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ORIGINAL ARTICLE

Effect of Three Aphid Species on the Life Tables Data of the Coccinellid Predator, *Cheilomenes propinqua vicina* (Mulsant)

Asma K. Mahmoud*, Najah E. Yousif and Abdalla A. Satti
Environment, Natural Resources & Desertification Research Institute,
National Centre for Research, P.O. Box 6096, Khartoum, Sudan;
*Corresponding author, E-mail: asmakhalid2000@hotmail.com

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Abstract

The family Coccinellidae comprises important predatory insects that contribute significantly to bio-control programs of some major economic pests worldwide. Several species of such predators including *Cheilomenes propinqua vicina* (Coleoptera: Coccinellidae) are prevalent in Sudan. In this study the effect of three prey (aphid) species (viz., *Melanaphis sacchari*, *Aphis gossypii* and *Aphis nerii*) on the life tables parameters of *C. propinqua vicina* was investigated under laboratory conditions (23.3ºC & 36.3%R.H) at the Environment, Natural Resources and Desertification Research Institute, Khartoum. The main parameters investigated include: duration of the immature stages, mortality among immature stages and life tables' data of *C. propinqua vicina*. The results showed that the total developmental period of pre-adult stages was longer when *C. propinqua vicina* fed on *A. nerii* (17.03±0.37), than on *M. sacchari* (12.69±0.34) or *A. gossypii* (13.00±0.43). Likewise, the highest mortality rate among such stages was recorded when the predator fed on *A. nerii* (35.25±11.14%), whereas, less mortality was detected when it fed either on *A. gossypii* (25.64±11.14%) or *M. sacchari* (25.26±11.14%). Regarding life tables' data, both the net reproduction rate and the intrinsic rate of increase were higher when the beetle fed on *A. gossypii* (769.55 and 0.284, respectively), followed by *M. sacchari* (176.65; 0.192) and *A. nerii* (22.43; 0.116). In contrast, the weighted generation time as well as the doubling time was lower when the predator fed on *A. gossypii* (23.46; 2.43) than on the other aphids; hence, rapid multiplication was achieved compensating other parameters. It is concluded that, *A. gossypii* is the best prey among the tested aphid species for augmentative program of *C. propinqua vicina*.

Keywords: Natural enemies, aphidophagous, active metabolite, *Aphis gossypii* and *Aphis nerii*.

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Introduction

The irrational use of synthetic insecticides in agriculture causes many problems worldwide. These mainly include: pest resistance to insecticides, outbreaks of secondary pests, toxic insecticide residues on food and forage crops, contamination of soil and water, hazards to human beings and animals (livestock and wild life), and killing of non-target organisms particularly natural enemies and pollinators prevailing in agricultural fields.

Therefore, there is an increasing interest in environmentally friendly alternative control measures. That's why IPM systems incorporating various control methods are designed (Dent, 2000). Successful utilization of predators and parasitoids in biological control of different economic pests help to boost IPM and reduce dependency on pesticides, so enhance sustainable agriculture with copious economic and environmental advantages (Kok, 1999; Bale *et al*., 2008, and Myers, 2015). The technique is selective and self-propagating, and also pest's resistance is unlikely to occur (Emden, 1990, and Hoy, 2000). It is reported that biological control is a better technique to control pests of different types by the use of natural means (Habeck *et al*., 1990, and Gilkeson and Kelin, 2001).

Predators prevalent in Sudan mainly belong to coccinellids, chrysopids, syrphids and spiders (Satti *et al*., 1998, and Kuol, 2003). Coccinellids are predators in both adult and larval stages (Amitava, 1998). They include several species like; *Hippodamia variegata* (Goeze), *Scymnus* spp., *Coccinella undecimpunctata* L., *Chilocorus nigritus* (Fab.), *Cheilomenes sulphurea* (Oliv.) and *Cheilomenes propinqua vicina* (Muls.) (Kuol, 2003, and Satti, 2015). The latter species (*C. propinqua vicina*) is found in different regions of the Sudan (Khartoum State, Gezira and Rahad schemes, Northern State, etc) as one of the dominant natural bio-agents of numerous soft insect pests, especially aphids and thrips (Bashir,1968; Sharafeldin, 1986, and Satti *et al*., 1998). The predator is found associated with its preys in many habitats of diversified crops like; cotton, alfalfa, cereals, vegetables, and wild herbaceous plants and shrubs (Schmutterer, 1969; Satti *et al*., 1998; Kannan, 1999, and Kuol, 2003). The efficiency and potential importance of this predator have not been fully demonstrated. The objective of this laboratory work was to study the effect of different aphid species as preys on the life tables data of *C. propinqua vicina*.

Materials and Methods

Life tables' studies on *Cheilomenes propinqua vicina* were conducted under laboratory conditions at the Department of Biopesticides and Biofertilizers - Environment, Natural Resources and Desertification Research Institute (ENDRI), National Center for Research, Khartoum. These studies were carried out during the winter season of 2015/2016, where the average temperature and relative humidity were 23.3ºC and 36.3%, respectively.

Adults of *C. propinqua vicina* were collected from sorghum fields at Shambat demonstration farm during November 2015. The predator was reared in glass cages and provided with leaves of sorghum (*Sorghum bicolor*) infested with *Melanaphis sacchari* (Zehntner) for feeding. Another two sets of cages were also prepared; in the first one the predator was provided with cucurbit (*Cucumis sativus* var. *flexusus*) leaves infested by *Aphis gossypii* (Glov.) and in the second it was provided with Sodom apple "Usher" (*Calotropis procera*) leaves infested by *Aphis nerii* Boyer. Eggs of second generation were collected and grouped. The hatchability, incubation periods, larval development, pupal formation and adult's emergence were followed and recorded daily. Newly emerged adults were paired and transferred to new three cages. Adults in each cage were provided with one of the above mentioned three aphid species; viz., *M. sacchari* on sorghum leaves, *A. gossypii* on cucurbit leaves and *A. nerii* on Sodom apple leaves. Ten replicates were made from each set. The number of eggs laid was recorded daily for each cage until the death of the adult female. The data obtained was used to calculate the life tables' parameters according to the method described by Birch (1948).

Accordingly, the following statistics were computed:

Net Reproductive Rate (Ro) = $\sum$ Lx*Mx

Where:

Lx = the fraction of the initial sample of individuals still alive.

Mx = the mean number of progeny produced by the adult females alive at such age intervals.

Weighted Generation Time (T) = ∑(X*Lx*Mx)/Ro.

X = the age of the sample in days from birth.

Innate Capacity of Numerical Increase (rm) = Natural Log Ro/T.

Doubling Time DT = Natural Anti log 2/rm.

Results and Discussion

Cheilomenes propinqua vicina attacks a wide range of prey species among economic insect pests including various aphids (kuol, 2003, and Satti, 2015). The current research dealt with the effect of three different aphid species (i.e., *M. sacchari*, *A. gossypii* and *A. nerii*) on life tables' data of *C. propinqua vicina*, as investigated under laboratory conditions (average, 23.3ºC & 36.3% R.H.), during winter season of 2015/16 at ENDRI, Khartoum. The durations of immature stages (eggs, larvae, pre-pupa and pupa) of the predatory beetle were affected when the beetles fed on the different three aphid species mentioned above (Table 1). The results showed that the total developmental period was long when the ladybeetle *C. propinqua vicina* fed on *A. nerii* (17.03±0.37) compared with the other two species; *M. sacchari* (12.69±0.43) and *A. gossypii* (13.00 ±0.43). These results agree with Ibrahim (1988), who reported that the kind of prey species fed upon has an effect on the duration of *C. propinqua vicina.* The predator fed on *M. sacchari* developed rapidly well; whereas that reared on *A.nerii* showed the longest developmental period, but when fed on *A. gossypii* it had an intermediate period of development.

Mortality among immature stages of *C. propinqua vicina* was affected by the different aphid species under investigation (Table 2). The highest mortality rate among all immature stages of this predator occurred when it fed on *A. nerii* (35.25±11.14%), whereas less mortality levels were obtained when it fed either on *A. gossypii* (25.64±11.14%) or *M. sacchari* (25.26±11.14%), with larval stages in the

Table 1. Duration of the immature stages of the coccinellid predator, *Cheilomenes propinqua vicina* fed on three aphid species under laboratory conditions, during winter season (2015/16), at Khartoum.

Aphid Species	Mean (±S.E.) duration (days) of immature stages of the predator			
	Egg	Larvae	Pre-pupa+Pupa	Total pre-adult duration
Melanaphis sacchari	1.88±0.13 a	7.44±.0.25a	3.38±0.25a	12.69±0.43a
Aphis gossypii	1.83±0.08 a	7.36±0.27a	3.81±0.25ab	13.00 ±0.43a
Aphis nerii	2.58±0.15 b	10.25±0.25b	4.20±0.22b	17.03±0.37b

Means followed by the same letter in each column are not significantly different at 0.5% according to Duncan's Multiple Range Test (DMRT).

Table 2. Mortality among immature stages of the coccinellid predator, *Cheilomenes propinqua vicina* fed on three aphid species under laboratory conditions, during winter season (2015/16), at Khartoum.

Predator's stage	Mortality means (%) according to aphid species being fed upon		
	Melanaphis sacchari	*Aphis gossypii*	*Aphis nerii*
Egg	25.59±6.86a	23.64±6.86a	34.18±6.51a
Larva	47.57±8.38a	45.64±8.38a	51.51±7.95a
Pre pupa + pupa	2.62±4.16a	7.65±4.16a	20.06±3.95b
Average mortality percent	25.26±11.14a	25.64±11.14a	35.25±11.14a

Means followed by the same letters in each column are not significantly different at 0.5% according to Duncan's Multiple Range Test (DMRT).

three prey cases showed the highest mortality percents while pre-pupa and pupa showed the lowest. Such variations in mortalities were thought to be induced by the differences in prey kind being fed upon, since these preys were nourished on plant species which differ in constituents of active metabolites (Yousif, 2005). For instances, *Calotropis procera* was reported to contain poisonous substances such as calotropin, calactin and calotoxin (Kuol, 2003, and Meena *et al*., 2010). In the same context, Iperti (1966) stated that *A. nerii* feeding on *Nerium oleander* L. was poisonous to most coccinellids except *Hippodamia variegata.* The results also agree with Ibrahim (1988), who reported that C. *propinqua vicina* larvae reared on *A. nerii* showed the highest mortality rate (75%) than other tested species.

On the other hand, mortalities among immature stages of C. *propinqua vicina* when fed on *A. gossypii* (25.64±11.14%) or *M. sacchari* (25.26±11.14%) were found to be relatively higher than what had been reported in previous research (Ibrahim, 1988). Ibrahim (1988) stated that the mortality among developmental stages of C. *propinqua vicina* reached 20% when the predator fed on *A. gossypii*, but no mortality was observed when the beetle was reared either on *M. sacchari* or *Rhopalosiphum maidis*. The reason could be attributed to certain experimental variations between the two studies, including differences in climatic conditions, besides an expected variation in constituents of the same plant species harboring aphids (Yousif, 2005). However, the effect of botanical metabolites derived by insect pests on breeding and development of natural enemies such as aphidophagous coccinellid predators may need further investigations.

As mentioned by Mandour *et al*. (2006) the failure of *Cydonia vicina nilotica* and other coccinellids in controlling aphid at higher population densities could be attributed to: i) the low oviposition rate of *C. vicina nilotica* at higher densities, ii) aphids excreted droplets, alarm pheromone, which affects the searching behavior of the predators, and iii) a high density of aphids is mostly accompanied by a great amount of honeydew, which is used by other coccinellids as contact kairomone (Meiracker *et al*., 1990), and is expected to preclude the searching behavior and reduce the searching efficiency of the predators. Generally, the highest mortality rate may be due to the cannibalism phenomena among the coccinellid predators (Banks, 1956; Dixon, 1959; Kuol, 2003, and Veesar *et al*., 2012).

Table 3 shows the life tables' data of *C. propinqua vicina* preyed on *M. sacchari*, *A. gossypii* and *A. nerii*. The net reproduction rate (Ro) was higher when the beetle fed on *A. gossypii* (769.55), followed by *M. sacchari* (176.65) and *A. nerii* (22.43). This may be due to the prey preference by the predator and/or the type of plants that they were reared on. The rejection of *A. nerii* can also be possible due to its bright coloration and/or bad odor (El-Fahal, 1986). Yousif (2005) stated that the highest Ro of *Hippodamia variegata* was recorded from potato crop and the lowest was reported in eggplant infested by *A. gossypii*, a phenomenon suggested to be connected to high protein content in potato leaves and

Table 3. A summary of life tables' data parameters of *Cheilomenes propinqua vicina* fed on three aphid species, under laboratory condition, during winter season (2015/16), at Khartoum.

Aphid species	Life table parameters			
	Ro	T	rm	DT
Melanaphis sacchari	176.65	26.93	0.192	3.63
Aphis gossypii	769.55	23.46	0.284	2.43
Aphis nerii	22.43	26.80	0.116	5.75

Ro= net reproduction rate, T= weighted generation time, rm= intrinsic rate of increase, DT= doubling time.

presence of hairs on eggplant leaves. Also, Kuol (2003) stated that the preference of *H. variegata* to *A. nerii* was low when compared to *A. gossypii* and *M. sacchari*. The beetle fed more on *A. gossypii* than on *M. sacchari* in the choice and no-choice tests.

The intrinsic rate of increase (rm) was 0.192, 0.284 and 0.116 when the predator fed on *M. sacchari*, *A. gossypii* and *A. nerii*, respectively. Accordingly, the highest intrinsic rate of increase (rm) was reported from *A. gossypii* and the lowest from *A. nerii*. This might be due to low generation time (T) when *A. gossypii* was used in feeding. It is clear that, the weighted generation time (T) was lower when the predator fed on *A. gossypii* (23.46) than on the other two aphid species. However, the obtained results agree with those of Ibrahim (1988) who pointed out that the short developmental period of the species is compensated by high "rm" value. Generally, "rm" is the statistic meant to indicate the biotic potentiality of the species. The doubling time (DT) was 3.63, 2.43 and 5.75 with *M. sacchari, A. gossypii* and *A. nerii*, respectively. This indicated that the predator multiply rapidly when it fed on *A. gossypii* and to some extent on *M. sacchari*, as opposite to *A. nerii*. It is well documented that the successful natural enemies are described by their high reproduction rate, good searching ability for host, adaptability to different environmental conditions and synchronization with host (Buchanan, 1996). Therefore, the encouraging results obtained with *A. gossypii* in this research concerning its effect on major parameters of life tables' data for *C. propinqua vicina*, particularly the highest Ro, rm and the lowest DT, ultimately reflect the potentiality of this prey species in rearing and multiplication programs of such predator. Thus, it can be said that the type of prey species as well as the host plant being raised on are among prominent factors affecting the development of a coccinellid predator. This finding is consistent with a report by Yousif (2005) which showed differences in the life tables' parameters of *Hippodamia variegata* fed on *A. gossypii* raised on different crops like okra, eggplant and potato.

Conclusion

The study revealed that the different aphid species tested (*Melanaphis sacchari*, *Aphis gossypii* and *Aphis nerii*) as preys had obvious effect on the life tables' data of *Cheilomenes propinqua vicina*. The predator multiplies rapidly when it fed on *A. gossypii*, followed by *M. sacchari* and *A. nerii*. The encouraging results obtained with *A. gossypii* concerning its effect on major parameters of life tables' data for *C. propinqua vicina*, particularly the highest Ro and rm and the lowest DT and T, ultimately reflected the potentiality of this prey species in rearing and multiplication of the predator. It's utilization in augmentation programs entails further investigation regarding the effects of surrounding factors under field conditions.

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