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Influence of Prey Availability on Immature Survival, Development and Predation of the Mantid Predator, *Sphodromantis viridis* Forskal

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ABSTRACT

Prey consumption, developmental period, survival and predation rates of the first three nymphal instars of the predator, *Sphodromantis viridis* Forskal were assessed under laboratory conditions with different preys available. The maximum daily prey consumption was recorded with the greatest number of available preys. Also, the duration of each instar was shortest at high prey available and longest at the minimum level. Survival rates were maximum (86, 85, and 82 % for the first, second and third instars, respectively) with prey available of 10 preys/predator. When prey available was one prey/predator/day these rates were in respective 71, 58 and 0 %. Predation rates differed according to the nymphal instar and also the preys available. Regression analysis revealed a significant positive correlation between prey availability and each of daily prey consumption, development and survival while a negative correlation was obtained concerning the predation rates of the three nymphal instars. These results show that, immature mantids could compensate under certain conditions like food deprivation (lack of preys) while could develop more quickly with the high prey available.

Key Words: Prey availability, Survival, Development, Predation rate, *Sphodromantis viridis*.

INTRODUCTION

Prey abundance can determine whether a predator can remain or enter a habitat, as well as the type of prey and the relative numbers that the predator consumes. Predators show several adaptations to low prey densities; these include changing trophic levels, *e.g.*, intra-guild predation, cannibalism, movement to areas with higher prey densities, switching to new prey, and entering prey-mediated dormancy (Murdoch and Marks, 1973; Tauber *et al.* 1986 and Chang and Snyder 2004). Prey availability affects prey consumption and the magnitude of change in prey consumption with prey availability may differ among predator species (Dixon, 1959; Coll and Ridgway, 1995 and Rutledge and O'Neil, 2005). The potential of a biocontrol agent is assessed not only in terms of its predatory potential but also in its adaptability to new surroundings deciphered through its ability to propagate itself under a given condition including the prey (Symondson *et al.* 2002).

Sphodromantis viridis Faskal is a highly predacious insect; feeds on a variety of insects, including moths, crickets, grass hoppers and flies. This mantid undergoes a simple metamorphosis going through 12 nymphal instars, all of which look like miniature, wingless adults (Zohdy and Younes 2002). During their developments, *S. viridis* nymphs change their prey species; they firstly prey on small insects and lately on bigger insects. The first three nymphal instars that can prey only one prey like *Drosophila melanogaster* were checked in the present investigation. In this study, the authors examined how prey availability affects the development, survival and predation rates of the first three nymphal instars.

MATERIALS AND METHODS

Source of the predator immatures

Stock culture began with *S. viridis* females collected from the field to be maintained in screen-topped cages (60 cm height by 40 cm diameter) and provided with grass hoppers as preys. Egg cases (oothecae) were obtained after being deposited to be stored in plastic containers (12 x 9 x 5 cm) where they kept moistened by wet paper towels, and incubated at 25 ± 2° C and 65 ± 5% RH until hatching. After hatching, nymphs were used in the experiments using *Drosophila melanogaster* as a prey; a culture of this prey was raised in the laboratory for this purpose.

Development and survival rate

Development and survival rate of the first, second and third nymphal instars were investigated. The newly hatched nymphs were kept individually in glass vials (3 cm diameter by 4 cm height) containing many of stalks to facilitate their moving. Development and survival rate were estimated at different levels of preys available. This was achieved by keeping nymphs of the same instar, each with a definite number of preys, ranged from one to ten individuals. The preys were offered daily till nymphs completed their development and moulted to the following instar.

Prey consumption and predation rate

Predaceous nymphs were removed individually from the culture directly after hatching or ecdysis to be confined into a screen-topped plastic cup (10 cm height by 7 cm diameter). Ten prey densities (ranged 1 – 10) were evaluated for each nymphal instar, with ten replicates for each density. Cups were held for 24 h, after which the preys were counted, and the predation rate (%) was calculated by: [(a-b) / a] x 100; where (a) is the number of prey introduced, (b) is the number of survived preys at the end of the day. Dead preys during the experiment were corrected according to Abbott formula (Abbott, 1925). All experiments were carried out in the laboratory under hygrothermic conditions of 25 ± 2º C and 65 ± 5 % RH.

Statistical analysis

Obtained data were analyzed using one-way ANOVA and regression correlation using software program system, GraphPad InStat (2003).

RESULTS AND DISCUSSION

Prey consumption and developmental period

Data obtained in table (1) and fig. (1) show the effect of the prey availability on the daily prey consumption of the predaceous nymphs. The data indicated that the mean prey consumption increased with increasing the prey availability for the three nymphal instars determined. Statistical analysis showed a significant interaction between prey availability and the daily prey consumption for the first (F= 38.8; P< 0.001), second (F = 149.8; P< 0.001) and third nymphal instar (F = 1638.2; P<0.001). However, increase in the prey consumption stopped at a definite number of prey availability, according to the age of the nymph. In general, mantid nymphs given low or intermediate numbers of prey ate most of what was offered in the course of the day, whereas this did not occur with high numbers of preys.

The number of prey availability also affected the developmental period of each nymphal instar (Table 2 and Fig. 2). Lower preys available led to an increase in the developmental period of the predator. On the contrary, more preys available led to a decrease in the developmental periods of the nymphs but to certain limits, after which any increase did not lead to a more decrease in the developmental periods (Fig. 2). Statistically, significant differences existed between the developmental periods and the preys available, either for the first (F = 14.6; P<0.01), second (F = 114.6; P < 0.001), or the third nymphal instar (F = 139.8; P < 0.001) (Table 2).

The aforementioned results reveal that prey available was essential for either development or consumption rate of *S. viridis*. Although equal numbers of preys were offered to the nymphal instars, yet differential prey consumption and developmental periods were observed. The decreased in consumption rate might lead to a state of semi-starvation and consequently, the slower development of the three instars tested. This state agrees with the studies of many workers on other predators (Dixon, 1959; Pickup and Thompson, 1990; Zheng *et al.* 1993; Tauber *et al.* 1995; Sharma *et al* 1997 and Tsaganou *et al*. 2004).

Survival rates

Survival rate of nymphs increased with the increase of the available preys for all the three nymphal instars. High survival percents (> 70 %) were obtained with the 3 preys/predator, for the first instar (F = 19.4; P < 0.01), with 5 preys / predator for second instar (F = 36.7; P < 0.001) and with 6 preys / predator (F = 31.5; P< 0.001) for the third one (Table 3). Data obtained from figure (3) also show that the third nymphal instar could not survive with the low preys available (0 % survival was obtained with prey available of one prey / predator).

Differences obtained in the survival percents through nymphs have the same instar revealed that predator survival was dependent on the prey availability. A lower rate of survival was obtained by the low prey available while higher rate of survival was obtained by the high prey available. This result implies that prey availability, which is common in the field, may have some influence on the survival rate of *S. viridis.* The magnitude of change in the predator survival rate with prey availability may differ among predators' species. The variation in these attributes among predator species could be important for selection of natural enemies to achieve successful

Table (1): Parameters estimated from regression coefficient for the daily preys consumed by *S. viridis* nymphs with different prey availability.

Nymphal instar	Slope	Correlation coefficient (r)	95% confidence interval	F	P-value
1st	0.401	0.911	0.252 : 0.549	38.8	< 0.0003
2nd	0.653	0.974	0.528 : 0.774	149.8	< 0.0001
3rd	0.907	0.997	0.855 : 0.959	1638.2	< 0.0001

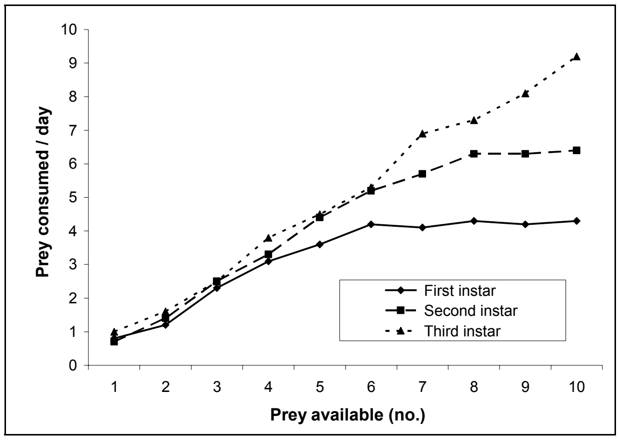

Fig. (1): Changes in the daily preys consumed by *S. viridis* nymphs with different preys available.

Table (2). Parameters estimated from regression coefficient for the developmental period (day) of S. viridis nymphs with different prey availability.

Nymphal instar	Slope	Correlation coefficient (r)	95% confidence interval	F	P-value
1st	-0.284	-0.804	-0.455 : -0.113	14.6	0.005
2nd	-0.508	-0.967	-0.618 : -0.398	114.6	< 0.0001
3rd	-0.068	-0.976	-0.798 : -0.934	139.8	< 0.0001

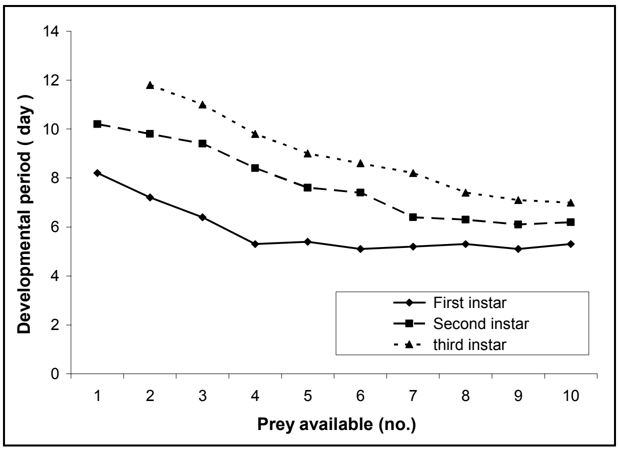

Fig. (2): Developmental periods (day) of *S. viridis* nymphs under different available preys

Table (3): Parameters estimated from regression coefficient for the % survival of S. viridis nymphs with different prey availability.

Nymphal instar	Slope	Correlation coefficient (r)	95% confidence interval	F	P-value
1st	1.4	0.841	0.666 : 2.13	19.4	0.0023
2nd	4.02	0.906	2.49 : 5.54	36.7	0.0003
3rd	7.59	0.893	4.47 : 10.71	31.5	0.0005

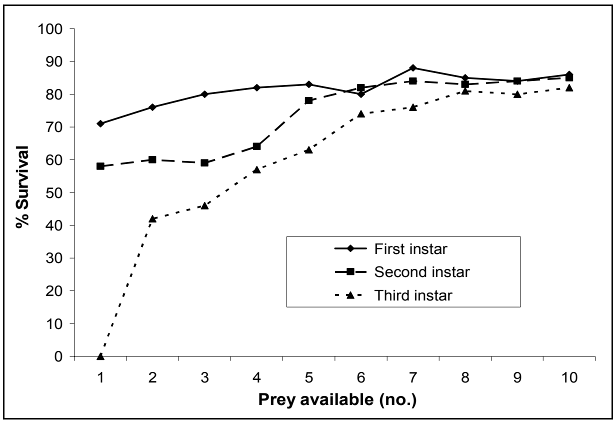

Fig. (3): Changes in the survival (%) of *S. viridis* nymphs with the different preys available.

Table (4). Effect of prey availability on the predation rates of *S. viridis* nymphs.

Nymphal instar	Prey available (no.)										F	P-value
	1	2	3	4	5	6	7	8	9	10		
1st	80 (0.8)	60 (1.2)	76.6 (2.3)	77.5 (3.1)	72 (3.6)	70 (4.2)	58.6 (4.1)	53.7 (4.3)	46.6 (4.2)	43 (4.3)	17.4	0.0003
2nd	90 (0.9)	90 (1.4)	86.6 (2.6)	82.5 (3.3)	88 (4.4)	86.6 (5.2)	81.4 (5.7)	78.7 (6.3)	70 (6.3)	54 (6.4)	17.9	0.0028
3rd	100 (1)	100 (2)	93.3 (2.8)	90 (3.6)	90 (4.5)	88.3 (5.3)	92 (6.9)	91 (7.3)	90 (8.1)	92 (9.2)	6.69	0.032

- Numbers between brackets are the mean numbers of preys consumed.

biological control (Kariluoto, 1980; Lawton *et al.* 1980; Ernsting and Isaaks, 1988 and Symondson *et al.* 2002).

Predation rate

Prey available had a significant effect (F = 17.4; P<0.001) on the predation rates of the first nymphal instar which consumed from 0.8 to 4.3 preys/predator/ day, with a predation rate from 80 to 43 % (Table 4). Second instar nymph showed a significant negative correlation with the increase of prey available (F = 17.9; P<0.01). The predation rate was nearly twice as high (90 %) with one prey / predator compared to 54 % with 10 preys/ predator. Similar phenomenon was also recorded with the first instar as this percent declined from 80 % with one prey/ predator to 43 % with 10 preys/ predator/ day. A similar trend was also noticed with the third nymphal instar; showing a significant negative correlation (F= 6.69; P< 0.05). The third nymphal instar showed a predation rate of 100 % at low preys available (1-2 preys/predator). Although the preys available increased from 1 to 10 preys, the predation rate decreased only from 100 to 90 %; indicating that the third instar has the ability to devour more preys than first and second instars.

The variation in the predation rates according to the available preys are previously reported for most insect predators (Dixon, 1959; Morgan *et al.* 1983 and Coll and Ridgway, 1995). As a conclusion it could be stated that the present findings indicated the most suitable number of preys required for the development and survival rate of the first three nymphal instars of the mantid, *S. viridis* when fed on *D. melangaster*.

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