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Efficiency of rodent control in upland rice and potential of forecasting chronic rodent infestation in Northern Laos

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ABSTRACT

This study followed up on results of an integrated rodent management program that was implemented from 2010 to 2011 in 18 treatment and 18 control villages in three provinces of Northern Laos. The program's impact on reducing rodent damage to upland rice was reported previously. Here, we focused on the efficiency with which upland villagers applied the proposed rodent control methods (snap traps, biological control using the protozoan parasite *Sarcocystis singaporensis*, community hunts) by comparing control effort (inputs) to an output of more than 73,000 rodents (mainly black rats) culled in Houphanh (HP) province. We also hypothesized that rice yields of a given crop year (2009) could predict rat damage in the three provinces in following years (2010, 2011). A survey of flowering of bamboo and fagacean 'nut' trees in 2011 was used to check for a potential influence of flowering events on rodent infestation. Using regression analysis we observed that efficiency (cumulative culls method^{-1}) of snap traps and biological control decreased significantly with increasing field size of upland rice fields, while the opposite trend was apparent with regard to paddy fields. Numbers of rodents culled by hunting and trapping increased with rising numbers of hunting villagers, but culls household^{-1} declined with increasing village size. We developed multiple regression models that predicted rodent culls by the paddy/upland rice area ratio and rodent control effort and explained >90% of the variation. Rat damage to wet season rice in 2010 and 2011 (and rodent culls ha^{-1}) increased with increasing village rice yields of 2009, while the treatments' regression line was positioned at a 5.5% lower rat damage level, in parallel to the controls. Integration of the observed relationships using the General Linear Model (GLM) allowed predicting rat damage under different treatment and seasonal scenarios. Surprisingly, 99.8% of the variation in rodent culls ha^{-1} in HP could be explained by a combination of rodent control effort, rice productivity, and flowering events. Herewith, we provide predictive and explanatory models that could be useful for future rodent management in the uplands. The observed relationships are discussed in view of potential forecasting of chronic rodent infestation and, ultimately, outbreaks.

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1. Introduction

Rice is the single most important food in Laos (Schiller et al., 2001). Although rice sufficiency has been achieved at national level (Wailes and Chavez, 2012), insufficiency persist locally, particularly in the Northern uplands (Eliste and Santos, 2012; World Food Programme, 2010). Upland farmers still highly depend on shifting cultivation agriculture, which has been intensified amid signs of environmental degradation (Thongmanivong et al., 2009; Saito et al., 2006). Episodic rodent outbreaks pose a major threat to food security in the uplands, whereby the entire harvest can be lost to rodents (Douangboupha et al., 2010). There is now scientific agreement that this is a regional phenomenon involving also neighboring countries with linkages between bamboo masting events, rodent outbreaks and famine (Normile, 2010). Black or house rats, *Rattus rattus*, have been identified as a

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major pest species (Jäkel et al., 2016; Brown and Khamphoukeo, 2007), which occurs in villages and associated rice fields but is also seen in forest habitats (Aplin and Singleton, 2003; Khamphoukeo et al., 2003).

In an integrated rodent management program in the Northern uplands of Laos in the provinces Houaphanh (HP), Luangprabang (LP), and Phongsaly (PS) we have demonstrated previously that upland farmers of 18 'treatment' villages were able to successfully reduce chronic rodent infestation in the village and associated rice fields in comparison to 'control' villages, if they applied principles of Ecologically-Based Rodent Management (EBRM) and implemented rodent control well before the cropping season. Reduction of rat damage to rice correlated with adoption of snap traps and biological control (using *Sarcocystis singaporensis*), while community hunting and rodent proofing of grain stores complemented the program. More than 73,000 rodents were culled by the six treatment villages of HP alone. Between 80% and 100% of the dead rodents included black rats, while other species encountered were mice (*Mus caroli*, *M. cervicolor*), white-toothed rats (*Berylmys* spp.), Himalayan rats (*Rattus nitidus*), the giant bandicoot rat (*Bandicota indica*), white-bellied rats (*Niviventer* sp.), red spiny rats (*Maxomys surifer*) and others (Jäkel et al., 2016).

The culling results of HP were the starting point of the present investigation. We were interested in analyzing potential relationships between rodent control effort and the observed outcome, hoping to gain insight into the efficiency of rodent control (e.g., culls tool^{-1} or method^{-1}) and the factors influencing it in the upland environment. We thought that such knowledge could be helpful in planning future rodent management programs in similar environments. Furthermore, given that black rats migrate between rice fields and the villages, feeding alternating on rice in the field during the growing season and on stored grains in the village during fallow (Douangboupha et al., 2009), we hypothesized that rice productivity of a given season could be a predictor of rodent abundance and damage to rice fields in the following crop season or even beyond. We tested this assumption by comparing yield data of the crop year 2009 from the target villages in three provinces with pre-harvest rat damage measurements of 2010 and 2011. Although we did not aim at revealing a potential relationship between bamboo flowering and rodent abundance, we included surveys of bamboo flowering in 2011 to account for it as a relevant environmental variable (Singleton et al., 2010).

2. Materials and methods

2.1. Target villages, time frame, and sources of data

This study analyzed data that were obtained during a rodent management program implemented from December 2010 to September 2011 in three provinces of the Northern uplands of Laos (PS, LP, HP) in three districts each. Details of the selection process of the 18 villages (6 in each province) where rodent control activities were conducted (treatment villages) and the other 18 that served as controls (common farmers' practice) have been published previously (Jäkel et al., 2016). Briefly, 36 villages were selected from a total of 231 villages, in which a rapid community appraisal (RCA) was conducted during the first half of 2010. Thus, we used two different sources of data: the RCA (demographic and agronomic information of the crop year 2009) and data and results of the rodent management program of 2010/11 (input quantities for rodent control, rat damage to upland rice, rodent culls). Here, we largely use input of rodent control tools as a synonym for rodent control 'effort', including villagers that could be engaged as hunters during community hunting campaigns (Table 1).

2.2. Data from rapid community appraisal (RCA)

The main village parameters of the RCA considered in our analyses included numbers of households (HHs) and villagers, rice cultivation area, and average village rice yields of 2009 (Tables 1 and 6; Fig. 2a,b).

Almost all upland rice farmers relied on a single annual crop of upland rice grown in the wet season, which usually commences in May or June. Because rice is harvested around September/October and then stored in the village for consumption, rice of the wet season 2009, for instance, would support villagers (and rodents for that matter) throughout the following year 2010. Added to this may be irrigated or rain-fed 'lowland' rice that is grown in flat valley bottoms or on terraced hillsides. Here, we refer to lowland rice grown in the uplands as 'paddy' (Linquist et al., 2006). Among the 18 treatment villages only four from HP (Nalang, Nokaen, Numnhao, Manth) cultivated paddy in addition to upland rice (Table 1), while all paddy fields were rain-fed. Farmers largely avoided growing irrigated paddy during the dry season (e.g., December–April) because rodents were too numerous, usually destroying rice plants at the seedling stage. Occasionally, irrigation was used for mitigating periods of drought during the wet season; especially the crop year 2010 showed poor and erratic rainfalls (FAO/WFP, 2011).

2.3. Design of the rodent management program and rodent culls in Houaphanh

The design of the rodent management program was described in detail (Jäkel et al., 2016). Briefly, we implemented community-based rodent management with the help of provincial and district agricultural officers in 18 treatment villages and associated rice fields through a combination of sustained trapping, rodent proofing of rice storage huts using metal guards, and rodent hunting and village sanitation. Second, three campaigns of biological rodent control were conducted in the village and rice fields using the parasitic protozoan *Sarcocystis singaporensis* (formulated as rat bait). We assessed pre-harvest rat damage to rice (% rat-cut tillers) by random sampling using frames during the pre-treatment phase in 2010 and in all treatment and control villages in 2011.

Villagers of the treatment villages of HP volunteered in counting all rodents that were killed by snap traps, community hunts, and biological rodent control. They were instructed how to recognize typical signs of disease of rats killed by the parasite (e.g., signs of bleeding around eyes and nose; Jäkel et al., 1999). There was no application of poison bait in the villages under study. The cumulative results of rodent culls of each village and by control method are listed in Table 1, including rodent control effort and input of tools. The impact of using metal guards on protection of grain stores was reported previously (Jäkel et al., 2016). Although villagers received forms for recording culled rodents, which also considered different collection sites (e.g., village versus rice field), recording was inconsistent at times rendering distinction between different habitats impossible. Due to time constraints it was also not possible to monitor habitat-specific application of rodent control tools. Numbers (Table 1) refer to quantities distributed among villagers at the start (snap traps: October 2010) or during implementation of the program (rat bait: 3 campaigns; December 2010, March and June 2011, respectively), whereby on-site monitoring confirmed that by March 2011 70% or more of the HHs applied the supplied rodent control tools (Jäkel et al., 2016).

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