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Research Article

Feeding strategy and Feeding capacity of duck (*Anas platyrhynchos domesticus*) as A Predator of Golden Snail (*Pomacea canaliculata*)

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ABSTRACT

The golden snail is a rice pest and outbreaks in several areas in Indonesia. Herding ducks in the irrigated rice field is intended to seek foods and control the pest. Age structure of the snails one week prior to transplanting was dominated by nymphs (61.45%), followed by juveniles (30.32%), and adults (8.23%). The ducks preyed up on golden snails with less than 40 mm in length, while the bigger ones were left to be escape from predation. This phenomenon is termed as feeding strategy to sustain prey availability in nature. Feeding test with 25 mm in length of the golden snails showed high feeding capacity of an adult duck. Actual maximum feeding rate was approximately 12 snails/18 minutes and expected one was approximately 53 snails/18 minutes. Functional response of the duck against density of golden snails fitted with Type II of Holling. The feeding strategy, feeding capacity, and the functional-response type indicated control potency of the ducks in preventing the pest outbreaks.

Keywords: Rice, snail, duck, functional response.

1. INTRODUCTION

The golden snail (*Pomacea canaliculata* Lamarck) is a rice pest in Indonesia and it outbreaks in several areas for instance in Malaka Regency, East Nusa Tenggara, within last decade [11]. Early vegetative stage in irrigated rice field is sensitive to the pest attack. A snail eats 1 seedling/3-5 minutes or 1 hill/15 minutes [1]. Rice hills close to water intake in rice plot are severity damage [11]. Yield loss is a function of the density and average size of snails as well as the age of the crop. Direct-seeded rice suffers significantly more damage than trans-planted rice, because golden snails consume greater amounts of the younger and more succulent plant [7]. Damage in uncontrolled fields can be as high as 100% for rice seedlings in the germinating stage, as opposed to 20% on average in the transplanting stage [6].

Livestock duck (*Anas platyrhynchos domesticus*) is commonly herded in the irrigated rice for seeking foods and controlling golden snails [3]. This study was intended to determine feeding strategy and feeding capacity of the ducks on the golden snails. Model of Holling's disc equation[3] was adopted to expect the feeding capacity.

2. MATERIALS AND METHODS

a. Age structure of golden snail. Field study was conducted at irrigated rice in Malaka Regency, East Nusa Tenggara Province. One week prior to transplanting, all sizes of golden snails were collected from 25 sampling units of 1 m x 1 m. These samples were taken at random by transect method in five villages. The collected golden snails were then separated into nymph (approximately less than 20 mm in length), juvenile (approximately between 21 – 30 mm in length), and adult (approximately more than 30 mm in length). Age structure was indicated by percentage of each developmental stage category.

b. Choice test of prey size. The suitable body size of golden snail as a prey for ducks was determined by allowing the ducks to eat up on various sizes of the prey. Length of the golden snails varied from approximately 2 – 70 mm, the elder the snails the longer their body length. Therefore, the tested golden-snails were categorized into five classes; 21 – 30, 31 - 40, 41– 50, 51– 60, 61 - 70 mm in length. Each class contained 50 snails. Body length, diameter, and weight of all individuals of the golden snails for each class were individually measured. The 15 months old ducks were used in this study. The tested ducks were allowed to eat on ordinary feed until getting saturation in the morning, and not feeding anymore for 8 hours latter prior to run experiment in the afternoon. The experimental arena was a cage with 100 cm length x 50 cm wide x 100 cm high in size. Five adult ducks were kept in the cage for 30 minutes before running experiment, and then 50 snails - a mixture of all class sizes containing 10 snails of each class – were offered in the cage. The ducks were allowed to prey up the snails. Feeding period was recorded from start until stop feeding. Number of snails that escaped from predation was counted. The experiment was run five times using different duck individuals. The most suitable prey size was the largest class at which 100% of golden snail was eaten.

c. Feeding rate and functional response tests. Actual and expected maximum feeding capability of an individual duck on the golden snail was determined such as follows. The suitable size of golden snail was used to determine maximum prey consumed by ducks. The tested duck characteristics and experimental arena were similar to those that used for choice test of prey size. An individual duck was kept into the cage for 30 minutes before experiment. Fifty snails were placed into the cage and the duck was allowed to prey up until getting saturation and stop to eat. Feeding period was recorded from start until stop to eat. The experiment was run five times using different duck individuals. The actual maximum feeding rate was determined by counting number of the rest snails. Meanwhile, the expected maximum feeding rate was calculated by applying analyses of functional response of the ducks against the golden snail.

Functional response is change in the rate of exploitation of prey by an individual predator as a result of a change in prey density [5]. Holling's functional response type and expected maximum feeding rate were determined. Protocol used for previous feeding rate test was applied except on prey number that was varied definitely. Series density of available prey (N_t) was made by dividing or multiplying the observed maximum feeding rate with 0.5 factor; resulting 3, 6, 9, 12, 15, 18, 21, 24 snails. Referred to time period for satisfied feeding, total time (T_t) of predation was 18 minutes. Actual number of prey eaten (N_a) was recorded and the expected one was determined.

The Holling disc equation [5]:

$$N_e = a'T_tN_t/(1+a'T_hN_t)$$

where N_e = Expected number of prey eaten. N_t = Total number of available prey. T_t = Total time for predator allowed to search, cupture, and feed. T_h = Handling time, a time period for a single predator catching and feeding a single prey. a' = Feeding rate, number of prey eaten per unit of time.

Values of T_h and a' were calculated by developing linear regression of

$Y = \alpha + \beta X$. $N_a/N_t = a'T_t - a'T_hN_a$. $\alpha = a'T_t$. $a' = \alpha/T_t$. $\beta = -a'T_h$. $T_h = \beta/-a'$.

N_e maximum=Tt/Th. N_a = Actual number of prey eaten. N_t was then plotted against N_e to determine type of functional response.

3. RESULTS AND DISCUSSION

The existing golden snail in Malaka Regency, East Nusa Tenggara Province, is likely similar to those in Java. However, morphological variation such as wide and number of bands has never been assessed yet. It was reported that variation in water depth had significant influence on the variation in the number of bands and the average band width [4].

a. Age structure of golden snail

The golden snails were observed on 21 out of 25 sample units. The density ranged from one to 95 snails and 29 ± 30 snails/m^2 in average. Age structure was indicated by various body sizes of golden snails (Figure 1). Out of total collected 729 snails, it was dominated by nymphs, followed by juveniles and adults (Figure 2). It seemed that nymphs from a breeding site floated and followed irrigated-water flow which entered to a rice plot. In context of control with duck, the body size of golden snails is important to take into account for determining the predator efficiency.

b. Suitable prey size

Amongst five classes of golden-snail body-size, 100% feeding rate was only observed on snails with up to 30 mm in length (Table 1). This size was the most suitable for feeding test. Some tested ducks were able to prey 58% of golden snails with 34.4 mm in length. The third class of golden snails – more than 40 mm in length - was 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 (2 snails/m^2 in wet season) by pasturing 200 ducks/ha for two days, 8 hours/day, and associated labor of 32 hr/ha, 1 duck herder for each 100 ducks, the success rate was 89%. The rest of 11% of golden snails might be left to be alive at rice field [8].

The golden snails that are 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.

Farmers may not allow many golden snails existing at their rice field. Golden snail can be used for food or feed. The big one is best because contain more meat than the small one. Integration between herding ducks and hand picking may be a compatible method for the pest control.

c. Maximum feeding rate and functional response.

Feeding capacity is one of desired attribute of good biological control agent. This study revealed that an adult duck showed actual maximum feeding rate as many as 12.20 ± 5.85 snails/17.6 minutes (Table 2). Actual feeding rates (N_a) of a duck within 18 minutes on series of prey density were 3, 6, 9, 12, 13, 15, 16, and 17 snails/18 minutes, respectively. Analyses of linear regression

$Y = \alpha + \beta X$ resulting $Y = 1.125959 – 0.02124X$, hence, $\alpha = 1.125959$ and $\beta = – 0.02124$. $a' = \alpha/T_t = 1.125959/18 = 0{,}062553$ snails/minute. $T_h = \beta/\text{-}a' = – 0.02124/\text{-}0{,}062553 = 0{,}339629$ minutes/snail.

N_e was then calculated with Holling disc equation and the results were 3, 6, 9, 11, 13, 15, 16, and 18 snails/18 minutes, respectively. The actual prey eaten (N_a) and expected prey eaten (N_e) were not significantly different ($P = 0.46$). N_e maximum was approximately 53 snails. The expected maximum feeding rate was approximately four times as compared with the actual one. The actual feeding rate was as biological basic, while the expected was mathematical basic with assumption that all the prescribed time for feeding. For predicting predator potency the actual feeding rate is more appropriate [11].

When N_t was plotted against N_e and N_a (Figure-3) the trend line fitted with functional response Type II of Holling. The duck's functional response to changes in golden snail density is an important component of population regulation. At low prey densities, predators spend most of their time on search, whereas at high prey densities, predators spend most of their time on prey handling. Plateau represents predator saturation. Prey mortality declines with prey density. Predators of this type cause maximum mortality at low prey density [5]. It implies that the ducks may play an important role in preventing the golden snail outbreak by killing nymphs and juveniles in low density at initial colonization. Feeding strategy and feeding capacity described in this study support the use of ducks for controlling outbreaks of golden snails in irrigated rice. The studies revealed that adult ducks were potential predator of golden snails.

Herding ducks combined with hand-removal and use of botanical molluscicide may a good strategy in controlling the pest. Hand-removal effectiveness was demonstrated by trial on a pond. The hand-removal program is successful and snails had been nearly eradicated from the relatively isolated pond. Compared with chemical methods, control was achieved with lower monetary cost and less ecological risk [2]. Combined crude extracts of *Sandoricum vidalii* fruit and barks of *Harpulia arborea* and *Parkia* sp. are effective organic molluscicide that effectively control golden apple snail (*P. canaliculata*) [9].

4. CONCLUSION

A week prior to rice transplanting, colonies of golden snails was dominated by nymphs (61.45%), followed by juveniles (30.32%), and adults (8.23%). Under the experimental condition at which preys were offered in arena of a cage, observed maximum feeding rate of an adult duck was approximately 12 and expected one was approximately 53 juvenile snails within 18 minutes. To leave behind undesirable golden snail with more than 40 mm in length was a feeding strategy made by the ducks to sustain availability of their food in nature. Functional response of duck against density of golden snail fitted with Type II of Holling. The duck is prospective to be exploited for biological control agent against this pest.

5. ACKNOWLEDGEMENTS

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Table 1.
Description and percentage of preyed golden snails by adult duck

Golden snails					
Length, mm		Mean Diameter, mm	Mean Weight, g	Numbers	
Class	Mean			Offered, individuals	Preyed,%
21-30	25.94±0.95	17.22±0.87	4.58±0.38	50	100
31-40	34.36±1.17	23.40±1.59	10.05±0.69	50	58
41-50	45.68±1.15	32.56±1.18	23.19±1.09	50	0
51-60	55.54±0.69	38.58±3.28	40.50±1.89	50	0
61-70	64.68±0.56	44.54±3.82	61.57±1.73	50	0

Table 2.
Observed maximum feeding rate of an adult duck on golden snails

Description of golden snails	Average
Length	24.16 ± 0.52 mm
Diameter	16.64 ± 0.48 mm
Weight	3.79 ± 0.24 g
Maximum actual feeding rate	12.20 ± 5.85 snails; 24.40 ±11.70 %
Feeding time period	17.6 ± 1.49 minutes

Figure 1
A colony of golden snail existing on irrigated rice field in Malaka Regency, East Nusa Tenggara Province

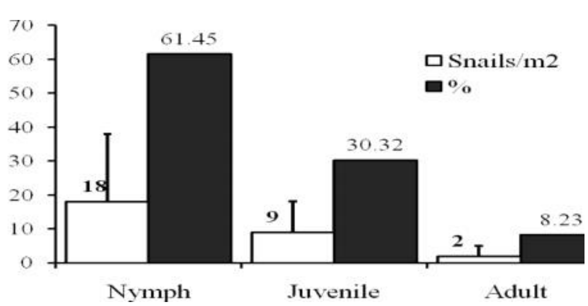

Figure 2
Age structure of golden snail; nymph approximately Ą < 10 mm, juvenile Ą 11 - 30 mm, and adult Ą > 30 mm

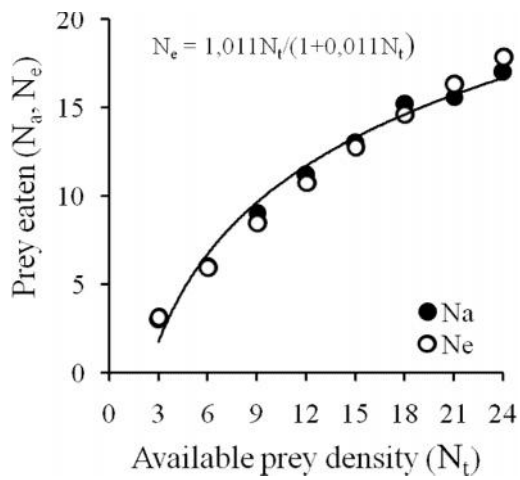

Figure 3
Type II of Holling's functional response of an adult duck against density of golden snail

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