cultural practices help manage RBB.

Biology of rice black bug

Life history

The mature RBB is shiny black or shiny brownish black in color. The adult is oval-shaped and about 8–9 mm long (Fig. 1) (Abeysiriwardena et al. 2003). The lifespan extends from 3 to 7 mo. Sexes are separate. The female adult is bigger than that of the male. A female lays about 200 eggs during her lifetime and guards the egg until hatching (IRRI 2003). Eggs are deposited on the lower part of the leaves or on the basal part of the rice plant near the water surface (Catindig and Heong 2007). The eggs are laid in masses of 40–60 eggs in each mass in several parallel rows. During dry conditions, a female bug deposits eggs on the leaves and stem of the rice plant (Fig. 1). Eggs are also laid in cracks on the soil and on roots. Freshly laid eggs are greenish in color and turn to pink with age. After incubation, brown and yellow nymphs with black markings come out (Catindig and Heong 2007). Young nymphs start feeding on the area around the egg masses and then move upward on the plants. The nymphs feed on rice in groups until 2–6 instars, and reach adulthood after four to five moltings. The newly emerged adult is white and tinted with green and pink. Like adults, the nymphs also remain in the basal part of the plant during the day, then move up and feed at night. Rice is the main host of this insect pest, but the insect also feeds on a number of grasses and broadleaves (Cuaterno 2007).

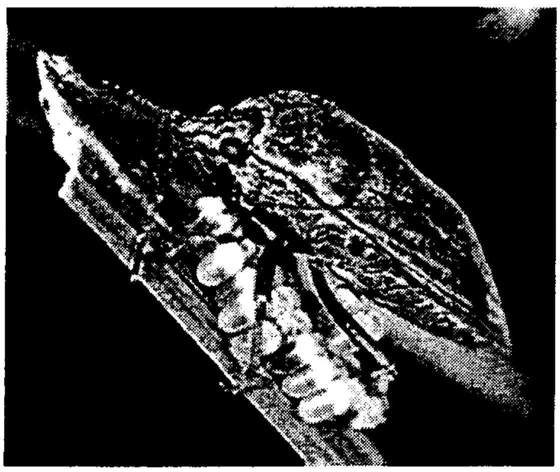

Fig. 1. Female RBB deposits eggs in the leaves (IRRI 2003).

The longevity of oviposition female ranges from 28 to 52 d, with an average of 38.00 ± 8.70 d. Males survive for an average of 42.20 ± 5.49 d. The female maturation period takes 5 d, and the oviposition period lasts for an average of 10.80 ± 1.32 d (Prakash and Rao 1999).

RBB is similar to many other oval-shaped shield or stink bugs that infest rice, but the nonpest species seldom occur in high numbers. RBB could be distinguished from *S. lurida* by the position of the spines on the pronotum (IRRI 2003).

The RBB has incomplete metamorphosis, which means that, from an egg, it will reach a nymph stage and then an adult stage (IRRI 2003); this takes about 3–7 mo. Oviposition takes place 12-17 d from mating. The eggs will be hatched in 3-4 d. The RBB nymph molts four to five times and passes five nymphal instars, which are completed in 25–30 d.

In general, RBB has one generation per year, but this depends on the climatic conditions and the system of paddy cultivation (Cuaterno 2007). Usually, each RBB is capable of producing approximately 680 eggs during its lifespan (PIA 2006). The intrinsic rate of natural increase was 0.084 per female per day, whereas multiplication rate was 28.0 times in a mean generation time of 39.90 d; the finite rate of increase was 1.08 and weekly multiplication was 1.79. The male to female ratio was 1:1.47 (Prakash and Rao 1999).

Pest status

The RBB attacks the rice plants at all stages from early vegetative to maturity, and the crop is most susceptible during maximum tillering to ripening. The pest is usually found at the base of the stem (Abeysiriwardena et al. 2003). Both nymphs and adults feed on plant sap using piercing and sucking modes of feeding, which leads to drying of tissues. Loss of water and drying out, discoloration, death of upper leaves and failure of young leaves to open are basic symptoms of attack. The damage during vegetative stage is called "deadheart," which refers to the dried dead shoot appearing as a result of sucking the plant sap at the base or in a slightly higher position in the emerging new shoot. If RBB attacks during booting, the resulting damage is the formation of dead or empty panicles similar to "whiteheads" caused by stem borers. RBB also feeds during the milking stage, affecting the rice grains. Severe infestations during this stage will result in a condition called "bug burn" and will lead to death. The nymph stage is the most destructive stage of RBB because the pest heavily feeds at the base of the rice plant (Morrill et al. 1995). It also prefers stem nodes because of the large sap reservoir (IRRI 2003). Infected plants become stunted, leaves turn reddish brown, and grain formation fails (Abeysiriwardena et al. 2003). Damage by this pest could result in severe crop losses or complete yield loss during heavy infestation. The extent of damage by RBB depends on the season and the crop stand. Crop damage in the dry season is more severe than in the wet season because nymphs take a longer period of time to reach maturity stage in the dry season (Cuaterno 2007).

Yield loss

Yield losses due to RBB can vary because of a number of reasons, of which seasonal and density (stand) effects are critical. Yield losses in terms of decreased number of tillers and hence decreased panicle number per plant, increased number of unfilled grains, and decreased number of filled grains per panicle are common with the attack of RBB. Ten adults of RBB per rice hill may cause a yield loss ranging from 15 to 35% (Cuaterno 2007, IRRI 2003).

Yield losses due to RBB have been recorded in many parts of Southeast Asia. Severe damage was recorded in the Philippines from 1979 to 1996. The first infestation was recorded in Palawan in 1979, which was followed by a major outbreak in 1982 damaging 4,500 ha of rice fields (Barrion et al. 1982). The estimated population averaged 79–188 adults m^{-2} and were as high as more than 400 m^{-2} in one field (Barrion et al. 1982). In late 1992, RBB was observed in Mindanao Island, specifically Zamboanga City, damaging about 2,070 ha (Anonymous 2005). Three years later, RBB invaded the whole of Region 9, including the Autonomous Region of Muslim Mindanao (Cuaterno 2007). In 1996, the pest was observed in Region 12, and an outbreak followed a year after. At present, the pest is already a part of the ecology of the whole Mindanao Island (Cuaterno 2007).

Since 1995, severe crop losses have been recorded in some parts of Thailand. Severe losses were recorded in Pattani Province in the southern region in 1995; a major infestation in Narathiwat Province was seen in 1999. There were two outbreaks recorded in Pathumthani Province in the central region in 2002 and 2005. Heavy infestation caused wilting of plants and incomplete panicle exsertion.

Food sources

The primary hosts of RBB are rice (*Oryza sativa*) and maize (*Zea mays*); alternate hosts are *Hymenachae pseudointerrupta* (Steud.) Gilliland, *Salix* sp. (willow), *Typha angustfolia*, *Panicum amplexicale*, *Echinochloa crus galli*, and *Scirpus grossus* L. (greater club grass). The latter three species are very common in rice ecosystems, enabling the RBB to continue with its repeated generations. In addition, the rapid life cycles of these grasses provide palatable food sources, including soft stems and new seeds during the milk stage.

Natural enemies

There are numerous natural enemies of RBB in the rice environment. *Telenomus triptus* (scelionid wasps, Hymenoptera: Scelionidae) is one of the major natural enemies of the RBB (Fig. 2a). This is an aggressive egg parasitoid. Red ants (*Myrmica rubra*, Hymenoptera; Formicidae) also heavily feed on the eggs of RBB (Fig. 2b). Frogs and ground lizards prey on nymphs and adults. The larvae and adults of coccinellid beetles, carabid ground beetles, or Schmidt-Goebel (*Ophionea nigrofasciata* (Coleoptera: Carabidae)) feed on eggs, nymphs, and adults of RBB (Fig. 2c). The increased diversity of natural enemies has made this pest a minor problem in many countries, including Sri Lanka and Thailand. As the RBB is suppressed by its natural enemies, it has now become a pest of less interest.

Ecology

Seasonal occurrence and abundance in rice habitats

RBB is found at all stages of growth of the rice plant in infested areas. Under favorable conditions during seedling stage, RBB adults migrate to paddy fields and begin feeding on the leaves or leaf sheaths of young plants. During tillering, RBB is found feeding on the leaf sheaths near the plant base, leading to stunted growth and reduced tiller number.

From booting to flowering, RBB attacks the rice plants and the crop shows stunted growth, incomplete panicle exsertion, and panicles with empty grains. At maturity stage, RBB affects the early

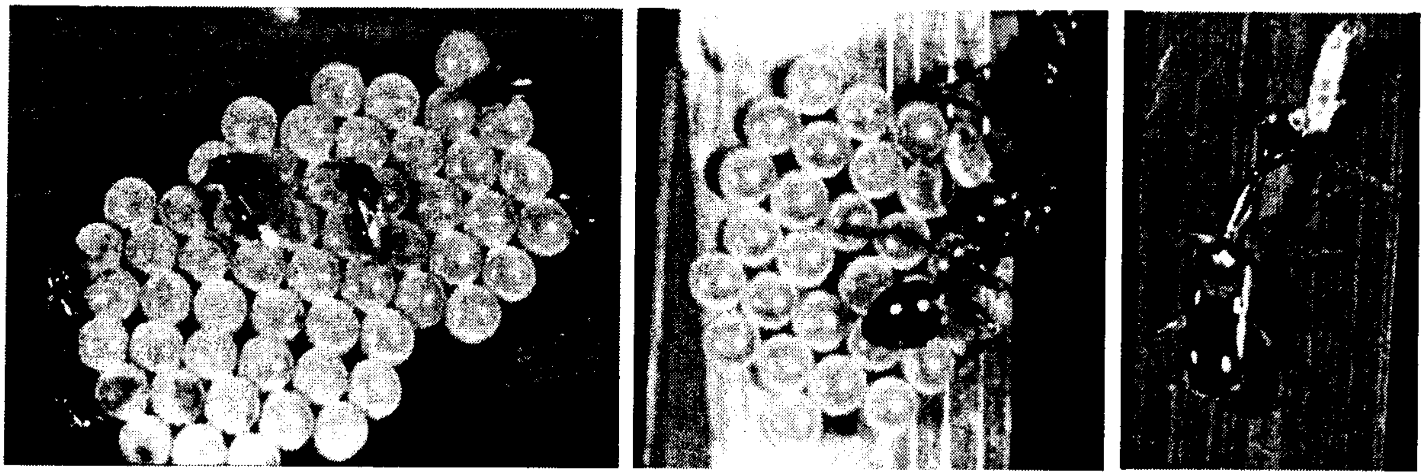

Fig. 2. Natural enemies of rice black bug: (a) *Telenomus triptus*, (b) *Myrmica rubra*, (c) *Ophionea nigrofasciata*.
Source: Figure 2a & 2c: Date seen: 30-07-2007 http://www.knowledgebank.irri.org/Beneficials/Copy_of_Beneficials_files/image102.jpg

stage of grain development, which prevents grain filling and increases the number of empty grains.

The outbreak of RBB significantly reduces the number of filled grains and grain weight and hence, total grain weight per panicle during the harvest period.

The RBB return to their resting sites in paddy fields after rice harvest. The bugs hide in cracks in the soil. Also, they try to find alternative hosts in the surrounding areas. These hosts are mainly the weeds of the Graminae family.

Flight activity and outbreak pattern of the RBB are mainly based on the light source. The bug is highly mobile and move as a heavy population, which helps to quickly invade a rice field. Flight pattern is affected by the lunar cycle. A large number of adults swarm to light sources 5 d before and 5 d after the full moon (Ito et al. 1993). It was also noted that the infested paddy fields are located near areas surrounded with bright light sources at night.

Monitoring and field population assessment techniques can be done by trained farmers. RBB numbers can be recorded weekly during the entire rice crop period. This can be done by randomly selecting 20 rice hills across the paddy field and counting the number of adults and nymphs. The use of light traps (Mercury bulbs) helps determine the numbers of egg-laying adults as these are attracted to light sources (Ito et al. 1993).

Yield loss and assessment techniques can be done by using a factorial treatment structure. This can be applied to several rice varieties and different infestation levels. Yield losses can be determined by the cage technique or by marking the plants. With the cage technique, RBB are reared in cages. Adult bugs can be placed on plants grown in cages at different population levels and using different varieties. The marking plant technique involves random marking of infested or damaged and healthy plants in large numbers (Anonymous 2007b).

The presence of alternate breeding sites favors population increase during nonrice periods; staggered planting of the rice crop and excessive nitrogen favor the buildup of the pest (IRRI 2003).

Even though the RBB are highly dispersive, they tend to be restricted in distribution to specific areas where they recur year after year. These areas tend to be near swampy places.

Management

Since RBB causes crop damage in all stages of the rice plant, timely management of RBB is essential to protect rice yield in RBB-infested countries. Numerous management options are found to suppress RBB, and suitable measures could be integrated for effective management. These methods include biological, cultural, and chemical management.

Biological control

Biological management appears to be the most effective in controlling RBB (Catindig and Heong 2007, Cuaterno 2007, IRRI 2003). This is because the pest becomes a prey of another biological agent. Different kinds of biological agents prey on many insect pests. The maintenance of a rice environment favorable to natural enemies would be the most effective method of RBB management. Biological management becomes ineffective when the rice environment is polluted with toxic pesticides as these pesticides equally bring negative effects to the natural enemies as well. Biological management is slow to control RBB, but better management could be achieved with time.

Many parasitoids/parasites may cause damage to RBB. Yet, *Telenomus triptus*, a scelionid wasp, is a very aggressive egg parasitoid that is naturally present in the field (IRRI 2003). These wasps are effective in reducing RBB populations. These parasites can be reared in the laboratories and released to affected fields.

Ground beetles and coccinelid beetles (Fig. 3), spiders, crickets, and red ants (*Myrmica rubra*) are predators of RBB eggs, nymphs, and adults. They abound in the fields and are effective in managing the RBB population. Ducks also help control RBB, but their use is very limited. The ducks can be released into the fields at a later stage only when the rice plants are already established.

Metarhizium anisopliae, a green muscardine fungus, infects the RBB, causing a complete kill of the RBB. The fungal spores attack, overgrow inside the insect present in the field, eventually killing the insect. There are three species of fungi attacking the nymphs and adults: *Metarhizium anisopliae*, *Paecilomyces lilacinus*, and *Beauveria bassiana* (Rombach 1987). In the Philippines, these fungi are cultured in the laboratory and produced as a filtrate containing conidia, which then is sprayed to the infested fields to control RBB (Cuaterno 2007).

Once the fungi are applied as suspensions of conidia and as suspensions of a dry mycelium product, the mycelium is grown in fermentors, dried, and milled. Conidia are produced on the mycelium clumps and these stick to the plants in the field. When the bugs attach to the plants, these conidia can infect the insects. Then the fungi penetrate into the cuticle of the insect and grow rapidly (Rombach 1987).

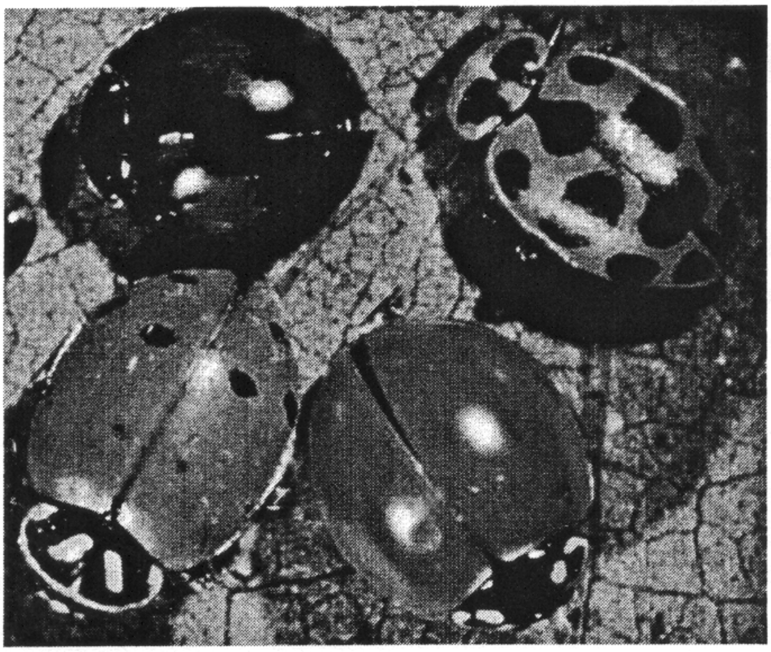

Fig. 3. Coccinelid beetles.
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Cultural control

Numerous cultural methods could be applied to manage RBB. Synchronous planting provides opportunities to avoid the completion of the life cycle of RBB. Maintaining a weed-free field provides more sunlight to reach the base of rice plants. Irrigating the field at 3–10 cm water depth may be done to submerge the eggs within 24–48 h after egg laying. This prevents the eggs from hatching; submergence after harvest and plowing prevent weed emergence and availability of stubbles, which in turn restricts access to egg-laying sites. The burning of rice stubbles/straws, although discouraged to avoid destruction of organic material, is recommended in RBB-infested fields. These activities help reduce the bug population.

It is appropriate to maintain a clean field by removing weeds and drying the rice field during plowing. Removal of weeds in the field and allowing more sunlight to reach the base of rice plants would help reduce RBB attack. However, Abeysiriwardena et al. (2003) noted that adult bugs are strongly attracted to light.

Intermittent flooding and draining of an infested field is also an effective technique to destroy the eggs of the RBB, which are usually found at the base of the rice near the water surface. During early infestation, the water level in the field may be raised for 2–3 d to force the insects to move upward. These eggs will fail to hatch when submerged in water for more than 24 h. Flooding the fields can also cause higher egg mortality.

Irrigation and plowing of stubbles in newly harvested RBB-infested field will also destroy the existing black bugs in all stages. Direct-seeded rice crops tend to have fewer tillers and this discourages population growth. After harvest, fields may be plowed to remove the remaining insects.

Although there are no specific details of rice varieties resistant to RBB attack, two IRRI varieties have been found to possess resistance to black bugs (IRRI 2003). These are IR13149-71-3-2 and IR10781-75-3-2-2 (Heinrichs et al. 1987, Domingo et al. 1985). Cultivation of these varieties may reduce pest incidence in RBB-prone areas. However, farmers would use high-yielding rice varieties to maintain satisfactory rice yields, along with other convenient pest management practices. Rice varieties of the same maturity date may be planted at the same time to break the insect's life cycle. Early-maturing varieties are also planted to reduce population buildup of RBB (IRRI 2003).

Chemical control

The RBB is controlled with conventional insecticides. In heavy infestations, pesticides are mainly applied to control RBB. Although pesticides are effective, they are expensive and may lead to secondary pest outbreaks as insects develop resistance to the compounds (Rombach 1987).

The most effective method is the use of foliar insecticides with directed application to the base of the rice plant. Application of carbosulfan 20% EC at the rate of 80 ml in 20 liters of water at the stage with five bugs per hill was recommended to control RBB. Other insecticides used to control RBB are Thiamethoxam (25% WG) and Dinotefuran (10% SL) in Thailand.

Other methods of control

Botanical pesticides such as neem (*Azadirachta indica*) extracts are known to be effective in preventing RBB attack in paddy fields. In addition, light traps are known to attract RBB. Both have the potential to be important components of an integrated pest management approach for RBB.

Future needs

RBB has already been recognized as a significant pest in some countries, whereas in some others, it appears to be a minor pest. This could generally be associated with the availability of population control measures. Rice environments could not be changed drastically, thus population control measures, integration of the insect into ecosystems, and other means would certainly be most effective. Biological agents such as predators, parasites/parasitoids, as well as disease-causing agents, and changing of habitats would make a negative impact on population increases of the insects. Pesticide use often results in an imbalance of both pest and natural enemy populations, which may or may not be a satisfactory or sustainable method to manage RBB. Therefore, it would be appropriate to enhance biological diversity, where the RBB is integrated into the ecosystem. The design and conduct of detailed studies on these aspects would be imperative for maintaining rice ecosystems with minimal RBB damage. Furthermore, identification of resistant or tolerant rice varieties would be another approach, which requires the concerted efforts of plant breeders, genetic engineers, agronomists, and crop physiologists.

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Notes

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