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Prey preference and predation efficacy of *Sycanus collaris* (F.) (Hemiptera: Reduviidae) on *Tenebrio molitor* (L.) (Coleoptera: Tenebrionidae)

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ABSTRACT: An assassin bug, *Sycanus collaris* (F.), has records to control pests in teak, marigold, and tea and has shown potential as a biological agent. Although the predator can be mass reared on alternative prey, *Tenebrio molitor* (L.), effects of different sizes of yellow mealworm to *S. collaris* preference, development and survival remains unknown. Hence, small, medium and large sized-larvae and pupae of yellow mealworm were offered to second- to fifth instar and adult *S. collaris* using choice test. Overall, the predator seemed to prefer larger prey as they grew. The choice-test experiment revealed that the most preference prey of 2nd, 3rd, 4th and 5th instar were small larvae (55%), medium larvae (33%) and pupae (33%), large larvae (40%), and medium larvae (80%), respectively. Both female and male attacked most frequently on large larvae (56% and 44%, respectively). In no-choice test, four prey choices did not affect developmental time in 2nd to 4th instar, but 5th instar grew faster when fed on pupae than medium larvae. Pupae enhanced female lifespan but did not affect male lifespan. Moreover, the findings indicated that *S. collaris* was expected to have a higher effect on the suppression of small sized-pest populations. Feeding each predator stage with their preferred prey size can improve feeding capacity, survival and later likely to increase reproduction output which is advantageous to the mass rearing program. Understanding the effect of different alternative prey sizes on the predator development and survival will provide evidence whether their preferred prey choice is suitable for the predator and may also provide implications on the predator feeding preference in the field after being released.

Keywords: alternative prey, assassin bug, biocontrol, prey preference, yellow mealworm

Introduction

Generalist predators as biological agents were useful to control a range of preys. Although they were not specific to which species of prey they ate, they exhibited a certain degree of preference (Ambrose and Ganesh Kumar, 2016). Prey preference was influenced by predator ease to attack the prey and prey nutrition (Eubanks and Denno, 2000; Jaworski et al., 2013). Assassin bugs were known to choose mobile prey over immobile prey (Rosenheim and Wilhoit, 1993; Eubanks and Denno, 2000). Moving prey acted as a stimulus and initiated arousal response in assassin bugs (Rajan et al., 2017). It was unclear whether generalist predators selected prey based on its nutritional quality (Eubanks and Denno, 2000). Furthermore, prey size was reported to affect predator-prey

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relationship. Smaller prey was easier to capture (i.e. high capturing success and short handling time) and resulted in higher feeding rate (Cogni et al. 2002; Hohberg and Traunspurger, 2005).

Assassin bugs used extra-oral digestion, which was advantageous to consume large prey, quickly ingested prey nutrient and attacked other preys (Cogni et al., 2002). An assassin bug, *Sycanus collaris* (F.) (Hemiptera: Reduviidae) predatory behavior was categorized into arousal, approach, capture, rostral probing, injection of toxic saliva and paralyzing, sucking and postpredatory behavior (Ambrose and Ganesh Kumar, 2016; Rajan et al., 2017). This predator had recorded to control pests in teak, marigold (Jamjanya et al., 2014) and tea (Sarkar et al., 2019). The distribution was mainly in South Asia and South East Asia (Sahayaraj, 2012; Jamjanya et al., 2014). Studies had demonstrated *S. collaris* potential as biological agents to control Lepidopteran caterpillars (i.e. teak defoliator, teak skeletonizer, poplar leaf defoliator, cotton leafworm and black looper) and suggested that *S. collaris* should be mass reared and released in biocontrol programs (Jamjanya et al., 2014; Ambrose and Ganesh Kumar, 2016; Rajan et al., 2017).

S. collaris was previously shown that the predator could be reared on yellow mealworm, *Tenebrio molitor* (L.) (Coleoptera: Tenebrionidae) (Maneerat and Sakarind, 2018). However, there was no report about appropriate sizes of yellow mealworm used as prey in the mass rearing of *S. collaris* early instar to adult. Feeding each predator stage with their preferred prey size could improve its feeding capacity, survival (Pravalika et al., 2016) and later likely to increase reproduction output which is advantageous to the mass rearing program. Understanding the effect of different alternative prey sizes on the predator development and survival will clarify whether their preferred prey choice is suitable for the predator and may also provide implications on the predator feeding preference in the field after being release. The aims of this study were to 1) determine *T. molitor* size preference of *S. collaris* as the predator developed and 2) investigate the different prey sizes affected predator survival, developmental time and the number of preys consumed.

Materials and methods

Insects rearing

S. collaris colony was obtained from Biological Control Laboratory, Prince of Songkla University, Songkla, Thailand, and were reared in a plastic container (24.5 cm-diameter, 11 cm-height) with screen. Non-sibling *S. collaris* males and females were allowed to mate in the containers to avoid inbreeding. Eggs were collected to rear in a separate container. First to second instar nymphs were fed with *T. molitor* pupae and filtered water using wet cotton balls. Third to fifth instar and adults fed on mixed sizes of *T. molitor* larvae. An orange jessamine branch, *Murraya paniculata*, was provided in the rearing container of first-, second- and third instars. A plastic basket (17 cm-diameter, 5 cm-height) was added in the rearing container of fourth to fifth instars and adults. Orange jessamine branch and plastic basket were used to increase surface area and provide microhabitats for the insects.

T. molitor eggs to adults were reared in plastic containers (24.5 cm-diameter, 11 cm-height) with screen and fed with a mixture of diet. The diet used the ratio of 1 kg wheat bran: 1 kg rice bran: 0.75 kg corn bran: 25 g yeast: 25 g calcium. Each stage was maintained separately. Pupae were left in the rearing container until adult emergence.

Adults were fed with the same diet as larvae and they were allowed to mate and lay eggs on wax paper. Eggs were collected every three days. Frass was sifted through a fine screen weekly to allow more access to diet.

Experimental procedure

S. collaris second to fifth instar nymphs and adults were tested for their preference toward various sizes of artificial prey, *T. molitor*, using choice test and no-choice test. *T. molitor* size determination was indicated in **Table 1**. Each larval size was separated using fine and coarse screen sifters. Small larvae were able to pass through fine screen (1.2 x 1.2 mm). Medium larvae were larger than fine screen but able to pass through coarse screen (1.8 x 1.8 mm). Large larvae were larger than coarse screen. Pupae were collected using forceps.

Table 1 Different size and weight of *Tenebrio molitor* (L.) larvae and pupae

T. molitor size	Width range (mm)	Length range (mm)	Weight range (mg)
small larva (s)	0.7-1.2	6.0-13.0	6.5-20.0
medium larva (m)	>1.2-1.8	>13.0-21.0	>20.0-50.0
large larva (l)	>1.8-2.3	>21.0-29.0	>50.0-106.0
pupa (p)	3.5-4.5	13.5-16.2	66.3-113.6

This study consisted of choice test and no-choice test. Both tests were completely randomized (CRD) and were repeated 20 times in second to fifth instar nymphs, 10 times in adult females and 10 times in adult males. In choice test experiment, the predator, 3-5 days old of each stage, was starved for 48 hours individually prior to prey exposure in a clear plastic container. Second to third instar nymph was tested inside an 8 cm-diameter and 6 cm-height container. Fourth to fifth instar nymph or adult was tested inside a 13 cm-diameter and 5 cm-height container. One of four sizes of preys, small larva (s), medium larva (m), large larva (l), pupa (p) and a wet cotton ball (1 cm-diameter), were given at the same time allowing a distance for the predator to move toward the prey. At 10, 20, 30, 40, 50, 60, 90, 120, 150, 180, 240, and 300 min, predator behaviors, prey sucking, proboscis on prey, leg on prey, antenna on prey which indicated or may imply prey preference were observed.

In no-choice test experiment, 1 day-old predators of second to fifth instar nymphs and adults were studied its feeding individually on four sizes of *T. molitor* (**Table 1**) until death or molt in a circumstance where the same size of *T. molitor* was given. The predator to prey ratio was shown in **Table 2**. Number of prey killed, adult emergence, and predator death were observed every 24 hours. Developmental time, longevity, and number of preys killed were analyzed by one way-analysis of variance (ANOVA) (SPSS version 23.0; IBM Corp., Armonk, NY, USA). Duncan's multiple range test (DMRT) was performed when significance differences were observed. Data were tested with the Shapiro-Wilk Normality Test prior to ANOVA tests and normal distributions were obtained. Choice- and no-choice tests were conducted during March-August 2019 under laboratory conditions (27±2 ^{o}c, 55-80% RH) at Biological Control Laboratory, Prince of Songkla University, Songkla, Thailand.

Table 2 In no-choice test, one of *Sycanus collaris* (F.) second to fifth instar nymphs (N = 20) and adults (female, N = 10; male, N = 10) per one container was fed with *Tenebrio molitor* (L.), in size small (s), medium (m), and large (l) larvae and pupae (p) (treatments). Numbers of *T. molitor* per container for each treatment were shown.

S. collaris stages	Number of preys/container			
	s	m	l	p
2nd instar	15-20	10-15	5-10	3-5
3rd instar	15-20	10-15	5-10	3-5
4th instar	15-20	10-15	5-10	3-5
5th instar	15-20	10-15	5-10	3-5
Adult	15-20	10-15	5-10	3-5

Results and Discussion

Choice test

When *S. collaris* was exposed to four prey sizes in the arena, *S. collaris* first response to prey was either turned its body toward a prey, or walked away to sidewall of testing container, or stayed on the container lid. Some probed the wet cotton ball to consume water prior to approach a prey. Approaching and capturing observed in this study was when *S. collaris* extended antennae and proboscis toward a prey. After prey capturing, *S. collaris* then pierced its prey not restricted to a specific region (i.e. head, thorax, or abdomen) multiple times, and prey hemolymph was seen after being pierced. The attacked prey appeared weaker (less movement in larvae and no movement in pupae) over time and at the same time *S. collaris* proboscis inserted inside prey body. Once the prey showed completely no movement, *S. collaris* sometimes released prey from its forelegs and lifted antennae. *S. collaris* carried the prey with its proboscis to the sidewall of the container and continued feeding (**Figure 1A-C**).

Figure 1 *Sycanus collaris* (F.) piercing and sucking behavior were used as a preference indicator under laboratory conditions (27±2 °c, 55-80% RH). (A) *S. collaris* third instar nymph was sucking a medium-sized *Tenebrio molitor* (L.) larva. (B) *S. collaris* fourth instar nymph was sucking a *T. molitor* pupa. *S. collaris* proboscis contact with prey before piercing was also observed. (C) *S. collaris* female proboscis probed a large-sized *T. molitor* larva

During the first 30 minutes of prey encounter, third instar nymph was observed to use antennae to touch on prey before probing and piercing more often than other stages. Proboscis pinning on prey was observed in all stages of *S. collaris*. Fourth instar nymph, fifth instar nymph, and female touched prey with antennae less than second instar nymph, third instar nymph, and male. Predator abdomen looked larger as the feeding persisted. Fifth instar nymph approached and killed prey within 30 minutes more than other stages. More males killed prey within the first 30 minutes than females did (**Table 3**).

Table 3 Numbers of *Sycanus collaris* (F.) second to fifth instar nymph and adult that showed predatory behaviors within the first 30 min of prey encounter when tested prey preference toward *Tenebrio molitor* (L.) using choice test under laboratory conditions (27±2 °C, 55-80% RH)

S. collaris stage	N	No. *S. collaris*			
		Antenna touched prey	Proboscis pinning	Leg touched prey	Piercing
2nd instar	20	2	12	5	1
3rd instar	20	8	11	3	3
4th instar	20	1	10	3	4
5th instar	20	1	17	5	10
Female	10	1	7	0	2
Male	10	3	8	2	6

After *S. collaris* finished feeding, younger instar nymphs released the dead prey and cleaned their proboscis and antennae with tibia pads. Some of late instar nymphs and adults captured another prey left in the container in which their behaviors were similar to as previously explained. However, not all approaching and capturing acts were successful. Often second instar nymph and third instar nymph attempted to capture *T. molitor* larvae that defensed itself by moving away, lifting its head and thorax, or rolled away in pupae. Piercing-sucking behaviors were observed much later after approaching and capturing mostly in larger *T. molitor* larvae. Second instar nymph and third instar nymph showed approach and capture behaviors toward large-sized larvae but did not successfully consume them (**Table 4**). While prey was escaping, *S. collaris* avoided other parts of the body, except proboscis and antennae to be reached by *T. molitor* larvae. *S. collaris* forelegs were also used in prey capturing.

Table 4 *Sycanus collaris* (F.) second to fifth instar nymph and adult were tested preference toward *Tenebrio molitor* (L.) larvae in size small (s), medium (m), large (l) and pupae (p) using choice test (nymph, N = 20; female, N = 10, male, N = 10) under laboratory conditions (27±2 ℃, 55-80% RH). Predatory behaviors were observed at 10, 20, 30, 40, 50, 60, 90, 120, 150, 180, 240, and 300 min after prey exposure

S. collaris stage	Prey size	Predatory behaviors in median time interval (min)			
		Approaching and capturing		Piercing and sucking	
		Median	N	Median	N
2nd instar	s	30	3	100	6
	m	-[1/]	1	-	2
	l	20	7	-	0
	p	20	5	240	3
3rd instar	s	20	5	40	4
	m	90	5	240	6
	l	40	5	-	2
	p	30	4	50	6
4th instar	s	-	2	-	2
	m	20	6	30	5
	l	40	6	90	6
	p	35	4	-	2
5th instar	s	-	2	-	1
	m	20	14	30	16
	l	240	3	300	3
	p	-	1	-	0
Female	s	-	1	-	1
	m	30	3	-	0
	l	20	4	40	5
	p	-	2	300	3
Male	s	-	0	-	1
	m	50	3	-	2
	l	10	5	25	4
	p	-	2	-	2

[1/]Insufficient data. Certain prey choices were approached or pierced by less than 3 predators

S. collaris nymphs tended to show preferences toward larger sizes of *T. molitor* larvae as the predator developed, except fifth instar nymph. Second instar nymph preferred small *T. molitor* larvae (55%) to the others. Third instar nymph equally preferred medium larvae (33%) and pupae (33%). The most consumption of the fourth and the fifth instar nymph were on large larvae (40%) and medium larvae (80%), respectively. Both female and male most preferred large larvae (56% and 44%, respectively) (**Figure 2**).

The predator behaviors (i.e. approaching, attacking, paralyzing, and piercing) toward *T. molitor* were the same as reported previously (Rajan et al., 2017; Sarkar et al., 2019). *S. collaris* seemed to increase its speed to capture and pierce prey as they became older (Rajan et al., 2017).

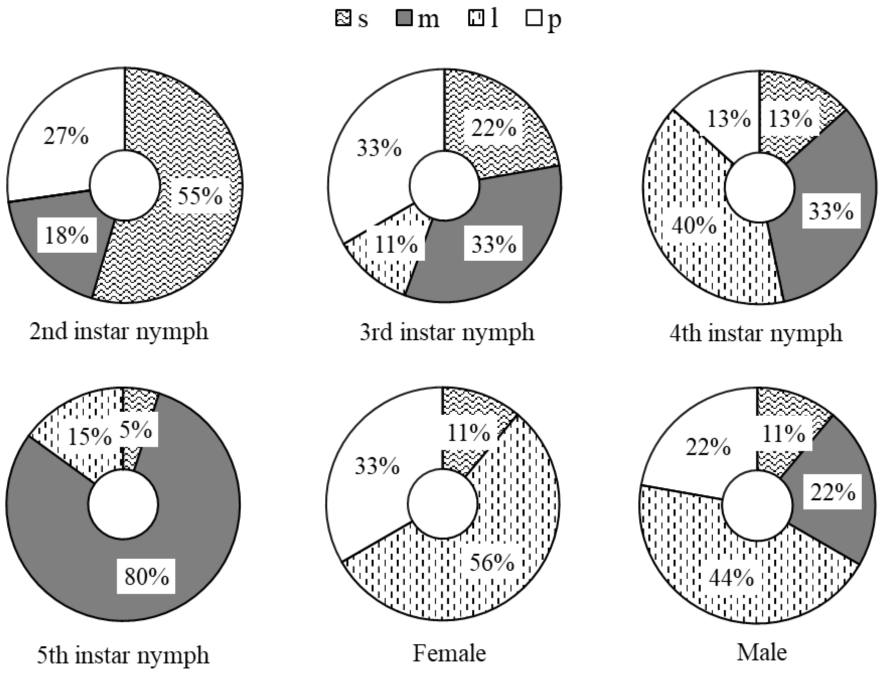


Figure 2 *Sycanus collaris* (F.) second to fifth instar nymph and adult were tested preference toward *Tenebrio molitor* (L.) larvae in size small (s), medium (m), large (l), and pupae (p) using choice test (nymph, N = 20; female, N = 10, male, N = 10). Preferred prey was determined using piercing-sucking behavior under laboratory conditions (27±2 °C, 55-80% RH).

S. collaris preferences in the present study were similar to *S. collaris* toward *Hyposidra talaca* (Walker) (Sarkar et al., 2019) and *Rhynocoris marginatus* (F.) preferences toward *Spodoptera litura* (F.) (Sahayaraj and Sivakumar, 1995; Sahayaraj, 2014), as larger predators tended to prefer large-sized prey. On the contrary, when *Zelus longipes* (L.) adults were tested on their prey size preferences on *Spodoptera frugiperda* (J.E. Smith) caterpillars, smaller preys were preferred and the success of predator attack on prey was higher with smaller prey (Cogni et al., 2002; Pravalika et al., 2016). Cogni et al. (2002) reported that the risk of injury was lower when the predator attacked small prey. *S. collaris* adults did not show high preferences toward smaller prey, but fifth instar nymph preferred medium-sized larvae the most. It is likely because medium-sized larvae are not too hard to capture, have lower injury risk, and offer sufficient energy per unit to develop into adults later. Different sizes of yellow mealworm seemed to affect predator success and energy spent while capturing prey before eventually consuming it.

No-choice test

Survival percentages of second instar nymphs when fed with small, medium, large larvae and pupae, were 75%, 45%, 5%, and 85%, respectively (**Figure 3**). Second instar nymph that was fed with large larvae did not have enough survived individuals and were excluded from developmental time comparison. Developmental time of second instar was not affected by small larvae, medium larvae and pupae (11.33±2.79, 13.22±2.81, 11.35±2.71, respectively) ($F_{2, 38}$ = 1.62, P = 0.211) (**Table 5**). While small larvae were the most preferred choice, small larvae resulted in lower survival than pupae (75% and 85%, respectively). In third instar nymphs, medium larvae and pupae showed high survival (95% and 100%, respectively) (**Figure 3**) and did not affect developmental time (10.79±2.82 and 10.15±1.90, respectively) ($F_{3, 69}$ = 2.15, P = 0.102) (**Table 5**). Four prey choices did not affect fourth instar nymph developmental time ($F_{3, 69}$ = 1.61, P = 0.195) and survival. The fifth instar nymph that was fed on medium-sized larvae developed slower than those that were fed on pupae (18.59±3.30 and 15.75±1.86, respectively) ($F_{3, 70}$ = 3.58, P < 0.05), and feeding on medium-sized larvae resulted in the highest female percentage (52.94%). In adults, pupa feeding showed longest female longevity (96.90 ±17.67) ($F_{3, 36}$ = 6.81, P < 0.01) but different prey choices did not affect male longevity ($F_{3, 36}$ = 0.81, P = 0.50) (**Table 5**).

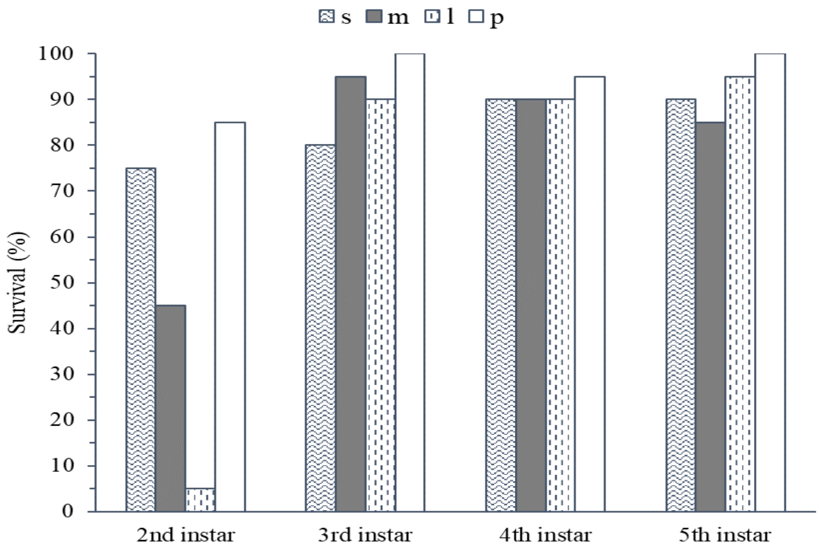


Figure 3 Survival percentage of *Sycanus collaris* (F.) nymphs when reared on small (s), medium (m), large (l) *Tenebrio molitor* (L.) larvae and pupae (p) using no-choice test under laboratory conditions (27±2 °C, 55-80% RH).

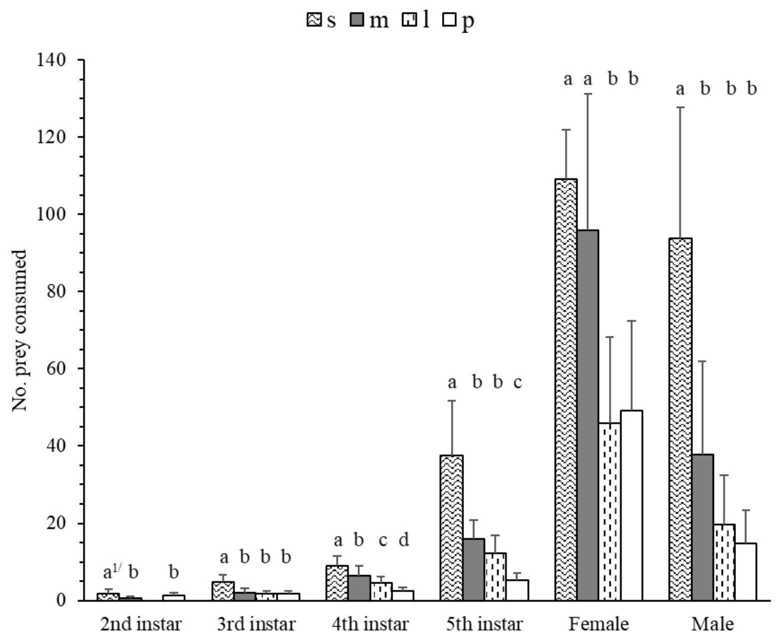
Table 5 Developmental time/lifespan of *Sycanus collaris* (F.) nymphs and adults when reared on small (s), medium (m), large (l) *Tenebrio molitor* (L.) larvae and pupae (p) using no-choice test. Number of survived individuals was also shown (N).

S. collaris stage	Prey size	N	Developmental time/lifespan (d)	
			Mean±SD	Range
2nd instar	s	15	11.33±2.79a[1/]	8-19
	m	9	13.22±2.82a	11-20
	l	1	-[2/]	-
	p	17	11.35±2.71a	6-16
3rd instar	s	16	9.44±1.09a	8-12
	m	19	10.79±2.82a	8-20
	l	18	11.67±2.25a	8-17
	p	20	10.15±1.90a	8-14
4th instar	s	18	10.67±1.53a	9-15
	m	18	10.39±1.03a	9-13
	l	18	10.67±1.97a	8-17
	p	19	9.74±1.28a	8-12
5th instar	s	18	16.78±2.67ab	13-23
	m	17	18.59±3.30a	13-28
	l	19	17.95±3.47ab	14-26
	p	20	15.75±1.86b	14-22
Female	s	10	65.20±12.24b	37-85
	m	10	71.40±20.93b	41-98
	l	10	69.50±17.51b	42-88
	p	10	96.90±17.67a	67-121
Male	s	10	50.90±18.30a	28-84
	m	10	36.10±16.68a	6-64
	l	10	38.40±27.69a	9-95
	p	10	43.30±27.17a	26-115

[1/]Different letters indicate significant differences (P < 0.05) using Duncan's multiple range test (DMRT).

[2/]Second instar nymph that was fed with large larvae did not survive enough and was excluded from developmental time comparison.

Smaller preys tended to be eaten more by *S. collaris* nymphs. Among four prey sizes, highest number of small larvae were consumed by second instar nymph (2.20 ±0.94) ($F_{2, 38}$ = 9.479, P < 0.01), third instar nymph (4.62 ±1.86) ($F_{3, 69}$ = 23.79, P < 0.01), fourth instar nymph (9.05 ±2.48) ($F_{3, 69}$ = 38.64, P < 0.01) and fifth instar nymph (38.78 ±12.06) ($F_{3, 70}$ = 86.66, P < 0.01) (**Figure 4**). As the predator developed, an increasing number of preys killed was observed. Female ate highest number of small and medium larvae (109.20 ±12.80 and 96.00 ±35.22, respectively) ($F_{3, 36}$ = 17.05, P < 0.01) and killed up to 135 small sized-larvae and 143 medium sized-larvae. Male consumed the highest number of small larvae (93.70±34.14) ($F_{3, 36}$ = 26.51, P < 0.01) (**Figure 4**) and showed the maximum number of small larvae killed of 149.



[1/]Different letters indicate significant differences (P < 0.05) using Duncan's multiple range test (DMRT).

Figure 4 Predation efficacy (number of prey consumed shown in mean±SD) of *Sycanus collaris* (F.) second to fifth instar nymph and adult when fed with *Tenebrio molitor* (L.) larvae in size small (s), medium (m), large (l) and pupae (p) (nymph, N = 20; female, N = 10; male, N = 10) using no-choice test under laboratory conditions (27±2 °C, 55-80% RH). Each stage was analyzed separately

Second instar nymph that was fed with large larvae did not survived enough and was excluded from predation efficacy comparison. Physical challenge during prey capturing may cause differences in the predator's developmental time, survival, and sex ratio. Failure to capture prey leads to starvation and death as clearly seen in second instar nymphs. Besides, moving prey stimulated arousal response in *S. collaris* before approaching and capturing (Rajan et al., 2017; Sarkar et al., 2019). Feeding on the preferred prey may enhance amount of prey consumed and later promoted the predator development (Pravalika et al., 2016). Specifically, fifth instar nymph when fed on medium larvae (80% preference using choice test) developed to the highest female percentage.

Yellow mealworm pupae and larvae contained different nutritional composition (Morales-Ramos et al., 2016). Amount of total protein and soluble protein in pupae was higher than in larvae but amount of lipid and polyunsaturated fatty acids in pupae was lower than in larvae (Morales-Ramos et al., 2016). In *Podisus maculiventris* (Say), pupae were shown to be better alternative prey in the mass production as shorter developmental time, higher survival rate, fecundity, adult weight, and reproductive output were observed when reared on pupae (Morales-Ramos et al., 2016). In this study, only fifth *S. collaris* instar fed on pupae developed faster than those fed on medium-sized larvae but did not grow faster than those fed on small and large larvae. The results from second to fourth *S. collaris* nymphs were different from Morales-Ramos et al. (2016)'s study. Second to fourth instar nymph reared on pupae did not develop faster than those reared on larvae. However, *S. collaris* nymphal survival percentage was the highest when fed on pupae (**Figure 3**) and this was relative to Morales-Ramos et al. (2016) study. As most *S. collaris* instar nymphs growth do not differ when given different sizes of *T. molitor* larvae and pupae, pupae might not have superior nutrition quality to *S. collaris* nymphs. Lifetable of *S. collaris* should be studied further when the prey for each *S. collaris* stage is adjusted according to the predator's preferences to assess parameters such as fecundity and reproductive output. Prey density and prey size may be investigated in future studies because various densities may affect predator consumption rates and potentially alter predator functional response.

Early nymphs such as second and third instar nymphs may have limits when trying to capture preys much larger than their sizes. Fourth instar nymph, fifth instar nymph and adults may have more ability to capture and kill preys in various sizes. Fifth instar nymph and males in particular killed yellow mealworm faster than other instar nymph and females. Results implied that the predator was likely to suppress a higher number of small preys. Release of *S. collaris* during early infestation may be more effective at controlling pests. Other assassin bugs, *Pristhesancus plagipennis* (Walker), and *Rhynocoris fuscipes* (F.), have demonstrated their ability to control cotton pests (Grundy and Maelzer, 2002; Tomson et al., 2017). *P. plagipennis* third instar nymphs using a release rate of 1.38 nymphs per meter row was shown to be effective at controlling *Helicoverpa armigera* (Hübner) in 8 x 10 m cotton field. Grundy and Maelzer (2002) suggested that inundative release of *P. plagipennis* was as effective as use of insecticide to reduce *H. armigera* population. In addition, another reduviid predator, *R. fuscipes* predation potential in cotton fields (3 x 5 m) was reported that release of first to fifth instar nymph (50 each) and 50 eggs on cardboard lowered populations of *Aphis gossypii* (Glover), *Phenacoccus solenopsis* (Tinsley), *Dysdercus cingulatus* (F.) and *H. armigera* by 28, 70, 29 and 50%, respectively. *R. fuscipes* did not cause any harm to other natural enemies found in the field (Tomson et al., 2017). Release methods for *S. collaris* (i.e. release ratio and combination with other bioagents) should be tested to ensure the effectiveness of the predator.

Conclusions

The predator preference changes as they develop. Preys that were relatively large compared to predator size were challenging for predator to feed on and likely reduce predator survival. From our findings, rearing of *S. collaris* will be adjusted and each stage of the predator will be given preferred prey. Second *S. collaris* instar should be reared on small *T. molitor* larvae. The third instar can be fed on either medium sized larvae or pupae. Fourth- and fifth- instar should receive large- and medium- sized larvae, respectively. Adult should be given large sized larvae. Future studies should investigate *S. collaris* lifetable to assess effect of preferred prey on predator performance and other parameters, such as, fecundity and reproductive output.

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