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FUNCTIONAL RESPONSE OF PREDATOR *Paederus* sp. (COLEOPTERA: STAPHYLINIDAE)

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ABSTRACT

Research on predatory predation of *Paederus* sp. (Coleoptera: Staphylinidae) was carried out to study the functional response of the predator *Paederus* sp. Functional response is a form and size predictor of consumer impact on resource populations, determining the effectiveness of a predator as an agent in biological control. Predation time in hungry and not-hungry conditions influences predator-prey interactions, which are essential in functional response. The method used in predating *Paederus* sp. on the prey of aphids was *Aphid* spp. They are using four levels of prey density with two different predator treatments. The results show the functional response model of *Paederus* sp. predators. against the prey of *Aphid* spp. Described in a type II model. The level of predation of *Paederus* sp. showed different results for the two treatments and an increasing cystoid curve at a rising rate. The level of predation is still increasing, along with the increase in host density, and can be a starting point for controlling the *Aphid* spp and using predators *Paederus* sp. in the field.

1. INTRODUCTION

The rove beetle, *Paederus* sp. (Coleoptera: Staphylinidae), is a genus of small beetle measuring 7–13 mm in length, which can be found in North, Central, and South America; Europe; Africa; Asia; and Australasia. Rove beetles have an orange pronotum and orange basal segments on the thorax, which contrasts sharply with the metallic elytra, which are often blue or green and brown or black on the rest of the body (Krinsky, 2019). The habitat of this beetle is damp areas such as swamps, the edges of freshwater lakes, and rice fields. *P. fuscipes* is a valuable insect in agricultural systems because it is a major polyphagous predator of several agricultural pests (Bong et al., 2012). Biological control has dealt with pests, vectors, or invasive species in ecological systems. Attempts to uncover the efficacy of agents by combining functional response and numerical response have been limited in practice, reducing the capacity predictive for effects at the population level (Costa et al., 2017). Functional response quantifies consumption under different resource densities, explaining the key components of search, capture, and handling times (Cuthbert et al., 2018). The form and magnitude of functional responsiveness are strong predictors of consumer impact on resource populations across taxonomic and trophic groups (Dick et al., 2017).

Functional response is the change in the amount of prey killed per individual predator per unit of time as a function of changes in prey density. Functional responses are critical behavioral responses to reveal various aspects of prey-predator interactions (Jafari & Goldasteh, 2009). This term denotes the response of individual natural enemies to various prey densities. Holling (1959) proposed three general functional responsiveness curves: type I is a linear increase in prey consumption to a plateau, and type II is a cyrtoid curve rising at a rate that increases towards height. Type III is a sigmoid curve with a positive acceleration rate up to the inflection point and will decrease until it stabilizes. Type IV in functional responses was proposed by Mori and Chant (1966), with a dome-shaped response that resulted from confusing or inhibiting behavior of shy predators and consequently lower attack rates at high prey densities.

Functional responses are one major component of population models and one of the most critical aspects of the dynamics of the predator-prey relationship (Berryman, 1992). These responses can be used to predict the mechanisms of behavior predator-prey to increase predictive potential in biological control. Therefore, this study aims to determine the functional response of *Paederus* sp. against various prey densities of aphids (*Aphid* spp.) in laboratory conditions.

2. METHODS

Research in September 2021 at the Biology Laboratory, FKIP, Universitas Muhammadiyah Palembang. The model predator is the beetle *Paederus* sp. (Coleoptera: Staphylinidae) with aphids (*Aphid* spp.). The predation rate is determined by observing the amount of lost or damaged prey. The predation test of *Paederus* sp. on aphid prey consisted of two treatments: hungry and non-hungry predators. The prey used is aphids (*Aphid* spp.). Each predator was put into a container and given prey at densities of 2, 4, 8, and 16 prey. The treatment was repeated five times. Observations were made to record the time needed to prey (consume) each exposed prey, both hungry and not-hungry predators. Observations were made until all the prey was used up or at least 3 hours of observation. The data obtained were analyzed using the t-test followed by an honest significant difference test at the 5% level.

3. RESULTS AND DISCUSSION

3.1. Results

The results of the *Paederus* sp. predation test On aphids prey are presented in Table 1. The average number of aphids predated by predators *Paederus* sp. was more in hungry conditions than predators in non-hungry conditions, although based on statistical tests did not show a difference. The calculated Chi-squared value is lower than the table's Chi-squared value of 5% (Table 1). The average aphids eaten by *Paederus* sp. in hungry and not-hungry conditions were 1.50 and 0.40, respectively. The condition of the predator affects the number of prey in the prey. *Paederus* sp. predators in a hungry condition will spend more significant prey than in a not-hungry condition (Figure 1). The predator functional response curve obtained is a type II curve. The proportion of prey consumed by aphids by *Paederus* sp. increases with increasing preying density, indicating consumption density. This shows that there is a positive correlation between predators and prey. According to type II, functional response develops because the predator is hungry, resulting in a certain stage of a constant level of predation before there begins to be an increase in the proportion of preying at higher densities. In contrast, predation in the condition of a not-hungry predator showed no correlation between predator and prey. This is because no predation activity occurs.

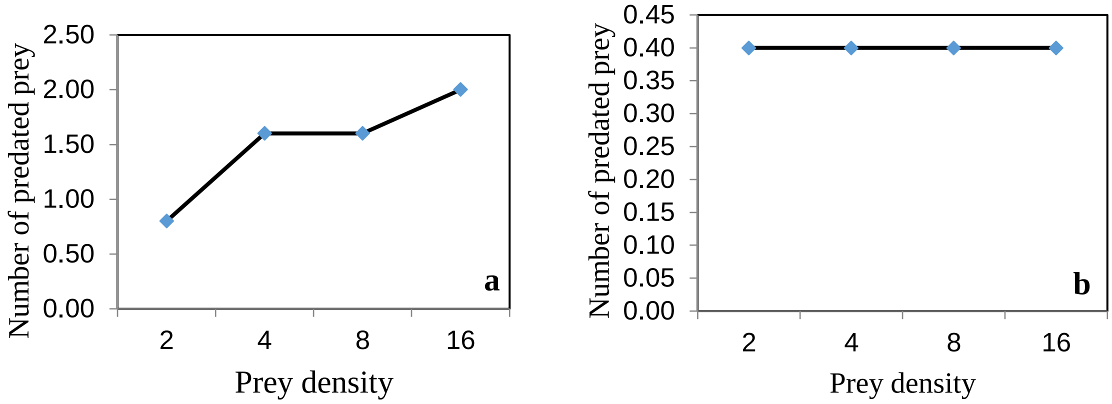


Figure 1 The relationship Between Prey Density and the Number of Predated Prey Under *Paederus* sp. when Hungry (a) and not Hungry (b).

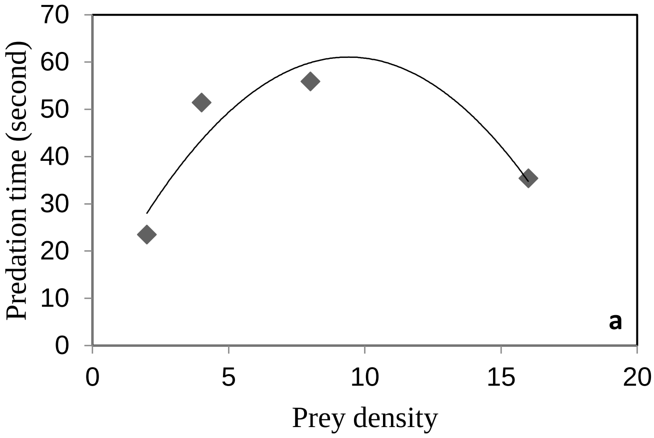
Table 1 Paederus sp predation on aphids under different predatory conditions

Test	Prey density							
	2				4			
	Hungry Predator	Not hungry predator	d	d^2_i	Hungry Predator	Not hungry predator	d	d^2_i
1	1	2	-1	1	3	1	2	4
2	0	0	0	0	2	1	1	1
3	1	0	1	1	1	0	1	1
4	2	0	2	4	1	0	1	1
5	0	0	0	0	1	0	1	1
Total	4	2	2	6	8	2	6	8
Mean	0,8000	0,4000	0,4000	1,2000	1,6000	0,4000	1,2000	1,6000
$\bar{d}$	0,4000				1,2000			
$S^2_{\bar{d}}$	9,3020				1,4310			
$S_{\bar{d}}$	3,0499				1,1962			
t count	0,1311				1,003			
t table (db = 4, taraf 5%)	2,776				2,776			

continued..

Test	Prey density							
	8				16			
	Hungry Predator	Not hungry predator	d	d^2_i	Hungry Predator	Not hungry predator	d	d^2_i
1	1	0	1	1	1	2	-1	1
2	2	2	0	0	4	0	4	16
3	2	0	2	4	0	0	0	0
4	1	0	1	1	3	0	3	9
5	2	0	2	4	2	0	2	4
Total	8	2	6	10	10	2	8	30
Mean	1,6000	0,4000	1,2000	2,0000	2,000	0,4000	1,6000	6,0000
$\bar{d}$	1,2000				1,6000			
$S^2_{\bar{d}}$	5,0087				30,7683			
$S_{\bar{d}}$	2,2380				5,5469			
t count	0,5361				0,2884			
t table (db = 4, taraf 5%)	2,776				2,776			

The amount of prey released affects the predator's discovery time sooner or later. More numbers in the same area (high density) will make it easier to find predators (shorter finding time) when compared to small numbers in the same area (low density) (Figure 2). The correlation shape for both predation conditions (during hungry and not-hungry conditions) shows a negative curved line relationship between the number and condition of predators and the time of predation.



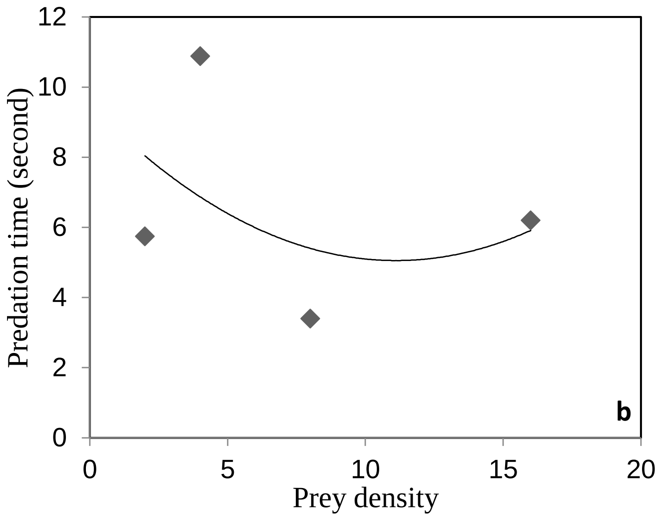


Figure 2 Relationship between Prey Density and Predation Time in Predatory Conditions *Paederus* sp. when Hungry (a) and not Hungry (b)

3.2. Discussion

Paederus sp. predator is a type of predator that benefits farmers in helping to minimize losses from loss of crop productivity. Purnomo (2010) states that 600 species of predators can be used as natural predators. *Paederus* sp. thrives in humid areas that tend to have sufficient water. Rove beetles in Malaysia are abundant in the Penang, Kelantan, Terengganu, and Selangor areas due to the availability of tropical rainforest areas and large rice cultivation areas (Tan et al., 2022). Based on the results, there are positive correlations between predator and prey (Figure 1a) A positive correlation implying mutual interference between predators

(Emerick et al., 2020; Singh, 2021). This type of positive correlation fits the type II model of functional responses (Shi et al., 2021). *Paederus* sp. predators in hungry conditions will consume more prey than in non-hungry conditions resulting in a type II functional response curve. The two parameters, which are *a* (level of attack) and *Th* (handling time), can be described in type II (Sepúlveda & Carrillo, 2008). Type II functional response is common in insect predation, such as in some ladybeetles, which prey on several *Aphid* spp. (Timms et al., 2008), predation of Coccinelid predators (Pervez, 2005), and predation of *H. variegata* (larval and adult stages) on *A. fabae* (Scolpoli) (Hemiptera: Aphididae) (Farhadi et al., 2010) Predation of female *Trichogramma ostriniae* showed type II or type III functional response depending on temperature (Wang & Ferro, 1998; Donelly & Philips, 2001). Type III to type II changes can also occur due to increased temperature (Daugaard et al., 2019). Another result showed a different correlation. In Figure 1b, there are no correlations shown. It may show that when predators start attacking prey at a constant speed (Singh, 2021), the density of prey cannot be suppressed (Stewart et al., 2022) without making the population dynamics unstable (Singh & Emerick, 2021).

Predation of predators is influenced by several factors, such as prey, light, color, and chemical factors in the form of odors that can stimulate predators to find prey. Based on the results of this study, there is no relationship between predation time and predatory conditions. The population density correlations may contain stabilizing mechanisms (Upadhyay et al., 2019) and resulting a negative correlation (Figure 2) (Emerick & Singh, 2016). in predator-prey densities implying a prey-dependent attack rate (Singh, 2021). Predators more do the level of attack and handling time (Singh, 2022) before predation. Because predators can take advantage of time (Schreiber & Vejdani, 2006; Knies & Kingsolver, 2010; Urban et al., 2020), metabolic (Valderrama & Fields, 2016; Linzmaier & Jeschke,2020), temperature (Riemer et al., 2018), and habitat (Canavero et al., 2018). The highest number of search and predation efforts for *P. fuscipes* was often shown in the live prey species *Nilaparvata lugens*. In contrast, other prey *P. fuscipes* spent more feeding time-consuming dead prey than live ones (Zuharah & Maryam, 2020). The ability to prey on P. fuscipes against soybean plant pests is very effective (Winasa et al., 2007). Predators of *P. fuscipes* can prey on whitefly nymphs (*Bemicia tabaci*) at speeds ranging from 0.83-8.17 nymphs per hour during the day and 0.75-8.00 nymphs per hour at night (Purnomo, 2010). *Stethorus tridens* consumes the most significant proportion of nymphs and adults of *Tetranychus bastosi*, with eggs usually consumed in the most significant quantities (Costa et al., 2020). The predator, *S. tridens* can easily attack *T. bastosi* eggs and larvae because predators can handle the eggs and larvae and are less resistant to attack (Costa et al., 2017). Predators need more time to handle the prey in later stages (nymphs and adults), resulting in less consumption at this stage. The ability of natural enemies can be measured by their ability to find low prey and consume much prey when the prey population is high with an ever-increasing diet (Sudarjat et al., 2009). Temperature also affects predation activity. Adults of *P. fuscipes* were found to be inactive at $\leq 18^0$ C but became active and prowled at 20^0 C (Huang et al., 2001) and temperatures between 23^0 C and 28^0 C (Bong et al., 2013).

4. CONCLUSION

This study concludes that the functional response of the predator *Paederus* sp. is a type II functional response. The area of the place will make it easier to find predators when compared to the small number in the same area.

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