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Exploration and Evaluation of Potential Dominant Predators as a Candidate for Biological Control Agent *Neotoxoptera Formosana* (Takahashi) (Hemiptera: Aphididae) Onion Plants (*Allium Fistulosum* L) in Bali

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ABSTRACT: *Neotoxoptera Formosana* Takahashi (Hemiptera: Aphididae) is an important pest in leaf onion plants and is also the cause of latent transmission of viruses in onion plants which currently has spread in various regions such as West Jawah, Central Jawah, Sumatra and Bali with attack intensity between 20 to 100%. The purpose of this study is to obtain predators that are effective in controlling *N. formosana* in all types of onion plants, especially leaf onions (*Allium fistulosum* L.) in Bali. The potential as a predator of *N. formosana* was carried out in two experimental stages, namely predator exploration, preference tests and functional responses to dominant predators. Predator exploration was conducted using survey method. The research was conducted in three districts in Bali (Denpasar, Tabana and Bangli) from May to July 2025. The exploration found 12 predator species, with *Menochilus sexmaculatus* (Coccinellidae) and *Oxyopes salticus* (Oxyopidae) as the dominant predator species. Preference tests showed that *M. sexmaculatus* larvae had a high predation rate of 8.83 per day, on *N. formosana* instar 4 and functional response tests showed *O. salticus* had a high predation rate of 44.00 within 24 hours at a prey density of 60 *N. formosana* instar 4, with a type I functional response pattern. *Menochilus sexmaculatus* (Coccinellidae) and *Oxyopes salticus* (Oxyopidae) are potential predator species in biological agent control of *N. formosana* aphids on spring onion plants in Bali.

KEYWORDS: *Neotoxoptera formosana*, Leaf onion, Biocontrol.

INTRODUCTION

Neotoxoptera formosana (Takahashi) (Hemiptera: Aphididae) is one of the most important pests in all types of onion plants, especially in leaf onions. This pest was first discovered in Indonesia in August 1995 on onion plants in Pacet, Bogor, West Java (Rauf 2022). The problem of *N. formosana* pests is not limited to Indonesia, but also attacks many types of onion plants in various countries in ASEAN and Europe. Pest attacks on leaf onions, especially by the onion aphid *Neotoxoptera formosana* Takahashi, can result in huge losses for farmers because they reduce yields and the quality of the products produced (Nugroho *et al*., 2021). The cuthudaun *N. formosana* (Takahashi) (Hemiptera: Aphidae) is a serious threat to leek (*Allium fistulosum* L.) crops in Indonesia, especially in the Bali region.

N. formossana control efforts commonly practiced by farmers have been the use of insecticides with an application frequency of 2-3 times per week throughout the growing season. Excessive use of insecticides is feared to have adverse effects such as the occurrence of pest resistance and resurgence, the emergence of secondary pests, the killing of natural enemies, environmental pollution and the danger of toxic residues for humans in general and especially for consumers of leeks. So it is necessary to explore and study the potential of natural enemies to control *N. formosana* in leaf onion plants that are safe and environmentally friendly. The purpose of this study is to obtain predators that are effective in controlling *N. formosane* in all types of onion plants, especially leaf onions (*Allium fistulosum* L.) in Bali.

RESEARCH METHODS

The research has been conducted in April - July 2025 which consists of two stages, the first stage explores the types of predators that have the potential as a biological control of *N. formosana* pest populations in leaf onion plants in three districts (Denpasar, Tabana, and Bangli) which are the centers of leaf onion and shallot production in Bali. The second stage of preference testing and functional response of dominant predator species found in the exploration that have high predatory power against nymph and imago stadia of *N. formosnan* at the Integrated Pest Management Laboratory, Faculty of Agriculture, Udayana University Bali. Exploration of predators was carried out by directly collecting insects suspected as predators (predator estimation based on observations and literature studies).

Predators that were tested for their preference for *N. formosana* were several predators that were commonly found and had a wide distribution from the results of exploration activities, namely predators *Monochilus sexmaculatus*, *Oxypes salticus* and larvae of *M. sexmaculatus*. Preference tests were conducted using the *free-choice* test method. The experiment was conducted using the method according to Legaspi *et al*. (2006).

The experiment was carried out in plastic jars measuring 35 x 27 x 7 cm. In each jar, pieces of leeks containing *N. formosana* intar I, II, III, and IV nymphs were inoculated with 10 individuals each. The ends of the leek stalks were given wet cotton so that they would not wilt quickly. Next, one predator imago and larva was released right in the center of the petri dish, which had previously been fed for 24 hours. All treatments in the experiment were repeated 6 times. Observations of the number of aphids preyed upon were made for 12 hours after the release of the predators. Then the degree of preference (preference index) of the prey was calculated.

This functional response test consisted of 5 treatments and 5 replications. Predation is done by inserting 1 individual predator insect that has been fed for 24 hours into a Petri dish that has contained prey with different amounts, namely as much as 5, 10, 20, 40, and 60, individuals for 5 replicates. Predator predation tests were conducted for 24 hours. Predatory ability was observed under direct laboratory conditions.

Observations were made by counting the number of *N. formosana* preyed upon and compared to the density of prey provided. In addition, the time required by the dominant predator to deal with one prey was also calculated. These observations were made to determine the functional response of the dominant predator to *N. formosana*. Determination of the type of functional response is by using regression analysis, namely by calculating the number of *N. formosana* onion aphids that are preyed upon and compared with the density of the number of prey given.

RESULTS

Predator species with potential as biological control agents against *Neotoxoptera formosana* Takahashi in onion plants in Indonesia, especially in Bali.

The inventory of predator species and the count of each predator species from the explorations are presented in Table 1. Based on the table, it appears that the predator species that are found in large numbers and have a wide distribution are *Menochilus sexmaculata* Fabricius and *Oxyopes salticus*, indicating that these two predatory insect species have the potential to be further studied and developed as biological agents for the natural control of *N. formosana* Takahashi aphids.

Table 1. Number of predators caught on corn and chili commodities in the around leek plants in several production centers in Bali.

No.	Species	Number Individuals			Total
		Bangli	Denpasar	Tabanan	
1.	*Micraspis discolor*	0	15	0	15
2.	*Verenia Lineata Thunberg*	0	38	0	38
3.	*Menochilus sexmachulata*	0	146	0	146
4.	*Harmonia axyridis*	0	20	0	20
5.	*Choelophora inagualis*	0	12	0	12
6.	*Choelopora bisella Musland*	5	1	2	8
7.	*Oxyopes salticus*	10	34	15	59
8.	*Sirpidae*	2	0	3	5
9.	Reduvidae (*Rhinocoris iracundus)*	0	4	2	6
10.	*Harlequin*	2	11	1	14
11.	*Calvia quatuordecimguttata*	0	3	0	3
12.	*Chilocorus nihgrita*	0	4	0	4

Preferences and functional responses of dominant predators to nymph and imago stadia of *Neotoxoptera formosana* (Takahashi) on leek plants

Based on the results shown in Figure 1, it can be seen that the dominant predators have different predation rates on nymphs and imago of *N. formosana*. Imago of *M. sexmaculatus* and *O. salticus* consistently preyed on *N. formosana* from the 1st instar to the 4th instar, while larvae of *M. sexmaculatus* were only seen preying on *N. formosana* from the 2nd to the 4th instar.

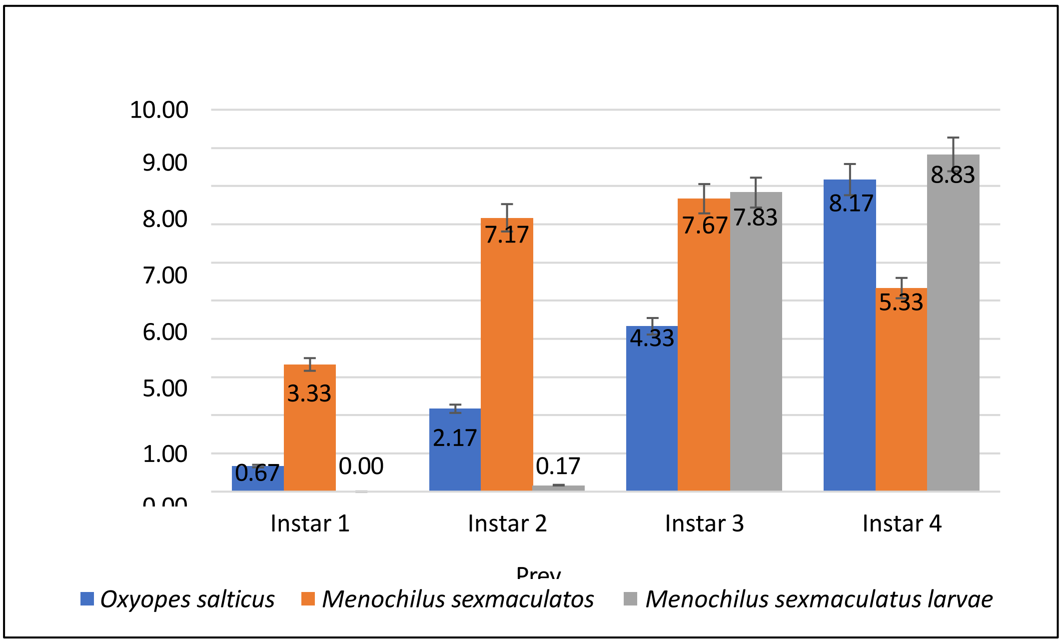


Figure 1. Preying Power of Dominant Predators on Nymph and Imago Stadia of *N. formosa* Takahashi

The results of the preference index test showed diverse preference values. Weak preference values (-1) of the three predators were shown at instar 1 to instar 2, but the preference index of *M. sexmaculatus* only showed a weak value at instar 1. *M. sexmaculatur* predator began to show its preference at instar 2 to instar 4, so the predation ability test of the three predators was taken at instar three of *N. formosa.*

Table 2. Preference index of dominant predators towards nymph and imago stadia of *Neotoxoptera formosana* (Takahashi) on spring onion plants

Predator	Preference index value (Li)			
	Instar 1	Instar 2	Instar 3	Instar 4
Oxyopes salticus	-1	-1	0	0
Menochilus sexmaculatos	-1	0	0	0
Menochilus sexmaculatus larvae	-1	-1	0	0

Functional responses of *O. saltcus*, imago and larvae of *M. sexmaculatus* to *N. formosana*

Prey density and type affect predator predation ability. An increase in the number of prey eaten by predators occurred as the prey density increased. All three predators ate the most prey at a prey density of 60 individuals and were statistically significantly different when compared to prey densities of 5, 10, 20 and 40 individuals of the same prey type (Table 3). The highest predation was shown by the larval predator *M. sexmaculatus, which* was able to prey on 43.60 individuals of *N. formosa*, followed by the predator *O. salticus* with 44.00 individuals, and *M. sexmaculatos* with 38.00 individuals. All three had almost the same ability to prey on *N. formosa* at all types of prey density (P > 0.05).

Table 3.
Predation ability of *Oxyopes salticus*, *Menochilus sexmaculatos*, and *Menochilus sexmaculatus* larvae at different prey densities

Density	Prey	Number of prey eaten by predators/tail (Mean±SB)		
		Oxyopes salticus	*Menochilus sexmaculatos*	*Menochilus sexmaculatus* larvae
5	*Neotoxoptera formosana*	5,00 ± 0,00 e	5,00 ± 0,00 e	5,00 ± 0,00 e
10		10,00 ± 0,00 d	10,00 ± 0,00 d	10,00 ± 0,00 d
20		15,20 ± 1,30 c	14,40 ± 1,14 c	13,8 ± 0,84 c
40		29,80 ± 1,48 b	26,00 ± 3,39 b	30,60 ± 1,14 b
60		44,00 ± 3,39 a	38,00 ± 3,54 a	43,60 ± 2,30 a

The same letter in one column indicates there is no significant difference based on Tukey test at 5% real level.

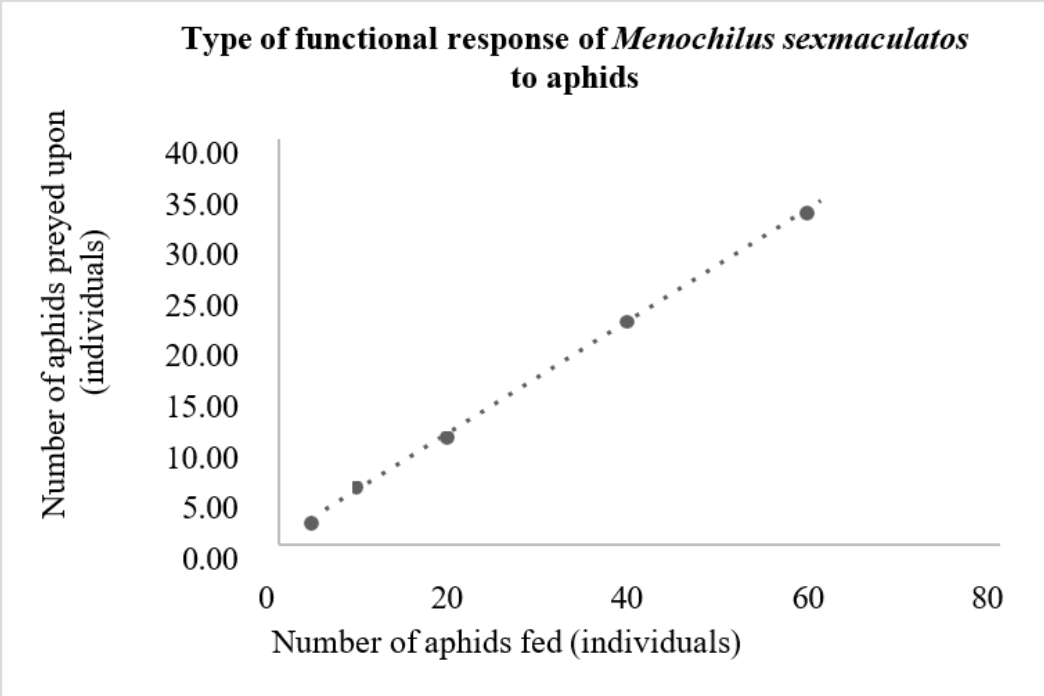
The results showed that the three predators *O. salticus*, imago and larvae of *M. sexmaculatus* had high predation rates on *N. formosa*. As with predation ability, the three predators also had high predation rates and were significantly different (P < 0.05) across all prey densities tested (5, 10, 20, 40, and 60 individuals). Predation rates tended to be stable at low prey density and increased at high prey density (Table 4).

Table 4.Predation rates of *Oxyopes salticus*, *Menochilus sexmaculatos* and *Menochilus*
sexmaculatus larvae at different prey densities

Density	Prey	Predator predation rate (Mean±SB)		
		Oxyopes salticus	*Menochilus sexmaculatos*	*Menochilus sexmaculatos* larvae
5	*Neotoxoptera formosana*	0,003 ± 0,000 e	0,003 ± 0,000 e	0,003 ± 0,000 e
10		0,007 ± 0,000 d	0,007 ± 0,000 d	0,007 ± 0,000 d
20		0,011 ± 0,001 c	0,010 ± 0,001 c	0,010 ± 0,001 c
40		0,021 ± 0,001 b	0,018 ± 0,002 b	0,021 ± 0,001 b
60		0,031 ± 0,002 a	0,026 ± 0,002 a	0,030 ± 0,002 a

The same letter in one column indicates there is no significant difference based on Tukey test at 5% real level.

The functional response type was determined based on the highest R^2value close to 1 from the regression analysis tested. The results of this study showed that the functional responses of *O. salticus*, as well as the imago and larvae of *M. sexmaculatus*, were classified as type I (R^2= close to 1) in all prey types, with predation rates increasing or decreasing with increasing and decreasing prey density (Figure 2.)



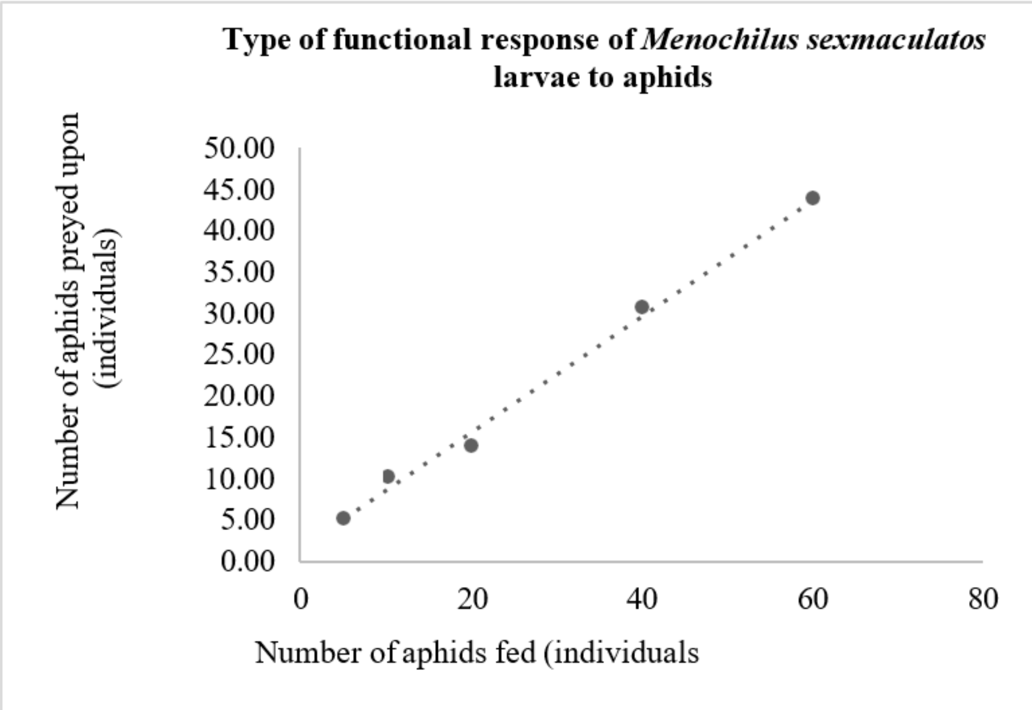


Figure 2. Functional response types of *Oxyopes salticus*, *Menochilus sexmaculatos*, and *Menochilus sexmaculatus* larvae predators

Based on the results of linear regression analysis, it can be seen that the functional response type of Oxyopes *salticus*, imago and *Menochilus sexmaculatus* larvae is classified as type I, with the value of r for each predator, namely r = 0.9982 in *O. salticus*, r = 0.9997 in *M. sexmaculatus*, and r = 0.9940 in *M. sexmaculatus* larvae (Table 5). The ability to prey *on O. salticus*, imago and larval *M. sexmaculata N. formasana* predators showed an increase with increasing prey density.

Based on the results of linear regression analysis, it can be seen that the type of functional response of Oxyopes *salticus*, imago and *Menochilus sexmaculatus* larvae is classified as type I, with the value of r in each predator, namely r = 0.9982 in *O. salticus*, r = 0.9997 in *M. sexmaculatus*, and r = 0.9940 in *M. sexmaculatus* larvae (Table 5). The ability to prey on *O. salticus* predators, imago and larvae of *M. sexmaculata N. formasana* showed an increase with increasing prey density.

Table 5. Functional response types of *O. salticus*, *M. sexmaculatus*, and *M. sexmaculatus* larvae on *N. formosa* based on regression analysis and R^2values

Predator	Regression equation	R^2value	Functional response type
Oxyopes salticus	Linear regression y = 0.6986x + 1.9389	0,9982	I
Menochilus sexmaculatos	Linear regression y = 0.5519x + 0.8626	0,9997	I
Menochilus sexmaculatos larvae	Linear regression y = 0.7019x + 1.6481	0,994	I

DISCUSSION

Potential predators should have a high ability to compete, disperse, and a wide range of environmental tolerance. When there are no host plants in the field, predators must be able to disperse to non-host plant habitats (evacuate and find alternative prey). When the host plant is present, the predator must be able to quickly colonize the habitat de Bach (1991). Therefore, the dominant predator species in the explorations need to be further tested for their predatory power and preference for *N. formosane* to determine their effectiveness as biological agents in controlling *N. formosane* in leaf onions. *Oxyopes salticus,* imago and larvae of *M. sexmaculata* Fabricius instar 4 tested had high predatory power with each: *M. sexmaculata* larvae preyed on 8.83 *N. formosana* instar 4 aphids and *Oxyopes salticus* was able to prey on 8.17 *N. formosana* instar 4 aphid nymphs per day. Prabaningrum *et al.* (2005) reported that the predator *M. sexmaculata* was able to prey on as many as 20-40 *B. tabaci* larvae at the experimental level in the screen house. The results of preference testing presented in Table 2 indicate that the three predator species are different towards *N. formosana*. According to deBach (1991), natural enemies can select suitable hosts or prey and the selection takes place through natural processes. Frazer (1988) and Legaspi *et al.,* (2006) stated that two important differentiators of host or prey range are host taxonomy and ecology. The results of this study indicate that the availability of prey greatly affects the predation ability of predators, the more prey the higher the predator's predation ability. The same results were also stated by Rachmalia (2013) and Wagiman (1997) in their research on the predation ability of the predator *M. sexmaculatus* against Aphis craccivora Koch showing that predators will prey more at higher prey densities compared to low densities. This relationship of predator predation ability to prey density is also explained in terms of functional response. As an essential component in the dynamics of interactions between predators and their prey, functional response is considered important in providing an overview of the effectiveness of predators in controlling prey populations (Nelly & Syuhadah 2012). Functional responses *of O. salticus* predators, imago and larvae *of Menochilus sexmaculata* in this study both showed type I. which means that the rate and ability of predation of *O. salticus* predators, imago and larvae of *M. sexmaculata* increased along with the increase in prey density. The increase in prey density is related to the ease with which predators can find their prey because predators and prey are in a limited space. This type I functional response generally occurs in laboratory experiments with one prey species provided (Van Alpen & Jervis 1996). *Menochilus sexmaculatus* instar 4 larvae have a type I or linear functional response where the amount of prey eaten is directly proportional to the amount of prey density. The ability to prey occurs at a prey density of 60 prey (Figure 2). According to Patel ((2015), the mean feeding ability of 1st instar larvae on *A. cracivora* was 20.7, instar 2 32.60, instar 3 and 4 39.60. This shows that the older the insect (instar), the more it needs to eat. This happens because the 4th instar larvae will change into pupae so that they need food reserves, which causes their food needs to increase. According to Purnomo and Nanang (2007), pupa is the phase where insects begin to be passive.

CONCLUSIONS

Menochilus sexmaculatus (Coccinellidae) and *Oxyopes salticus* (Oxyopidae) are potential predator species in biological agent control of *N. formosana* aphids on spring onion plants in Bali.

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