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Is there hope for sustainable management of golden apple snails, a major invasive pest in irrigated rice?

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ABSTRACT

The golden apple snail or GAS (*Pomacea canaliculata*) is an important invasive pest in irrigated rice that feeds on young rice plants. In many countries in SE-Asia, governments have recently decreased their support of training courses for snail management, because farmers are now considered to know how to effectively manage this pest. Although a great number of sustainable control methods is recommended which do not involve the use of pesticides, it is uncertain whether these are taken up by farmers. Probably, the easiest way to control GAS, is the application of synthetic 'instant kill' molluscicides, which can have detrimental effects on the environment, non-target species, and health. The aim of this study was to develop ideas for solutions on how to achieve a sustainable management of GAS without or at least a decreased use of molluscicides. In a large-scale approach, we conducted interviews with rice farmers in seven regions across Vietnam and the Philippines, assessing the participation in training courses, knowledge on snail ecology, the methods of controlling and the utilization of the snail, and the farmers' suggestions on how to improve pest snail control. Only 23% of the farmers had previously received training in GAS management. We found that training neither had positive nor negative effects on the number of sustainable methods applied, molluscicide avoidance, concern about using molluscicides, or on the farmers' knowledge about GAS. As much as 74% of the respondents applied molluscicides. Contrary to recommendations, farmers applied only few sustainable control methods. All farmers had clear knowledge gaps about GAS, especially in species identification, which can even further the ongoing decline of native mollusks in rice landscapes. We conclude that the decision to phase out information campaigns has been taken to rash, and that trainings in our study regions carried through previously had limited success, and thus need revision. To decrease molluscicide use, and to promote sustainable management on the large scale, we synthesized our results, and we suggest that information for farmers might be provided through media often accessed, such as TV, radio or the internet (e.g. by entertainment – education). We further discuss the potential of community cooperation to achieve sustainability. As

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there are distinct limitations to these approaches, we have developed the concept of local GAS management and utilization companies (GASMUC) which could take over sustainable control and utilization of GAS, and native mollusk conservation for an entire community.

1. Introduction

Agricultural intensification, such as the increase in pesticide application, leads to a loss of biodiversity, which impairs important ecosystem functions and services, especially biocontrol and pollination [1]. The increased input of chemical pesticides through agricultural intensification holds a number of environmental hazards, including the contamination of freshwater resources and of the soil, the acquisition of pest resistances, and threats to human welfare [39,45]. With the environmental consequences of agricultural intensification becoming more evident, implementing integrated methods for pest management is one of the top priorities in striving towards a more sustainable agriculture [39,45,57]. In rice production systems, there is a great demand for increasing yields in the future, based on a more efficient use of natural resources, while at the same time sustaining the environment [20]. Rice pesticides, which include insecticides, fungicides, herbicides and molluscicides, have a strong impact on the environment and on the farmers' health, and can facilitate insect pest outbreaks by depleting populations of biocontrol agents [44,48]. The implementation of environment-friendly integrated pest management (IPM) practices on the large scale is facing several obstacles, such as a failure in knowledge dissemination to farmers, or the influence of pesticide companies on stakeholders, and therefore new approaches have to be considered for its successful establishment [48]. An important component of novel IPM strategies is the integration of humans, from farmers to policy-makers, and their impact on rice ecosystems, landscapes, and biodiversity [45,48,58]. *Ecological Engineering*, as a component of IPM, has a great potential to facilitate biocontrol of insect pests in rice [58]. The implementation of novel techniques in pest management, however, is often hindered by the farmers' lack of knowledge of pests, combined with wrong beliefs or preconceptions, and a tendency to overestimate the destructiveness of highly visible pests [11]. Thus, a successful adoption of sustainable management practices must include direct communication with the farmers, in order to change their beliefs and modify their practices [11].

For invasive species, population control by naturally occurring native predators is often limited [35]. Golden apple snails (GAS; *Pomacea canaliculata* and *P. maculata*) were intentionally introduced from South America to Southeast Asia as a cheap and protein-rich food source, but in SE-Asia they have become a major pest in irrigated rice over the past 30 years [22]. The snails devastate plantings of rice seedlings, and farmers suffer high costs in the form of snail control and yield loss [30]. Nghiem et al. [41] estimated the annual costs associated with GAS of 806 – 2138 million USD for only three (Vietnam, Philippines, and Thailand) out of 24 invaded countries [22]. Though a variety of native animal species, occurring naturally in rice fields, prey on GAS [63], their abundance is often too low to have an effect on population densities of the pest snail (which, however, could also be related to paddy management and pesticides) [63,61]. If natural predators and competitors of GAS occur in higher densities than in conventionally managed rice fields, such as in natural rivers, they bear the potential to keep GAS densities low [61]. Nevertheless, in rice fields farmers have to take management actions to control GAS. Numerous suggestions for sustainable management methods of the pest snail have been made that do not impair non-target organisms and bring no long-term harm to the ecosystem: cultural (replanting, water management), mechanical (handpicking, screens, traps, crushing eggs), biological (ducks and fish introduced to rice fields as predators), botanical (plant derived molluscicides), and crop control (transplanting older seedlings, seedling broadcasting, reduced seed densities, crop rotation) [9,50,30,23,62]. In most countries, the government advises farmers to use a combination of these sustainable methods, although often together with chemical control when necessary [30]. It is alarming that programs on pest snail control and farmer education run by the governments of many SE-Asian countries attenuate, as farmers nowadays are supposed to know how to manage the pest snails properly [30]. Although application of several sustainable methods in combination can be effective in controlling the snails [30], we assumed, however, that most farmers rely on regular molluscicide application rather than on time- and work-intensive sustainable methods, which was also observed in recently invaded rice fields in Ecuador [21]. In addition, a similar behavior of farmers has been observed in rat control [52].

The two major active agents currently used in GAS control in SE Asia are niclosamide and metaldehyde. Both substances are moderate in their impact on the environment, compared to other – often banned – moluscicides [10]. However, niclosamide is toxic to a wide variety of freshwater organisms, including fish [42] and is detrimental to the growth of rice seedlings if used as a preseeding snail control treatment in direct-seeded rice [28]. Metaldehyde is recently under emerging concern as a pollutant of ground water, lakes and rivers [31]. Both before mentioned molluscicides and all others, of course, are toxic to a wide range of mollusks, to pests and important native decomposers, edible snails, and mussels. Further, it is not clear how the environment might change after the regular application of molluscicides in rice fields each cropping season over several decades, especially as native snail populations providing essential ecosystem services, in the form of decomposition and nutrient cycling, or serving as food for generalist predators [47], are strongly reduced [22]. Thus, a reduction in the large-scale application of molluscicides, as for all other pesticides, should be a prioritized aim to achieve a sustainable management of rice ecosystems [45,48].

In this study we conducted a survey on GAS in irrigated rice fields with farmer respondents in a large-scale approach in Vietnam and the Philippines. Rather than focusing on regional differences, we tried to find general aspects of the current status of GAS for large geographical distances spanning different regions with varying cultural and structural diversity and land-use intensity. We aimed at integrating the insights we gained from the farmers' knowledge and suggestions, and recent literature, to develop ideas allowing for sustainable management of the pest snails. To develop these ideas, we first addressed the following hypotheses: (i) farmers consider GAS still to be one of the most important pests in rice; (ii) farmers prefer synthetic molluscicides to sustainable management methods; (iii) training courses on GAS management have a positive effect on pest snail knowledge and sustainable management; (iv) farmers are not aware of the impact of GAS and its management on non-target species.

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