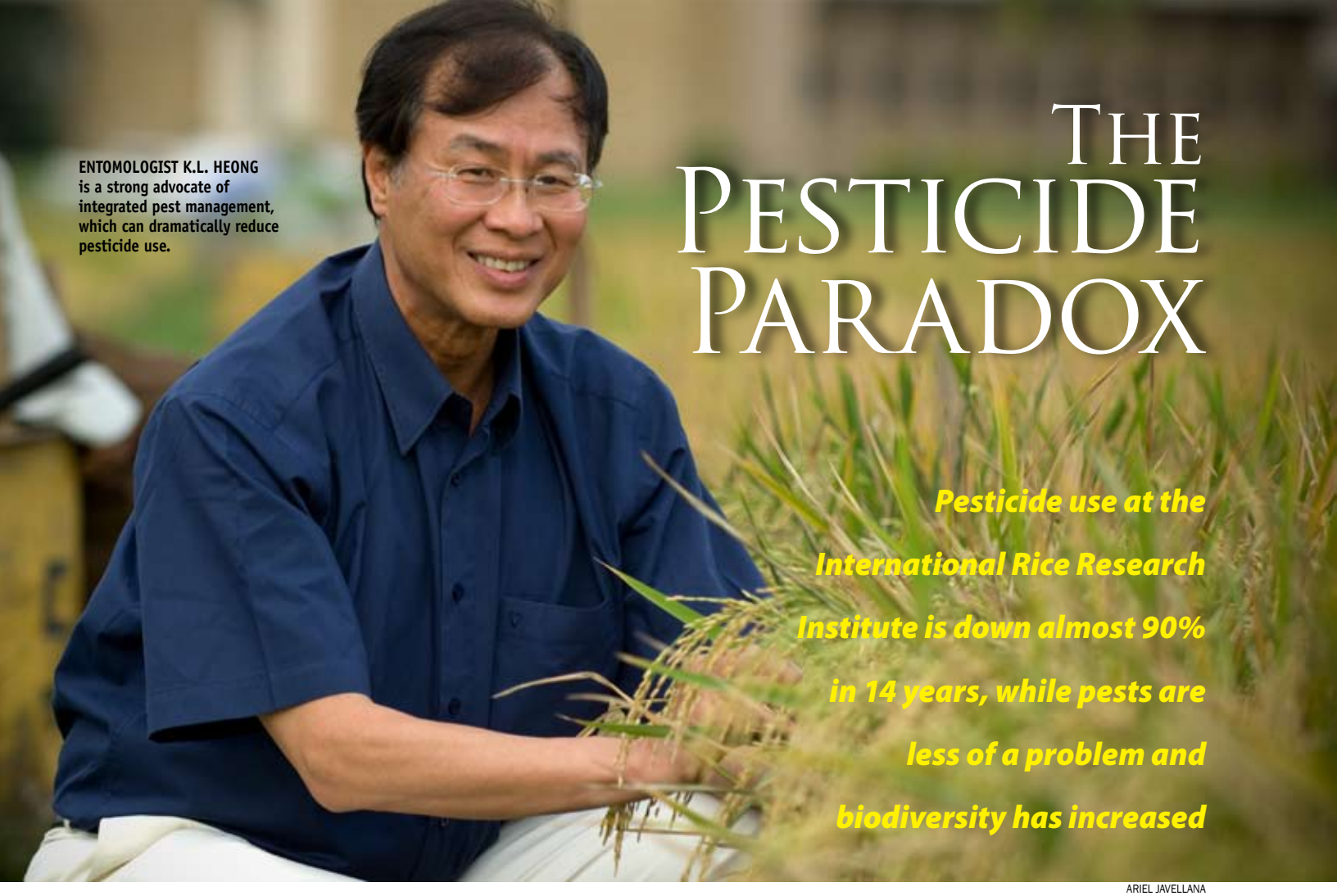

ENTOMOLOGIST K.L. HEONG is a strong advocate of integrated pest management, which can dramatically reduce pesticide use.

The Pesticide Paradox

Pesticide use at the International Rice Research Institute is down almost 90% in 14 years, while pests are less of a problem and biodiversity has increased

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by Henry Sackville Hamilton

If pesticides are supposed to control pests, why does an enormous reduction in use actually lower their numbers? Tests performed on the research farm at the Philippines-based International Rice Research Institute (IRRI) have shown that, if pesticides are used less and less, then nature itself, in the forms of predators and parasitoids, will join the fight on the farmers' side.

The research, performed by a team led by IRRI entomologist K.L. Heong,[1] describes how, when IRRI farm operations were centralized in 1993, a new scheme for spraying pesticides was introduced. Instead of routine spraying once a week, pesticides would be sprayed only when pest densities in a field reached a certain level. Dr. Heong writes that "in most seasons, insect pest populations did not reach threshold levels and thus no insecticides were used." After 14 years of the program, pesticide use on the farm has decreased by a staggering 87.5%. Insecticides, which are the main type of pesticides used on the farm, have fallen in use by 95.8%.

The study focuses on arthropods: invertebrates with a tough external protective layer (called a chitinous exoskeleton) and segmented bodies, and which make up more than 80% of all living animal species. For the paper, the arthropods were separated into four functional groups: herbivores, predators, detritivores, and parasitoids. Herbivores attack rice plants. Predators and parasitoids attack herbivores and detritivores. Detritivores eat detritus in the field.

Arthropods on the farm were surveyed in 1989, well before the introduction of the spraying scheme in 1993, and in 2005, well after it. Comparing those two surveys reveals some telling figures. In 1989, 46.2% of the arthropod population on the farm was herbivores. In 2005, when arthropods were next counted, only 11.2% was herbivores. The number of predators had risen from 40% in 1989 to 58% in 2005. Detritivores in 2005 formed 26.1% of the total arthropod density, up from 8.1% in 1989. Parasitoids experienced a smaller change: 5.6% in 1989 to 4.3% in 2005.

The reason for these swings is the unintended effects of pesticides. Pesticides can affect all creatures. Predators, parasitoids, and detritivores can be killed along with herbivores. In fact, because of their superior mobility, predators are more likely to come into contact with the poison and

[1] K.L. Heong, A. Manza, J. Catindig, S. Villareal, and T. Jacobsen. *Changes in pesticide use and arthropod biodiversity in the IRRI research farm*. Outlooks on Pest Management, October 2007, p 1-5.

thus are often more exposed to the toxins than herbivores. And, if predators are killed off, they can't help suppress herbivore numbers.

As well as killing nontarget arthropods, heavy pesticide use can help "secondary pests"—which are favored when predator numbers are lowered—to rise to power. In a balanced ecosystem, the numbers of secondary pests stay relatively low. But, if large numbers of predators have been killed, secondary pests face less competition from primary pests and can thrive.

Reducing pesticide use lets both the predator and parasitoid populations recover, thereby keeping secondary pest populations low. Also, because fewer predators are being killed through pesticides, their food sources—pests and detritivores—remain abundant and their numbers can swell. This is natural pest control.

Dr. Heong's team also compared the arthropod diversity before and after the introduction of the low-pesticide regime. Sure enough, the 2005 survey showed that the diversity of all four types of arthropods has increased significantly. According to the paper, "there were twice as many species of herbivores, about 48 more species of predators and parasitoids, and greater than 5 times more species of detritivores."

More species of herbivores may not seem good for rice, but such an across-the-board increase in diversity is a sign of a healthy ecosystem, especially as many of the species that survive under low-pesticide conditions are unimportant pests. For an ecosystem to thrive, the organisms in it must be diverse and adaptable. In particular, a diverse range of predators helps prevent pest invasions or outbreaks, which can often be caused by abnormal climatic conditions. Thus, a balanced ecosystem with adequate functional biodiversity will also have reduced vulnerability to adverse effects of climate change.

For poor farmers, the key part in the question of pesticide use remains the debate of "yield versus profit." With intelligent and focused use of pesticides, yield can be increased. However, Dr. Heong suggests that many poor farmers do not benefit financially from using pesticides. For example, a study in the Philippines showed that farmers overestimated their potential loss of profit due to stem borer infestation by ten times (see *The unsung heroes of the rice field* on pages 30-31). The money they were spending on pesticides was more than double their actual loss. On top of that, the low-quality sprayers that poor farmers use often result in less than 10% of the pesticide reaching its target.

For poor farmers, then, the cost of spraying pesticides can outweigh the benefit. To lower pest numbers, improve diversity, and increase profits, many farmers should steadily cut down on the pesticide they use. The challenge is to persuade them to reduce their pesticide use in the first place. Poor farmers, who have too narrow a profit margin to experiment with production techniques to improve yield, tend to be loss-averse—if the crop fails, they go hungry.

This is where advertising and national governments can play a key role. In Vietnam, for instance, the national government and IRRI cooperated on a large-scale information campaign called *Ba Giam Ba Tang* (Three Reductions, Three Gains). One of those reductions was in pesticide use. The campaign has contributed to decreasing pesticide use in Vietnam, and ongoing economic analyses by IRRI are positive.

Ideally, Dr. Heong wants to go even further than significant reductions in pesticide use. He firmly believes that "pesticide does more harm than good in rice ecosystems." For rice, he says, insecticides need not be used at all in most cases. A rice plant, for example, can lose half of its leaves without yield being significantly affected. Pesticides won't be disappearing quite yet, though. Farmers need to adapt to using fewer toxins. Only when farmers are confident that lowering their pesticide use will not lower their profit will the ecosystem be able to recover.

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REDUCING PESTICIDE applications can allow predators of rice pests, such as this orb-weaver spider (*Argiope* sp.), to help farmers keep pests under control.