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Sustainable Control of the Golden Snail (*Pomacea canaliculata* Lamarck) on Irrigated Rice Field in Malaka Regency, East Nusa Tenggara Province, Indonesia

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Abstract

The long-term goal of this research is to manage and control golden snails (Pomacea canaliculata Lamarck) – the rice pest of irrigated rice field - in a sustainable manner at Malaka Regency, East Nusa Tenggara Province, with emphasis on the snail utilization as economic resources so that the pest population would always be under control. Influence of day light to the snail behavior, the capability of snail hunting, feeding strategy of duck, and the snail for duck ration were studied from 2014 to 2016. Results showed that the snails existed on the surface of the mud in dark conditions (93.6 %) significantly more than in the light conditions (78.5 %), while in the mud they were 6.4 % in dark conditions and 21.5 % in light conditions. It implies to ease in the snails hunting at night. The ability to collect snails by a child was similar with adults of both women and men, i.e., between 9.42 to 12.82 with an average of 11.49 kg · 4 h^{-1}. The ducks were able to eat fresh snails of less than 4 cm in size and rejected the bigger ones. The snail was very good for duck ration, the ducks fed on snails in their local ration produced eggs as many as when they fed on standard ration. With the price of fresh snail IDR 1 000 · kg^{-1} and usefulness of the snail, it may motivate to collect the snail continuously, and in turn, sustainable control of the pest will go on.

Keywords: Duck, Golden snail, Malaka, *Pomacea canaliculata*, Rice

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1. Introduction

Malaka Regency is previously part of Belu Regency in East Nusa Tenggara Province until 2013, bordering with the Democratic Republic of East Timor in the east, Belu Regency in the north, Regency of South Central Timor and North Central Timor in the west, and the Timor Sea in the South. Irrigated rice field is about 7 378 ha [1]. Rice yield is low, less than

2 t · ha^{-1}, due to complicated problems one of them is an infestation of the golden snail (*Pomacea canaliculata* Lamarck), the noxious pest of rice seedlings [2]. Hereafter, the *P. canaliculata* is called as a snail. Studies on the management and control of the snail had been done from 2014 to 2016 in District of Central Malaka at which the outbreaks of the snail to occur on the irrigated rice fields.

The studies involved farmers, extension workers, and agricultural services, in particular, the field of livestock. The goal of this research was to manage and control the snails in a sustainable manner at Malaka Regency, East Nusa Tenggara Province, Indonesia, with emphasis on the snail utilization as economic resources so that the pest population would always be under control. The specific targets to be achieved was the availability of baseline data and supporting information related to the population dynamics of the pest and the growing duck farms where the snails being an alternative protein-source of the duck ration.

2. Invasive Snail and Outbreaks in Malaka Regency

The snail is well known as the most invasive species in the world [3]. Until before 1999, the snail was not recognized in Belu Regency including districts that now being the Malaka Regency. History of the snail outbreaks was studied by interviewing respondents. It was about 82.3 % out of 254 respondents stated that they recognized the snail just recently and mostly in 2010, the rests did not recognize the rice pest. Someone whom exodus from East Timor to Central Malaka District in 1999 brought five individuals of the snail then it was thrown to the pond of Sukabi Wedik at Kamanasa. The snail was then reproducing very fast, and from there they spread quickly to the vicinity rice fields. Introducing the snail was intended for food, but because of the outbreaks that were unpredicted before the snail had been threatening the rice production significantly. The pest attacks increased since 2006 along with the construction of irrigation channels. The problem continued to increase, and in 2012 the complaints of farmers were reported to the provincial level.

3. Impact of the Snail Infestation

The snail outbreaks are very harmful. Impact of the snail infestation on rice growth and yield was studied by interviewing 254 respondents. Based on their knowledge and experiences in handling the snail problems, the respondents revealed the seriousness of the snail as a rice pest. Majority of respondents (94.88 %) stated that the snails become

a big problem because it is harmful and may cause no yield of rice. Rice yields might reduce about 8 % to 97 % with 49 % on average. The snail attacks (48.43 % respondents) or may not attack (11.81 % respondents) rice seedbed. The respondents (99.6 1%) revealed that the snails feed on rice since rice on seedbed up to 3 wk to 4 wk especially 2 wk after transplanting. If the snails do not be controlled; 76.31 % of the seedlings would be damage (99.21 % respondents), the snail attacks would cause hefty damage (more than 40 %) of rice plants (26.38 % respondents) or even 100 % (66.93 % respondents).

4. The Snails Feeding Rates on Rice Seedlings

The severity of the rice crops damage is determined by feeding capability of the snail individuals, their body size and age of rice seedlings. The research trial is used by small, medium, and big of the snails, i.e., the shell lengths of (11 to 20) mm, (21 to 30) mm, and (31 to 40) mm, respectively. A single snail fed on over supply of 60 rice seedlings of (1 to 6) wk old within 24 h, it showed maximum feeding rate as indicated by less than 100 % of eaten seedlings (Table 1). The 1 wk old of seedlings seemed to be the most preferred. It showed that the bigger the snails, the more voracious and the elder the seedlings the smaller feeding capability. The snail is a very voracious and noxious pest of rice. It attacks the base of rice *seedlings* and then devours aerial parts. A large *snail* can consume a blade of rice in (3 to 5) min [4]. It is interesting to note that the snail does not eat the old rice plants. The small, medium and big snails (Table 1) were only destroying the rice seedlings of (1 to 4) wk old, (1 to 5) wk old, and (1 to 5) wk old, respectively. It implies that the rice farmers have to protect their crops intensively from the pest attack at early plant growth.

TABLE 1: Feeding rates of the single snail with various body sizes for 24 h on various ages of rice seedlings.

Overed rice seedlings		Average *) number and percentage of seedlings eaten by single snail with body sizes of:					
		(11 to 20) mm		(21 to 30) mm		(31 to 40) mm	
Age (wk)	Numbers	Seedling	%	Seedling	%	Seedling	%
1	60	19.4	32.33	50.8	84.67	55.4	92.33
2	60	12.0	20.00	28.4	47.33	40.6	67.67
3	60	5.4	9.00	14.2	23.67	20.2	33.67
4	60	1.6	2.67	7.8	13.00	12.8	21.33
5	60	0.0	0.00	4.2	7.00	7.6	12.67
6	60	0.0	0.00	0.0	0.00	0.0	0.00

*) Five replications

5. The Snail Movements

Illumination and water influence the snail movements. The research has consisted of two recently studies, (i) study on the snail biological clock and (ii) effect of water depth on the snail movements. In this study, the term biological clock is simply defined as the same activities were done repeatedly at the same time of day to day.

Study on the snail biological clock was conducted during three consecutive days under conditions of 12 h night and 12 h daylight. Each pair out of ten pairs of snails were allowed to feeding, mating, laying eggs, and moving, on the arena of the bucket containing mud with 6 cm in depth of water and 20 rice seedlings. The snail activities were observed periodically at every 1 h started from 05.30 a.m. Results revealed that the snails activities were significantly affected by illumination, but the snail existence or numbers was not affected by illumination (Table 2). The snails were significantly more active in the night rather than in the daylight. Feeding and mating were not affected by illumination, but moving was significantly more active in the night rather than in the daylight. Egg laying was just to occur at night. The snails much more exist on mud surface. They are more passive during the day so that the ducks may easily hunt the prey.

Meanwhile, people may collect easly snails at night because the snails are more active. It implies that it is reasonable to collect the snail at night and herding ducks during the daylight. Several snails move to inside the mud; 21.53 % at daylight and 6.39 % at dark night. The little snail numbers in the mud may escape from predation; hence, the snail will sustain their new generation.

Table 2: The biological clock of snail during three consecutive days under dark and light.

Activities	Daylight (%)	Dark night (%)	P
Active:	22.92	63.20	0.0390
Moving	5.70	29.58	0.0043
Feeding	13.33	22.50	0.1978
Mating	3.89	10.56	0.1474
Egg laying	0	0.56	
Passive:	77.08	36.80	0.0390
Total (Active + Passive)	100	100	
Existence			
On mud surface	78.47	93.61	0.1270
Inside the mud	21.53	6.39	0.1270
Total existence	100	100	

Trials on the effect of water depth against snail movements were conducted on the arena of a bucket containing mud and 20 rice seedlings for snail food. Levels of the water depth were without puddles, half of snail shell height, equal to snail shell height, and twice of the snail shell height. Each treatment was replicated 10 times. The snails were singly put on an arena at 18.00 p.m. with the position of 5 cm from rice seedlings. A red stick was placed on the first point where the snail was put on firstly. The snails were then allowed to move away within the arenas. The snail movement was observed periodically at every 2 h started from 18 p.m. and finished in the next day at 10.00 a.m. by recording mileage in cm from the first point to the next. It was assumed that the snails moved straight away. At the first observation – 20.00 p.m. – the snail already moved away. A green stick was placed at the point where the snail stayed on. The mileages were measured from the first point to the second point and continued to the next points. Results showed that water availability is vital for snail movement. The mileage on the treatment without puddles was significantly shorter than with puddles (Table 3). This finding supports the snail control-measure that is done by rice farmers in Malaka Regency by drying rice field immediately after transplanting. The snail movement is facilitated by water availability [5].

TABLE 3: The influence of water depth on the mileage of snails.

Water depth or puddles	Average ± SD of mileage (cm) of juvenile and adult snails	
	Juvenile	Adults
Without puddles	3.55 ± 3.508 a	0.95 ± 1.717 a
Half of the snail shell height	10.36 ± 2.831 b	4.40 ± 3.525 b
Equal to snail shell height	11.26 ± 2.735 b	6.38 ± 4.234 b
Twice of the snail shell height	10.39 ± 2.895 b	5.40 ± 3.743 b

6. The Snail Collection

Removing snails from the rice fields intended to reduce its population density. Th snail collection is provided by the personal ability. Ability to collect snails by any person for 4 h from 13.00 p.m. to 17.00 p.m. was not influenced (P = 0.3482) by gender and age, such as illustrated in Table 4. A boy and a girl were able to collect snails ca. 12.82 kg · 4 h–1h and 7.67 kg · 4 h^{-1}, respectively. While an adult male and an adult female were able to collect snails ca. 13.85 kg · 4 h^{-1} and 11.63 kg · 4 h^{-1}, respectively. CV value of more than 30 shows a high variation of the ability to collect snails between each individual person. The total amount of collected snails in five villages as much as 1 149.40 kg was used as fodder, particularly ducks [6].

Table 4: The gender abilities to collect snails at five villages in Malaka Regency, East Nusa Tenggara Province.

Villages	Total (kg)	Males		Female	
		Boy	Adult	Girl	Adult
Kamanasa	371.30	22.48	18.96	10.18	22.64
Kletek	161.30	6.26	13.32	8.12	4.56
Umakatahan	215.80	9.80	10.74	9.60	13.02
Wehali	139.70	7.16	9.06	4.68	7.04
Harekakae	261.30	18.42	17.18	5.76	10.90
Total	1 149.40	64.12	69.26	38.34	58.16
Mean	229.88	12.82	13.85	7.67	11.63
S.D	92.22	7.226	4.186	2.388	6.977
C.V	40.12	56.34	30.22	31.15	59.98

7. The Preference of Ducks Against Snail Size

Herding ducks in the rice field are intended to control the snails, but some snails are left not to be eaten because of too big. Amongst five classes of *P. canaliculata* body-size, 100 % feeding rate was only observed on snails with up to 30 mm in length (Table 5) [7]. This size was the most suitable for feeding test. Some tested ducks were able to prey 58 % of *P. canaliculata* with 34.4 mm in length. The third class of *P. canaliculata* – more than 40 mm in length - were rejected because the prey was too big. It implies that when the ducks are foraging the snails in a rice field, big size of snails (> 40 mm in length) will probably be left. It was reported that control techniques for the golden snails (two snail $\cdot$ m^{-2} in wet season) by pasturing 200 ducks $\cdot$ ha^{-1} for 2 d, 8 h $\cdot$ d$\cdot$ 4 h^{-1}, and associated labor of 32 h $\cdot$ ha^{-1}, one duck herder for every 100 ducks, the success rate was 89 %. The rest of 11 % of *P. canaliculata* might be left to be alive at rice field [8]. The *P. canaliculata* that is escape from predation may be a little number and will reproduce for new generations. This phenomenon is termed as feeding strategy made by the predator to sustain prey availability for future time.

Table 5: Preference feeding by adult duck on various body sizes of golden snails.

Golden snail size				Eaten (%)
Length (mm)		∅ (mm)	Weight (g)	
Class	Mean			
21 to 30	25.9	17.2	4.58	100
31 to 40	34.4	23.4	10.1	58
41 to 50	45.7	32.6	23.2	0
51 to 60	55.5	38.6	40.5	0
61 to 70	64.7	44.5	61.6	0

8. The Snail Utilization for Duck Ration

The feed rations for duck constituted local materials were available in Malaka Regency. The snail, leaf powder of *Chromolaena odorata* and other materials were mixed in such away with certain composition (Table 6). Treatment F0 was a standard ration for comparison, while F1, F2, and F3 were made with the local materials without standard concentrate at which the snail and green beans were used as a replacement. The adult ducks were cultured for 3 mo. Egg production for 49 d—from (41 to 89) d after start culturing—was recorded. Results showed that the egg production was not significantly different ($P > 0.05$), meaning that the egg production on ration with local materials was as many as compared to the standard ration. The duck farms are not developed yet in Malaka Regency. Therefore, it is very feasible to develop duck farms in this area. Except for economic purposes, it is also for sustainable control of the snails.

The duck is a good snail predator. When the ducks are allowed to hunt the snail in the rice fields and other snail habitats they can catch and eat snails directly especially snails with less than 40 mm in size. It was reported that an adult duck had maximum feeding rate as many as 12 snails of (21 to 30) mm in size within 18 min [7].

9. Discussion

The snail outbreaks in Malaka Regency were just initiated with five snails only. Because of the highly biotic potential of the snail, it is the capabilities to survive and reproduce, and environmental conditions may be optimal mainly host plants and water, the snail develops well exponentially. It was about 7 yr from 1999 to 2006 the snail spreading widely and shocking farmers when they realized that the transplanted rice seedlings in the morning and had gone in the afternoon. More serious problems were the snail outbreaks in 2012. Creating strategies in the control management of rice pest has been tried in last research studies (2014 to 2016) to cope the problems in the rice farmers that may be able to suppress and maintain the snail population density under tolerable levels.

The economic value of the snails is believed to be strong motivation to collect snails as much as possible. It was interesting to note that trial on collecting snails within 4 h from 13.00 p.m. to 17.00 p.m. in Malaka Regency, the collectors either males or females of children and adults before collect they were promised to be given a prize and money. As a result, they did snail collection maximally.

TABLE 6: The composition of feed rations and egg production.

Feed materials	The composition of feed rations (in part)			
	F0	F1	F2	F3
Corn mill	34	30	32	29
Rice bran	40	42	40	40
Fresh snails	0	0	5	10
Concentrate	18	0	0	0
Green bean	0	20	18	16
Leaf powder	5	5	5	5
Snail shell mill	3	3	0	0
Total	100	100	100	100
Egg production mean:				
Egg numbers	186.60	207.60	198.20	170.20
Egg weight (g)	0.66	12.01	11.58	9.19

The *P. canaliculata* is utilized for several purposes. For example, the digestive tract of *P. canaliculata* can produce lytic enzymes for protoplast isolation *Pichia manshurica* DUCC-Y15. At 75 % and 100 % concentration rates of lytic enzyme, it liberated protoplasts as much as 6.7×10^{17} (33.4 %) and 9.9×10^{17}(45 %), respectively [9]. The *P. canaliculata* can be a promising animal feed in the Philippines. The different meal forms that can be extracted are *P. canaliculata* meal (30 % calcium and 15 % crude protein), *P. canaliculata* meat meal (62 % crude protein and 3 336 kcal $\cdot$ kg^{-1}) and golden shell meal (35 % calcium). Feeding trials indicate that *P. canaliculata* meal can be a part of swine and chicken layer diets up to 15 %. *P. canaliculata* meat meal can be a part of broiler chicken diet up to 12 %. Feeding fresh and ground *P. canaliculata* to ducks can replace 50 % of their diet under total confinement system. Whereas, *P. canaliculata* meat meal (75 % of the diet) plus rice bran can be beneficially fed to tilapia [10]. Mollusks are consumed by many communities and believed to use as a reliable drug. The highest cholesterol content was found in fresh *P. canaliculata* (0.101 mg $\cdot$ 100 g^{-1}). The best treatment method for muscle heating was steaming, because it gave the lowest effect on the proximate composition and essential fatty acids [11].

Recently, several duck farmers in Malaka Regency are collecting and even buying snails continuously for their duck ration. Price of the snails was about IDR 1 000 $\cdot$ kg^{-1}. If the duck farming can be developed well and the snail is used for the duck ration, local people will collect snails continuously and intensively to fulfill their own need or to be sold. The government of Malaka Regency launched the duck farming (Jose, 2016; personal communication). Hence, this works may support the development of duck farming in this area.

10. Conclusion

P. canaliculata is an effective control measure. The continuous collecting snails and using it for duck ration and other purposes may support sustainable control of the snail outbreaks in this area.

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