Journal of Plant Protection and Pathology

Journal homepage & Available online at: www.jppp.journals.ekb.eg

Influence of Plant Surface on Biological Aspects of *Cydnoseius negevi* (Acari: Phytoseiidae)

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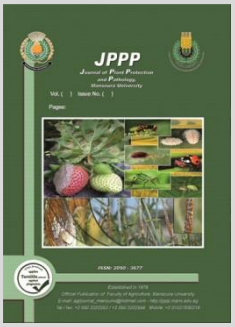

ABSTRACT

The study aimed to evaluate the comparison effect of leaf structure of the four different host plant species, eggplant (*Solanum melongena* L), hipiscus (*Hipiscus rosa chinenses* Lin.), lemon (*Citrus limon*),and green bean (*Phaseolus vulgaris* L.) on development and reproduction of the predatory mite *Cydnoseius negevi* (Swirski and Amitai) fed on date palm pollen. There were significant differences in the characteristics of leaf trichomes and domatia of the tested plants. The phytoseiid mite, *C. negevi* successfully developed to adulthood and completed its life span on all four tested plant species. The duration of female immature stages of *C. negevi* fed on date palm pollen was the shortest when mites was reared on green bean leaves with only 4.75 days, while those kept on citrus leaves had the longest pre-oviposition period (5.80 days) and the shortest oviposition period (8.80 days).Total fecundity was highest on green bean (40.70 eggs/female) and lowest on citrus leaves(13.75 eggs/ female).The net reproductive rate (R_o),which is the total number of females born in two successive generations was 8.80 when mites were reared on citrus leaves, 10.15 on hibiscus, 15.08 on eggplant, while it reached 16.68 on green bean leaves. Also, the intrinsic rate of increase (r_m) was 0.107, 0.113, 0.127 and 0.161 female/female/day when mites were reared on the same previous host plants, respectively. In conclusion, among the four host plant species, green bean leaf was the most favorable host substrate to rear the predatory mite, while citrus was the worst one for the development and reproduction of *C. negevi*.

Keywords: *Cydnoseius negevi*, biology, life tables, plant surfaces and trichomes.

INTRODUCTION

There are many environmental factors can affect the biological aspects of mites such as temperature, relative humidity, food source (Zaher, 1986). The host plant species is one of these factors, where they can affect the population establishment, performance as well as different biological activities of predatory mites (Walter, 1996; Romero and Benson, 2004 and Tanga *et al*., 2013). Although the microenvironment on plant surfaces seems uniform to the human eye, arthropods, especially mites find it to be extremely complicated (Buitenhuis *et al*., 2015; Roda *et al*., 2003). Herbivore mites and their enemies may interact differently depending on the characteristics of the host plant (Norton *et al*., 2001; Momen and Hussein, 2011). Predatory mite growth, development and oviposition can be influenced by host plant species in a number of ways, including: (i) by influencing predatory mite activity; (ii) by shielding the residing mites from natural enemies; (iii) by changing the microenvironment; and (iv) by trapping and holding on to food sources like fungal spores and date palm pollen (Romero *et al*., 2011; Rebecca, 2014; and Buitenhuis *et al*., 2014). The biology and life table parameters of the two predatory phytoseiid mites, *Neoseiulus californicus* (McGregor) and *Amblyseius swirskii* Athias-Henriot affected by strawberry cultivars, where the length and number of leaf trichomes varied among the two tested cultivars Fahim and El-Saiedy (2021) in Egypt. Small arthropods are more susceptible to the effects of leaf surface features due to their smaller size. Trichomes and domatia are two examples of the many structures found on leaf surfaces that contribute to the complexity of the microenvironment that arthropods live in (Rebecca, 2014). In order to increase the effectiveness of these species as biological control agents, it has been suggested that phylloplane features be changed. Plant structure can also have an impact on the performance and retention of predators and parasitoids. Predatory mites belonging to the family Phytoseiidae have a long history as biological control agents of pest mite species in agricultural ecosystems. This association has been explained by a number of theories, which include boosting pollen capture for use as a food source, avoiding unfavorable abiotic conditions, escaping natural enemy predation, and increasing or decreasing prey capture. Potential and significant predatory mites on a wide variety of crops are found worldwide in the family Phytoseiidae (Kostiainen and Hoy, 1996 and Mc Murtry and Croft, 1997). Some phytoseiid species play an important role in controlling phytophagous mites and insects in North African and Middle Eastern countries (Momen and El-Laithy, 2007; Momen *et al.* 2009; Palevsky *et al*., 2009; Hountondji *et al.*, 2010; Jafari *et al.*, 2010; and Kreiter *et al.* 2010). However, as date palm pollen grains are typically grown in hot, humid provinces, several phytoseiid species were able to effectively complete their life spans by feeding on them (Bakker et al., 1993). As a result, the effectiveness of phytoseiids as control agents may not be sufficient. Since *Cydnoseius negevi* (Swirski and Amitai) and *Neoseiulus barkeri* (Hughes, 1948) are common species found in the Middle East, looking for native phytoseiids adapted to the desert date palm growing areas should yield more promising findings for the control of *Oligonychus afrasiaticus.* (Abou-

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DOI: 10.21608/jppp.2024.325325.1270

Awad *et al.*, 1998; Fouly and El-Laithy, 1992; Palevsky *et al.*, 2009; Hountondji *et al.*, 2010 and Jafari *et al.*, 2010). Widely distributed throughout the Middle East, including Saudi Arabia, the generalist phytoseiid predator *C. negevi* is found naturally on date palm trees and grasses in association with the date palm red spider mite *O. afrasiaticus* under low relative humidity conditions (Negm *et al*., 2012a, b and Alatawi *et al*., 2017).

The present study aims to determine the effect of the plant surface of four different plant, green bean (*Phaseolus vulgaris*), hipiscus (*Hipiscus rosa chinenses*), eggplant (*Solanum melongena*), and limon (*Citrus limon*) on the biology and life tables of the predatory mite *C. negevi* fed on date palm pollens (*Pheonyx dactylefira* L.) under constant temperature and relative humidity.

MATERIALS AND METHODS

Biological studies were conducted on the predatory phytoseiid mite, *Cydnoseius negevi* at the Plant Protection lab, at Faculty of Agriculture, Damietta University, Egypt during 2022-2023.

1. Cultures of the predatory mites:

C. negavi culture were collected from eggplant (*Solanum melongena*, Solanaceae) leaves that growing under protected cultivation (in the greenhouse) of Agricultural Zoology Department, Mansoura University, during July and August 2022. Plant samples were collected in paper pages and directly transferred to the laboratory for examination by stereomicroscopic binocular. A pure culture of *C. negavi* was reared on date palm pollen grains and kept under constant temperature 26±1 °C and relative humidity 60±5% (in an incubator). The predatory mite cultures maintained on hibiscus leaves, *Hibiscus rosa chinenses* and feed on date palm pollen. Leaf disks were placed on petri dishes (10 cm diameter) over wet cotton. To keep the cotton pad always moistened drops of water were added daily to the dishes, where leaf discs have being changed as needed by fresh ones.

2. Collection and preparation of date palm pollen

Flowers of date palm were collected from palm trees and pollen grains were collected by using a manual shaker to release the pollen and left for 3 h in an incubator at 35°C. Pollen grains were kept in a small glass vial in a refrigerator until use as a food source of the predatory mite *C. negavi* (Al-Shammery, 2011).

3. Host plants used

The four plant species used were: green bean, *Phaseolus vulgaris* L, hipiscus, *Hipiscus rosa chinenses* Linn, eggplant, *Solanum melongena* L, and lemon, *Citrus limon*. A stereo-microscope (Zeiss Discovery V20) was used in a comparable study to compare the length and density of leaf trichomes of different tested plants. A Scanning Electron Microscope (JEOL-JSM.6510 LV) (Japan) was used to photograph the lower surface of plant leaves to compare the shape, structure and distribution and length of trichomes as well as leaf domatia found on the lower leaf surface. These steps were carried out in EM. Unit, Mansoura University, 2023.

4. Biological aspects and life table data of predatory mite.

Newly deposited eggs of *C. negevi* were transferred daily from mite culture to new replicates where each replicate with only a single egg by using a fine brush. The percentage of egg hatching was calculated. The period of incubation, duration of larva and nymph stages for both males and females was also registered twice a day. The longevity and adult males' life span of *C. negavi* was calculated. The newly emerged adult female individually was paired with a newly emerged adult male that obtained from the mite colony for its entire life. The pre-oviposition, oviposition, and post-oviposition periods were recorded. For calculating the adult longevity of female and male mites and estimating the total number of eggs and daily deposited eggs in order to calculate the life table parameters the method of Birch (1948), Abou-Setta *et al*. (1986) and Fouly and El-Laithy (1992) were used.

5. Experiment Technique

Freshly laid eggs of the predatory mite *C. negevi* were collected daily for a week and placed individually on 2.5 cm leaf discs of the four plant species that were evaluated. For each plant, 30 replicate (single newly deposited egg / leaf disc). Eggs have been inspected twice daily, the newly hatched larvae and nymphs were given an enough amount of fresh date palm pollen powder, and the sex ratio (females + males / females) and the number of immature stages attained adulthood were noted. Each newly emerged female was paired with a male mite for copulation, and the two were maintained together for the duration of their lives. Every day, the number of eggs per female in each replicate was recorded. Constant temperatures of 26±1 °C and 60±5% relative humidity were used to regulate the treatments. For daily inspection a stereo-microscope (Zeiss Discovery V20) was used.

Effect of plant surface on life table parameters of *Cydnoseius negevi*

parameters of the life table, Birch (1948), Laing (1968), and the Basic Computer Program of Abou-Setta *et al*. (1986) were used to calculate the age-specific survival rate (Lx), the oviposition rate at age x (Mx), the net reproductive rate (Ro), the intrinsic rate of natural increase (rm), and the mean generation time (T in days) of *C. negevi*.Furthermore, the doubling time (Dt) time needed for mite to double its population was calculated using the methods of Laughlin (1965) and Carey (1993). The hatchability and survival rate were used to determine Lx. No.♀/total ♀+♂, the proportion of females, was used to compute the Mx values.

Analysis of Biological Data

The Duncan Multiple Range Test and one-way ANOVA were used to examine all criteria of the many biological aspects of *C. negevi* (Costat Software Program, 1990). for comparative analysis between means.

RESULTS AND DISCUSSION

1. Effect of plant surface on *Cydnoseius negevi* development

(Table 1) demonstrated that the length of the predatory mite's incubation periods varied significantly, which was kept on different host plants, where the shortest period (2.60 days) was noticed when *C. negevi* was reared on citrus leaves, while the longest period was recorded on eggplant leaves with 3.20 days. The other host plants, green bean, hibiscus caused durations of 2.80 and 2.73 days, respectively. when *C. negevi* was reared on either citrus or eggplant leaves with 6.72 and 6.46 days, respectively, the total duration of female immature stages (Larva and 1st nymph and 2nd nymph) was significantly longer. The shortest developmental time was noted on green bean leaves with only 4.75 days. Hibiscus leaves caused intermediate time where the predatory mite needed 5.58 days to complete its development and reach adulthood.

Table 1. Duration (days) (Mean ± SE) of incubation period and immature stages of *Cydnoseius negevi* female fed on date palm pollen, reared on four different plants and kept at 26ºC and 60% RH.

Biological aspect	Plants				F	P	L.S.D (0.05)
	Citrus	Hibiscus	Eggplant	Green bean			
Incubation period	2.60±0.10 a	2.73±0.09 a	3.20±0.10 b	2.80±0.15 a	5.598	0.0014**	0.317
Larva	1.33±0.10 a	1.26±0.10 a	1.40±0.10 a	1.22± 0.09 a	0.749	0.525 ns	0.272
1st nymph	1.86±0.14 b	2.06±0.12 b	1.93±0.11 b	1.40±0.11 a	5.822	0.0011**	0.338
2nd nymph	3.53±0.10 c	2.26±0.13 a	3.13±0.15 b	2.13±0.09 a	31.695	0.000***	0.339
Life cycle	9.32±0.22 c	8.31±0.23 b	9.66±0.21 c	7.55±0.20 a	19.615	0.000***	0.612
Generation period	15.12±0.35 c	12.77±0.27 b	12.92±0.30b	10.28±0.30 a	41.796	0.000***	0.858

Means followed by different letters in each row are significantly different, Duncan Multiple Range Test (P≤ 0.05).

From the previous data, It is evident that the female life cycle was significantly longer when *C. negevi* was reared on eggplant leaves with 9.66 days, Green bean leaves, on the other hand, had the shortest life cycle, lasting just 7.55 days. (Table 1). In other hand, green beans accelerated the predatory mite's development, while eggplant prolonged it. On the other hand, the two host plants, citrus and hibiscus occupied the second and third ranks because *C. negevi* female life cycle recorded 9.32 and 8.31days, respectively. Accordingly, The tested plant surface had a significant effect on the generation period of *C. negevi* females reared on citrus with 15.12 days. The total generation period was significantly longer, whereas the shortest one, which lasted just 10.28 days, was found on green beans. Moreover, female generation time of *C. negevi* reared on eggplant and hibiscus took 12.92 and 12.77 days, respectively (Table 1). The previous results clearly indicated that there was a relationship between leaf structure and the duration of predator development. These findings are in line with those of Kreiter *et al*. (2002), who investigated the connection between the phytoseiid mite *Kampimodromus aberrans* (Oudemans) population density and leaf structure (trichomes, pollen densities, and quantity and structure of domatia). They noted a correlation between high host plant trichome densities and the frequency of appearance and quantity of *K. aberrans* per cm2. A complex phylloplane, which consists of numerous hairs and shelters or domatia on the lower leaf surface, may give *K. aberrans* an edge over other phytoseiid mite species. Additionally, they noted that the number and rating of domatia were crucial to the growth of *K. aberrans*, as only plants containing these structures showed high proportions of immature stages. Trichomes and pollen concentrations showed a strong correlation, but domatia structure had a marginally smaller impact. Additionally, their study demonstrated that abundant trichomes and pollen levels are conducive to the growth of the *K. aberrans* population and provided additional insight on the domatia's innocence with regard to this significant predaceous mite.

On the other hand, Saber and Momen (2005) found that *Cydnoseius zaheri* (Yousef and El Borolossy) have successfully grown and reproduced on the leaves of various plants, including figs, guava and camphor. The shortest generation period for individuals and the highest reproductive rate were on guava and camphor leaves, which are the most suitable surfaces. On the other hand, they discovered that the least suitable surface for *C. zaheri* development is fig leaves.

Concerning male development of *C. negevi*, the same previous trend was obtained, When *C. negevi* was reared on hibiscus leaves with 2.08 days, where the shortest incubation period was recorded, while the other host plants caused similar duration (2.25 days) as shown in Table (2). The present data showed that the longest male life cycle occurred when mites were reared on hibiscus leaves (8.90 days) and followed by citrus and eggplant leaves with 8.76 and 7.84 days, while the shortest life cycle was on green bean (7.17 days), respectively (Table 2).

Table 2. Duration (days) (Mean ± SE) of incubation period, immature stages and adult male of *Cydnoseius negevi* fed on date palm pollen, reared on four different plants and kept at 26ºC and 60% RH.

Biological aspect	Plants				F	P	L.S.D (0.05)
	Citrus	Hibiscus	Eggplant	Green bean			
Incubation period	2.25±0.10 a	2.08±0.05 a	2.25±0.12 a	2.25±0.16 a	0.585	0.626 ns	0.322
Larva	1.19 ±0.09 a	1.41±0.11 a	1.16±0.11 a	1.18±0.10 a	1.227	0.305 ns	0.29
1st nymph	2.16±0.15 b	2.08±0.09 b	2.01±0.13 b	1.58±0.15 a	3.776	0.013*	0.375
2nd nymph	3.16±0.18 b	3.33±0.15 b	2.42±0.13 a	2.16±0.17 a	12.7003	0.000***	0.443
Life cycle	8.76 ±0.24 b	8.90±0.18 b	7.84±0.28 a	7.17±0.37 a	8.483	0.001***	0.777
Longevity	11.75±0.26 b	13.66±0.21 c	13.75±0.34 c	8.75±0.27 a	73.05	0.000***	0.77
Life span	20.51±0.41b	22.56±0.30 c	21.59±0.49bc	15.92±0.46a	47.676	0.000***	1.192

Means followed by different letters in each row are significantly different, Duncan Multiple Range Test (P≤ 0.05)

Concerning longevity of *C. negevi* male, the current findings proved that host plants affected its life time but didn't show any significant differences. Male longevity was longer when mites kept on eggplant leaves (13.75 days) as compared to hibiscus (13.66 days) and citrus (11.75 days). The shortest life of males was noticed when *C. negevi* was reared on green bean with only 8.75 days as shown in Table (2). Therefore, it can be concluded that males and females of *C. negevi* were variably able to survive and feed on date palm pollen and reared on different plant surfaces such as green bean, eggplant, hibiscus and citrus (Tables 1 and 2).

2. Effect of host plants on adult female of *Cydnoseius negevi*

Mite females lived also for a shorter time (18.08 days) when hibiscus was used as a host substrate, but they lived for a longer time (22.05 days) when they reared on eggplant leaves and followed by green bean and citrus with 20.92 and 19.33 days, respectively (Table 3). Contradictory, Negm *et al.* (2014) found that the duration of female longevity of *C. negevi* kept at 25ºC and 35±10% R.H. was 31.8 days. Table (3) showed that *C. negevi* mated females started laying eggs after 2.73, 3.26, 4.46 and 5.80 days from copulation when reared on green bean, eggplant, hibiscus and citrus, respectively. Furthermore, oviposition period was 15.33 days when *C. negevi* females were reared on eggplant leaves, and that was significantly

longer than on other host plants (green bean, hibiscus) which took 15.13 and 10.40 days, respectively. The shortest oviposition period was 8.80 days when *C. negevi* females were reared on citrus leaves (Table 3).

As in other phytoseiid mites, it was clear that females live longer more than males. The present experiment indicated that the longest post-oviposition period (4.73 days) was recorded on citrus leaves, while it was shorter (3.06 days) on green bean leaves. Hibiscus, eggplant plants caused 3.22, 3.46 days, respectively (Table 3). Generally, the obtained results presented in Tables (2 and 3), it can be concluded that male and female life span significantly affected by the type of leaf surface. The longest life span of male and female of *C. negevi* was 22.56 and 31.71days and that was recorded when hibiscus, eggplant were used as a rearing substrate, while the shortest life span of male was 15.92 days when mites were reared on green bean. The shortest life span of mite female was 26.39 days on hibiscus.

Table 3. Duration (days) (Mean ±SE) of adult female of *Cydnoseius negevi* fed on date palm pollen, reared on four different plants and kept at 26ºC and 60% RH.

Biological aspect	Host plants				F	P	L.S.D (0.05)
	Citrus	Hibiscus	Eggplant	Green bean			
Pre-oviposition period	5.80±0.22d	4.46±0.15c	3.26±0.14b	2.73±0.17a	62.84	0.000***	0.483
Oviposition period	8.80±0.26 a	10.40±0.26 b	15.33±0.29 c	15.13±0.24c	162.104	0.000***	0.731
Post-oviposition period	4.73±0.20 b	3.22±0.15 a	3.46±0.16 a	3.06±0.11 a	23.407	0.000***	0.447
Longevity	19.33±0.39 b	18.08±0.30 a	22.05±0.34 d	20.92±0.31c	26.931	0.000***	0.942
Life span	28.65±0.53 b	26.39±0.27 a	31.71±0.46 c	28.47±0.37b	27.23	0.000***	1.178

Means followed by the same letters in each row are insignificantly different, Duncan Multiple Range Test (P≤ 0.05).

From the previous table, it is clear that the pre-oviposition period was shortened when predatory mite was reared on green bean leaves but it was at its longest duration on citrus leaves. Moreover, the egg-laying period was shortest when the predatory mite was raised on citrus and longest on eggplant leaves, followed by green bean, while the post-oviposition period was highest on citrus leaves and shortest on green bean. Accordingly, the female's life span was longest on eggplant and shortest on hibiscus. Therefore, these observations proved that the most preferable plant surface for rearing *C. negavi* was green bean plants to get best biological aspects such as short pre-oviposition period and longest oviposition period, while the worst plant surface was citrus leaves.

The results in Table (4) regarding the fecundity of *C. negevi* indicated that the total number of deposited eggs was significantly influenced by the various host plants. The mite female's egg-laying quantity was highest when it fed on date palm pollen and reared on green beans (40.70 eggs/ female). This indicates that a female can lay 2.69 eggs on average every day. These findings are consistent with those of Alatawi *et al*. (2018), who evaluated the predator's development and life table parameters at 30°C and 60% relative humidity in order to determine the nutritional adequacy of date palm pollen for *C. negevi*. They discovered that feeding *C. negevi* fresh date palm pollen resulted in successful development and reproduction. Additionally, Fouly *et al.* (2021) discovered that the predatory mite produced the most eggs when it was fed date palm pollen (30.0 eggs/female, with a daily rate of 2.3 eggs/female/day) on hibiscus leaves, while receiving *Trialeurodes ricini* (Misra) (Hemiptera) eggs produced the least amount of fecundity (10.0 eggs/female, with a daily rate of 0.9 eggs/female/day). Additionally, Saber and Momen (2005) investigated the impact of the plant leaf surface on various biological characteristics of the predatory mites and demonstrated that *C. zaheri* was able to develop and reproduce on three distinct plant leaves. They discovered that the highest rate of reproduction was caused by guava and camphor leaves, on the other hand, the least suitable surface, was fig leaf. According to the same author, using guava, camphor, and fig leaves as rearing substrates resulted in a total of 53.0, 41.6, and 36.9 eggs/female of *C. zaheri*. On fig leaves, however, the predatory mite showed the lowest fecundity rate and the highest survival rate. The development and reproduction of the predatory mite *Neoseiulus bicaudus*, which feeds on the spider mite *Tetranychus turkestani*, are also significantly influenced by the leaf structure of the host plant, as demonstrated by Zhang *et al*. (2016). They noted that the properties of the leaf trichomes on the surfaces of the studied host plants varied significantly. They discovered that cucumber leaves had the lowest total fecundity (20.81 eggs/ female) and green bean leaves had the highest (42.4 eggs/female).

Table 4. Oviposition period duration per day, daily and total numbers of eggs deposited by *Cydnoseius negavi* that fed on date palm pollen, reared on four different plants and kept at 26ºC and 60% RH.

Biological aspect	Plant species				F	P	L.S.D. (0.05)
	Citrus	Hibiscus	Eggplant	Green bean			
Oviposition. Period	8.80±0.26 a	10.40±0.26b	15.33±0.29c	15.13±0.24c	162.104	0.000***	0.731
Total No. deposited eggs	13.75±0.49 a	20.58±1.01b	35.58±0.65c	40.70±0.41d	34.85	0.000***	1.917
Daily rate	1.56 ±0.08 a	1.97±.011b	2.32±0.06c	2.69±0.05 d	35.321	0.000***	0.224

Means followed by the same letters in each row are insignificantly different, Duncan Multiple Range Test (P≤0.05).

3. Effect of plant surfaces on life tables of *Cydnoseius negevi*

The survival rate of female predator *C. negevi* reached its highest levels when kept on eggplant and green beans leaves where it reached 85%, while rearing the predatory mite on hibiscus leaves caused 82% survival rate. Mite survival rate was 74% when females of *C. negevi* remained on citrus leaves as shown in Table 5 and Figure 1. Figure (1) also showed that Lx value of *C. negevi* gradually decreased during the egg-laying period. It was also found that plant surface had no significant effect on the sex ratio, as the percentage of females on eggplant leaves reached 0.65 and decreased to 0.62, 0.54and 0.53 when reared on green bean, hibiscus and citrus leaves, respectively Table 5. The reproductive capability, as indicated later in the life table parameters, was directly impacted by these values. The surface of the host plant also had an impact on the mean generation time (T)., so data showed that eggplant leaves prolonged T time (21.29 days), while green bean leaves caused the shortest T period

(17.45 days). T values were 20.36, 20.30 days when the predatory mites were reared on hibiscus and citrus leaves, respectively. Therefore, green bean leaves were more suitable as a host plant for growing *C. negevi* because they shortened the mean generation time. The same pattern was noted with the time required for reproduction of *C. negevi* (D_t) where the host plants gave an average of 8.76, 11.10, 12.48 and 13.18 days, when the predator was reared on green bean, eggplant, hibiscus and citrus leaves, respectively. Similar findings were made by Saber and Momen (2005), who discovered that when *C. zaheri* were raised on guava, camphor, and fig leaves as rearing substrates, the guava leaves had the highest fecundity rate (Mx), which made up for the lowest survival rate (Lx). On fig leaves, however, the predatory mite had the lowest fecundity rate and the highest survival rate.Results in Table (5) demonstrated that the plant surface had a substantial impact on the net reproductive rate (Ro), which is the total number of females born in two consecutive generations (number of reproductions / generation). This value increased to 16.68 and 15.08 females/females when *C. negevi* was raised on green bean and eggplant leaves, and subsequently dropped to 10.15 and 8.80 females/females when *C. negevi* was raised on hibiscus and citrus leaves, respectively. According to Zhang *et al.* (2016), who raised *N. bicaudus* on five different host plants, the net reproduction rate (Ro) was 14.55 on cucumber, 23.54 on cotton, 21.79 on eggplant, 24.05 on tomato, and 34.61 on green bean, respectively. These results are consistent with their findings. In conclusion, the scientists discovered that green beans were the best host plant species for *N. bicaudus* growth and reproduction, while cucumbers were the worst. These results also proved that green bean and eggplant leaves were the best substrates for *N. bicaudus* breeding, while other species did not perform as well. In reference to the intrinsic rate of natural rise (rm), a valuable metric for forecasting the possibility of population expansion in an infinite setting, where the impact of growing density need not be taken into account (Birch, 1948).

The present data showed that r_m averaged 0.107, 0.113 females/ female/ day when *C. negevi* was reared on citrus and hibiscus, respectively. The corresponding values relatively increased to 0.127 and 0.161 females/female /day when the predatory mite was placed on eggplant and green bean leaves, respectively as shown in Table (5). These results are consistent with the findings of El-Sawi and Alazzazy (2007) who found that smooth leaves of Yaeel strawberry are better host plants for predators in terms of r_m. They added that characteristics of leaf hairs (trichomes)were determined on the midrib and leaf blades of strawberry Yaeel and Vantana. Moreover, Saber and Momen (2005) found that the intrinsic rate of increase (r_m) and the limited rate of increase (exp r_m) were higher on guava and camphor leaves than on fig leaves. It is also consistent with Researchers Nguyen and Shih (2012) examined the *N. womersley* life table parameters when fed on the spider mite *T. urticae* and reared on green bean plants. The average generation time (T), they discovered, was 15.31 days, with a sex ratio of 1:3, while R_o was 28.77, r_m was 0.23. In other word, the expected number of new females that will be added to the population per day represents the limiting rate of increase e^{rm} (λ) was 0.10. The present data showed similar trends to those observed by Nguyen and Shih (2012). Again, it is clear that the limiting rate of increase e^{rm} (λ) is influenced by the plant host, as it was at its highest value of 1.175 when *C. negevi* was placed on green bean leaves (Table 5).

Table 5. Life table parameters for *Cydnoseius negevi* fed on date palm pollen, reared on different kinds of leaves of four host plants and kept at 26ºC and 60% RH

Biological aspect	Host plants			
	Citrus	Hibiscus	Eggplant	Green bean
No. of individuals	21	24	20	20
Mites reached maturity %	76	82	85	85
Sex ratio (♀/♀+♂)	0.53	0.54	0.65	0.62
Mean generation time (T) (days)	20.30	20.36	21.29	17.45
Doubling time (D_t) (days)	13.18	12.48	11.10	8.76
Net reproductive rate(R_o)	8.80	10.15	15.08	16.68
Intrinsic rate of increase (r_m)	0.107	0.113	0.127	0.161
Finite rate of increase λ (e^{rm})	1.113	1.120	1.138	1.175

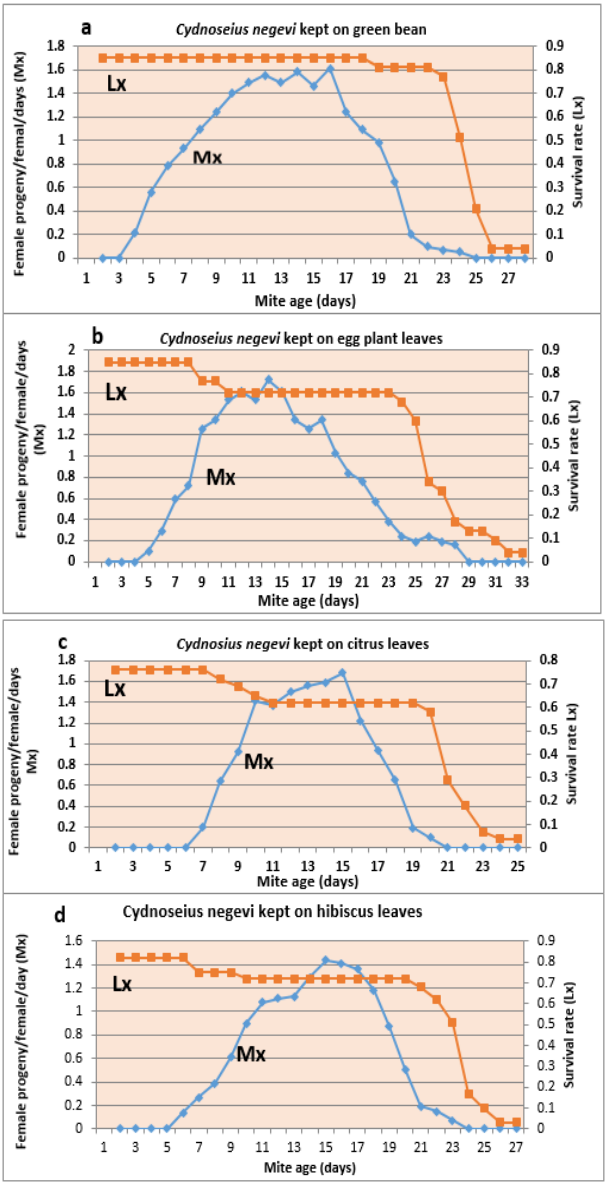

Figure 1. Age specific survivorship (Lx) and Age specific fecundity (female progeny/female Mx) of Cydnoseius negevi fed on date palm pollen, reared on four different plant leaves and kept at 26ºC and 60% RH.

4. Leaf structure of four tested plant species

The type and number of trichomes differed among the four host plant species (Table 6). The trichomes of eggplant was in clusters, whereas those of green bean was single. eggplant trichomes were acicular and hard, whereas

trichomes in the green bean, erect, villiform and soft. While the citrus leaves were soft and smooth and had no hairs. While the hibiscus leaves have hairs on them. Multicellular, either unicellular, tetracellular or pentagonal, erect and acute. A complex, either a quadruple or a quintuple.

It is well known that phytoseiid mites have a long history in their inter relationship with leaf trichomes and domatia. The current data revealed According to Nassar *et al*. (2010), this association was explained by numerous studies, which included increased pollen capture for use as an alternative diet, escape from predation, avoiding unfavorable abiotic circumstances, and increased/decreased ease of prey capture.

The present results proved that leaf trichomes and domatia structure had an obvious effect on all biological aspects of the predatory mite. The results clearly proved that green bean is the best plant surface for rearing *C. negavi*. This may be due to the morphological structure of the leaf surface, as it has soft, downy hairs and cavities that provide protection and help their movement, walk quickly and search for a prey as well as sites of laying eggs as shown in Figure (2 and 3). This is consistent with Zhang *et al.* (2016) who showed that The development and reproduction of the predatory mite, *N. bicaudus* can significantly affected by leaf structure of the host plant when fed on the spider mite *T. Turkestani.*

Table 6. presented the leaf structure and trichome characteristics (fine outgrowths, appendages or glandular hairs) of the four tested host plants.

Host plants	Description	Trichome length (mm)	No. trichomes/cm^2
Green bean	Single, erect, villiform, soft	103.70	58
Eggplant	Clustered, erect, acicular, hard	294.40	250
Citrus	Soft and smooth, no trichomes	0	0
Hibiscus	Multicellular, either unicellular, tetracellular or pentagonal, erect and acute. A complex, either a quadruple or a quintuple	389.53	15

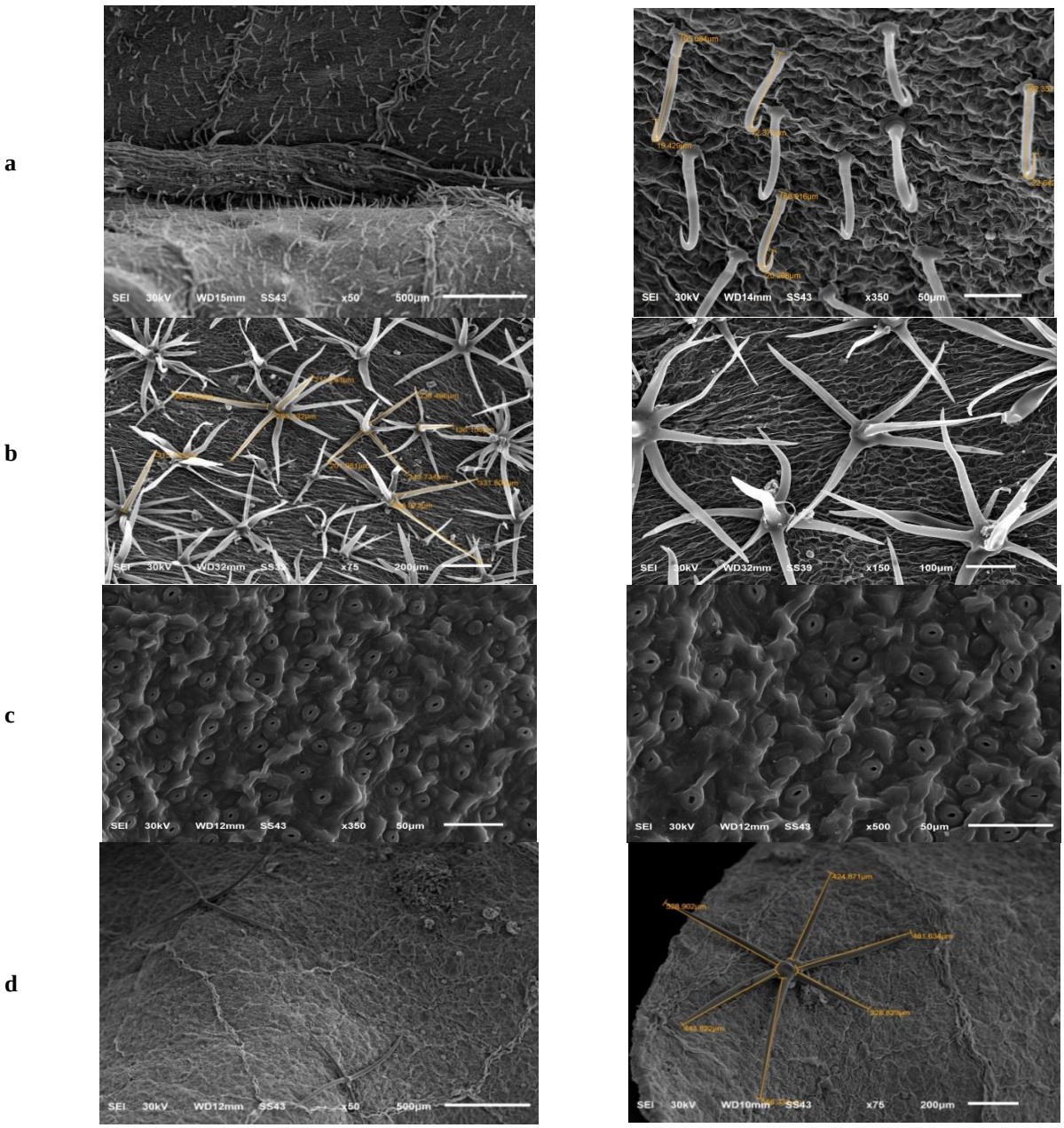

Figure 2. Shape and structure of trichomes on leaves of green bean (a), eggplant (b), citrus (c) and hibiscus (d)

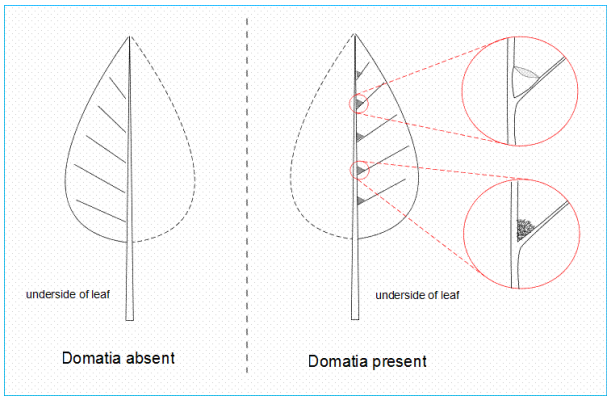

Figure 3. Presence and absence of leaf domatia (https://keys.lucidcentral.org/keys/v3/malpig/key/Malpig%20Key%20Test/Media/Html/

They noticed that there were significant differences in the characteristics of trichomes on the surfaces of the host plant species. They mentioned that total fecundity was highest on green bean and lowest on cucumber leaves. Also, Fahim and El-Saiedy (2021) found that strawberry cultivars affected on different biological aspects and life table parameters of the two phytoseiid mites, *A. swirskii* and *N. californicus*. On the other hand, they noticed that the worst plant surface for rearing both mites was citrus, as the leaf is completely smooth and has no hairs (trichomes), in addition to the oil glands present on the leaf, which may make it unsuitable for the development and reproduction of phytoseiid predatory mites. Similarly, in the absence of predators, Oku *et al.* (2006) investigated how leaf trichomes and leaf quality affected the phytophagous spider mite *Tetranychus kanzawai's* acceptance of the host plant. Acceptance by the host plant was positively correlated with the height and density of the leaf hair. In order to investigate the impact of leaf hairs on the dispersal and fertility of *T. kanzawai* in the presence of the predatory mite *Neoseiulus womersleyi*, the authors employed two model plants, *Phaseolus vulgaris* and *P. lunatus*, with the former having higher and denser leaf hairs than the latter. T. kanzawai females distributed from a *P. vulgaris* leaf far less frequently than from a *P. lunatus* leaf when *N. womersleyi* was present. Furthermore, while the two plants were equal in terms of host quality, *T. kanzawai* females' fertility on *P. lunatus* was noticeably lower than that on *P. vulgaris* when the predator was present *T. kanzawai* females raised on *P. vulgaris* spent more time on webs than those raised on *P. lunatus* when *N. womersleyi* was present. Furthermore, the predator appeared to have less access to webs than to leaf surfaces. These findings imply that mature female spider mites of *T. kanzawai* find refuge in leaf hairs. On the other hand, **Nassar *et al.* (2010)** found that the highest feeding capacity and egg production were obtained when *Phytoseiulus persimilis* fed on spider mites and reared on green bean leaves, while the results were declined when it was kept on apple, cotton, mango and fig leaves. They came to the conclusion that elevated veins, in addition to trichome density and venation type, can have a significant impact on the quantity of *P. persimilis* eggs deposited.

Therefore, they suggested rearing the predatory mite on green bean leaves to obtain short development, high feeding capacity and high fecundity. Accordingly, they preferred green beans as a suitable substrate to rear the predatory mite for biological control purposes. It was previously studied that many plants can utilize their leaf trichomes to produce physical barriers and chemical defenses, effectively repelling a wide range of pests. That means the plant having more trichomes may help to reduce pest mite populations. Trichomes also provide a multifaceted defense against many pests by acting as physical barriers, producing toxic and sticky substances, modifying both pests and biological agent's behavior. Therefore, trichomes can enhance the plant's overall defense mechanisms (Han *et al.*, 2022 and Wang *et al.*, 2021). These functions make trichomes a crucial component of the plant's defense strategy against herbivores and improve the natural enemy capability. Stimulating compounds enhance trichome development through a combination of nutrient supply, hormonal regulation, and stress response mechanisms. By optimizing these factors, the compounds promote the formation and growth of trichomes, which serve as a physical defense against pests and environmental stresses (Wang *et al.*, 2021 and Li *et al.*, 2021).

CONCLUSION

Based on the earlier findings, it can be said that rearing the phytoseiid mites *C. negevi* on green bean leaves as rearing substrates and providing mites with date palm pollen gave the shortest development, adult longevity and life span. Also, green been leaves caused significant high egg production and best life table parameters.

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تأثيرالسطح النباتى على النواحى البيولوجية المختلفة للمفترس الإكاروسي *Cydnoseius negevi* (Acari: Phytoseiidae)

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الملخص

تهدف هذه الدراسة الي تقييم تاثير اختلاف السطح النباتي لأربعة أنواع من العوائل النباتية وهي الباذنجان (*Solanum melongena* L)، والهيبسكس (*Hipiscus rosa chinenses*)، والليمون (*Citrus limon*)، والفاصوليا الخضراء (*Phaseolus vulgaris* L) علي نمو وتكاثر الأكاروس المفترس *C. negevi* والذي تم تغذيته علي حبوب لقاح نخيل البلح. حيث أن هناك اختلافات معنوية في خصائص الشعيرات والتجاويف لأوراق النباتات محل الدراسة. أوضحت النتائج أن الأكاروس *C. negevi* تطور بنجاح ووصل إلى الطور اليافع واكتملت دورة حياته علي الأربعة أنواع النباتية المختبرة، حيث كانت إجمالي مدة الأطوار غير اليافعه لأنثى المفترس *C. negevi* التي غذيت على حبوب لقاح نخيل البلح الأقصر عندما تم تربية الأكاروس على أوراق الفاصوليا الخضراء بمدة (4.75 يومًا) فقط. في حين أنه عند تربية المفترس علي أوراق الليمون إتضح ان فترة ما قبل وضع البيض كانت الأطول بـ (5.80 يومًا) بينما كانت فترة وضع البيض الأقصر بـ (8.80 يومًا). سجلت اناث المفترس أعلى خصوبة على أوراق نبات الفاصوليا الخضراء بـ (40.70 بيضة / أنثى) وأقلها كانت على أوراق الليمون بـ (13.75 بيضة / أنثى). وكان معدل التكاثر الصافي (R0) والتي تعنى العدد الكلي للإناث الناتجة خلال جيلين متتابعين 8.80 عندما تم تربيه الاكاروس علي أوراق الليمون، 10.15 على الهيبسكس، 15.08 على الباذنجان بينما وصل هذا المعدل إلى 16.68 على الفاصوليا الخضراء. وكان معدل تزايد العشيرة (r_m) 0.107، 0.113، 0.127 و 0.161 أنثى/ انثى/ يومًا عندما تم تربية الأكاروس علي نفس العوائل النباتية السابقة علي التوالي. وفى الختام يتضح أنه من بين العوائل النباتية الأربعة، كانت الفاصوليا الخضراء هي العائل الأكثر تفضيلًا لتربية المفترس الاكاروسي بينما كان الليمون الأقل تفضيلًا لتطور وتكاثر الاكاروس *C. negevi*