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Hira Mannan Shaikh
Department of Entomology, Faculty of Crop Protection, Sindh Agriculture University, Tandojam-Pakistan

Razique Ali Nahiyoon
Department of Entomology, Faculty of Crop Protection, Sindh Agriculture University, Tandojam-Pakistan

Bina Khanzada
Department of Entomology, Faculty of Crop Protection, Sindh Agriculture University, Tandojam-Pakistan

Maqsood Ali Laghari
Department of Entomology, Faculty of Crop Protection, Sindh Agriculture University, Tandojam-Pakistan

Mir Nadir Ali Marri
Department of Entomology, Faculty of Crop Protection, Sindh Agriculture University, Tandojam-Pakistan

Muhammad Abubaker Hassan
Department of Entomology, Faculty of Agricultural Sciences & Technology, Bahauddin Zakariya University Multan-Pakistan

Corresponding Author:
Hira Mannan Shaikh
Department of Entomology, Faculty of Crop Protection, Sindh Agriculture University, Tandojam-Pakistan

Effect of aphid species on development and morphometrics of *Menochilus sexmaculatus* (Fabricius) (Coleoptera: Coccinellidae) under laboratory conditions

Hira Mannan Shaikh, Razique Ali Nahiyoon, Bina Khanzada, Maqsood Ali Laghari, Mir Nadir Ali Marri and Muhammad Abubaker Hassan

Abstract
Menochilus sexmaculatus (Fab.) is a potential biocontrol agent that is commonly used in augmentative release programs and necessitates more ecological and biological data information. The experiment was conducted to determine the consequences of different aphid species (*Aphis nerii*, *Lipaphis erysimi* and *Bervicoryne brassicae*) on development and morphometrics of *Menochilus sexmaculatus* at the laboratory of Biocontrol, Department of Entomology, Faculty of Crop Protection, Sind Agriculture University Tando Jam, Sindh, Pakistan during 2018. The longest development period *Menochilus sexmaculatus* female and male were observed on *A. nerii* 39.00±2.08 and 30.33±1.20 days followed by *B. brassicae* 38.00±1.53 and 30.33±0.33 days and *L. erysimi* 34.33±1.20 and 27.33±0.88 days, respectively. The longest length and breadth (mm) of larval instars from 1st to 4th instar were recorded on *A. nerii*. Where in the pupal stage it was recorded on *L. erysimi* but in the female and male adult stages of *Menochilus sexmaculatus* Fab. was recorded on *L. erysimi*, respectively. The ANOVA showed a significant ($P<0.05$) difference in metamorphic measurement in length and breadth in all developmental stages.

Keywords: Aphid, *Aphis nerii*, *Lipaphis erysimi* and *Bervicoryne brassicae*, development period, morphometrics, *M. sexmaculatus*.

Introduction
The family Coccinellidae are a well-known group of dynamic predators that check the aphid population keeps them below the economic injury level, possessing huge economic importance due to its predaceous encounter on aphid in both grubs as well as adult stages [1]. The zigzag beetle belongs Coccinellidae sub-family is a generalist predator that devours on soft-bodied insects comprised of aphids [2]. In Sindh, many aphid species are found serious pests of vegetable crops, i.e. wheat aphid, safflower aphid, mustard aphid, and berseem aphid, etc. These species of aphids are wingless and reproduce parthenogenetically. If the environmental conditions are favorable the population's aphid species may expand very quickly [3]. Predatory zigzag beetle, *Menochilus sexmaculatus* (Fab.), is well-known ladybird beetle is an entomophilous coccinellid having a wide range of distribution in South-Western Asia, South Africa, Philippines, Indonesia, India, and Pakistan [4]. The adult as well grub of *Menochilus sexmaculatus* is voraciously fed on prey (aphid) species which is a serious threat to various cereal crops in Pakistan. *Rhopalosiphum padi* (L) is considered serious pests of wheat in cereals at present. Furthermore, that directly causes losses in yield, because this aphid also acts as the vector of barley yellow dwarf virus [5]. Rose aphid, *Macrosiphum rosae*, denoted as a serious pest of the rose as well as other crops. Both stages of aphid adults as well as nymphs attack the rose plants and suck the cell sap from tender shoots, buds, and flowers, eventually reduced the value of flowers in the market. About 20-40 % of losses recorded due to the infestation of aphid that declined capacity of flowering in the crop [6]. Aphids are unisexual and multiply on parthenogenesis. Under natural conditions, the aphid population may increase rapidly. *Menochilus sexmaculatus* is a common insectivorous ladybug that feeds on soft insects including aphids. The adult beetles are about 2 mm in size, bright yellow, and have black vertical uneven lines on the backside of both elytra. Polymorphs of various colors may exist in the species [7].

Keeping in view the above facts so this study was conducted to determine the effect of aphid species on the development and morphometrics of *Menochilus sexmaculatus* on different aphid species under laboratory conditions.

Materials and Methods

The experiment was conducted in the laboratory of the Entomology Department, Sindh Agriculture University, Tando Jam. The adult of zigzag beetle was collected from different crops and rear on natural hosts in the laboratory. The aphid species (Akk, Mustard, and Cabbage) were collected from respective crops. The prey species were provided to the predator larva and adult beetle to determine the development period and morphometrics of different larval instars of under laboratory conditions. The temperature was maintained between 26±2°C and Relative humidity 60±5%. The experimental design was Complete Randomized Design (CRD) with five replications. There were three treatments i.e. $T_{1=}$ *Aphis nerii*, $T_{2=}$ *Lipaphis erysimi*, and T_3= *Bervicoryne brassicae*. Ten eggs of *Menochilus sexmaculatus* were shifted in each Petri dish for the experiment. After hatching, grubs were feed on aphid species on the leaves of respective crops. The observation was taken daily to determine the developmental time and morphometric was measured of each life stage daily with the help of a magnifying glass scale. The newly emerging adults were fed with the same aphid species. The collected data were subjected to statistical analysis and statistical differences existed between data sets (P<0.05), Fisher's Least Significant Differences (LSD) was used to separate the differing means.

Results

Development period of *Menochilus sexmaculatus* on different aphid species

The result in table 1 indicates that the development of 1st instar of *Menochilus sexmaculatus* took maximum days (2.67±0.33 days) on *Aphis nerii* than *Bervicoryne brassicae* (2.33±0.33 days) and *Lipaphis erysimi* (2.67±0.03 days). Maximum days (2.67±0.33) for development of 2nd instar of *Menochilus sexmaculatus* were recorded for *Bervicoryne brassicae* than *Lipaphis erysimi* (2.00±0.58 days) and *Aphis nerii* (1.67±0.03 days). Maximum days (2.67±0.33) for the development of the 3rd instar of *Menochilus sexmaculatus* were recorded for *Lipaphis erysimi* than *Bervicoryne brassicae* (2.00±0.58 days) and *Aphis nerii* (1.67±0.03 days). Maximum days (2.33±0.33) for the development of the 4th instar of *Menochilus sexmaculatus* were recorded for *Lipaphis erysimi* than *Aphis nerii* (1.33±0.33 days) and *Bervicoryne brassicae* (1.33±0.33 days). Maximum days (4.67±0.33) for the development of pupa of *Menochilus sexmaculatus* were recorded for *Bervicoryne brassicae* than *Lipaphis erysimi* (3.67±0.33 days) and *Aphis nerii* (3.33±0.33 days). Maximum days (39.00±2.08) for the development of females of *Menochilus sexmaculatus* were recorded for *Aphis nerii* than *Bervicoryne brassicae* (38.00±1.53 days) and *Lipaphis erysimi* (34.33±1.20 days). Maximum days (30.33±1.20) for the development of males of *Menochilus sexmaculatus* were recorded for *Aphis nerii* than *Bervicoryne brassicae* (30.33±0.33 days) and *Lipaphis erysimi* (27.33±0.88 days).

Table 1: Development period of *Menochilus sexmaculatus* on different aphid species under laboratory conditions

Life stages	*Aphis nerii* (T_1)	*Lipaphis erysimi* (T_2)	*Bervicoryne brassicae* (T_3)
1st instar	2.67±0.33	2.33±0.33	2.67±0.33
2nd instar	1.67±0.33	2.00±0.58	2.67±0.33
3rd instar	1.67±0.33	2.67±0.33	2.00±0.58
4th instar	1.33±0.33	2.33±0.33	1.33±0.33
Pupa	3.33±0.33	3.67±0.33	4.67±0.33
Female	39.00±2.08	34.33±1.20	38.00±1.53
Male	30.33±1.20	27.33±0.88	30.33±0.33

Morphometric measurements of *Menochilus sexmaculatus* on different aphid species

The data in table 2 depicted that the maximum length of 1st instar of *Menochilus sexmaculatus* (2.27±0.17 mm) was recorded for *Aphis nerii* followed by *Lipaphis erysimi* (2.0±0.06 mm) and *Bervicoryne brassicae* (1.87±0.15 mm), respectively. The maximum length of 2nd instar of *Menochilus sexmaculatus* (3.53±0.15 mm) was recorded for *Aphis nerii* followed by *Lipaphis erysimi* (3.33±0.24 mm) and *Bervicoryne brassicae* (2.93±0.07 mm), respectively. The maximum length of the 3rd instar of *Menochilus sexmaculatus* (6.05±0.35 mm) was recorded for *Aphis nerii* followed by *Lipaphis erysimi* (5.89±0.06 mm) and *Bervicoryne brassicae* (5.30±0.21 mm), respectively. The maximum length of the 4th instar of *Menochilus sexmaculatus* (7.17±0.17 mm) was recorded for *Aphis nerii* followed by *Bervicoryne brassicae* (7.07±0.22 mm) and *Lipaphis erysimi* (7.00±0.04 mm), respectively. The maximum length of the pupa of *Menochilus sexmaculatus* (4.33±0.33 mm) was recorded for *Aphis nerii* followed by *Lipaphis erysimi* (5.17±0.93 mm) and *Bervicoryne brassicae* (4.87±0.19 mm), respectively. The maximum length of females of *Menochilus sexmaculatus* (5.33±0.33 mm) was recorded for *Aphis nerii* followed by *Lipaphis erysimi* (5.67±0.17 mm) and *Bervicoryne brassicae* (5.50±0.29 mm), respectively. The maximum length of males of *Menochilus sexmaculatus* (4.70±0.07 mm) was recorded for *Aphis nerii* followed by *Lipaphis erysimi* (4.03±0.03 mm) and *Bervicoryne brassicae* (4.03±0.09 mm), respectively.

The results further revealed in table-2 that maximum breadth of 1st instar of *Menochilus sexmaculatus* (1.11±0.06 mm) was recorded for *Bervicoryne brassicae* followed by *Lipaphis erysimi* (1.06±0.06 mm) and *Aphis nerii* (1.03±0.03 mm), respectively. Maximum breadth of 2nd instar of *Menochilus sexmaculatus* (1.67±0.09 mm) was recorded for *Aphis nerii* followed by *Lipaphis erysimi* (1.60±0.10 mm) and *Bervicoryne brassicae* (1.40±0.06 mm), respectively. Maximum breadth of 3rd instar of *Menochilus sexmaculatus* (3.08±0.08 mm) was recorded for *Aphis nerii* followed by *Lipaphis erysimi* (2.50±0.10 mm) and *Bervicoryne brassicae* (2.42±0.08 mm), respectively. Maximum breadth of 4th instar of *Menochilus sexmaculatus* (3.67±0.17 mm) was recorded for *Aphis nerii* followed by *Lipaphis erysimi* (3.25±0.14 mm) and *Bervicoryne brassicae* (3.00±0.05 mm), respectively. The maximum breadth of the pupa of *Menochilus sexmaculatus* (3.50±0.01 mm) was recorded on *Lipaphis erysimi* followed by *Aphis nerii* (3.33±0.17 mm) and *Bervicoryne brassicae*

(3.20±0.15 mm), respectively. The result further revealed that the maximum length of females of *Menochilus sexmaculatus* (5.67±0.17mm) was recorded on *Lipaphis erysimi* followed by *Bervicoryne brassicae* (5.50±0.29 mm) and *Aphis nerii* (5.33±0.33 mm), respectively. Similarly, the maximum length of males of *Menochilus sexmaculatus* (4.70±0.07 mm) was recorded on *Lipaphis erysimi* followed by *Aphis nerii* (4.03±0.03 mm) and *Bervicoryne brassicae* (4.03±0.09 mm), respectively. The maximum breadth of females of *Menochilus sexmaculatus* (4.50±0.06mm) was recorded for *Lipaphis erysimi* followed by *Aphis nerii* (4.00±0.03 mm) and *Bervicoryne brassicae* (3.90±0.06 mm), respectively. The maximum breadth of males of *Menochilus sexmaculatus* (3.27±0.19 mm) was recorded for *Aphis nerii* followed by *Lipaphis erysimi* (2.90±0.06 mm) and *Bervicoryne brassicae* (3.10±0.06 mm), respectively.

Table 2: Morphometric measurements of *Menochilus sexmaculatus* on different aphid species under laboratory conditions

Life stages	*Aphis nerii* (T_1)		*Lipaphis erysimi* T_2)		*Bervicoryne brassicae*(T_3)	
	Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)
1st instar	2.27±0.17a	1.03±0.03a	2.0±0.06a	1.06±0.06a	1.87±0.15b	1.11±0.06a
2nd instar	3.53±0.15a	1.67±0.09a	3.33±0.24a	1.60±0.10a	2.93±0.07b	1.40±0.06b
3rd instar	6.05±0.35a	3.08±0.08a	5.89±0.06a	2.50±0.10b	5.30±0.21b	2.42±0.08b
4th instar	7.17±0.17a	3.67±0.17a	7.00±0.04a	3.25±0.14a	7.07±0.22a	3.00±0.05b
Pupa	4.33±0.33b	3.50±0.01a	5.17±0.93a	3.33±0.17b	4.87±0.19b	3.20±0.15b
Female	5.33±0.33b	4.00±0.03b	5.67±0.17a	4.50±0.06a	5.50±0.29a	3.90±0.06b
Male	4.03±0.03a	2.90±0.06b	4.70±0.07a	3.27±0.19a	4.03±0.09a	3.10±0.06a

Discussion

The findings of the current study showed that maximum days for the development of *Menochilus sexmaculatus* 1st instar were observed on *Aphis nerii* than *Bervicoryne brassicae* and *Lipaphis erysimi*. Similarly, maximum days for the development of 2nd instar was noted under *Bervicoryne brassicae* than *Lipaphis erysimi* and *Aphis nerii.* Maximum days for the development of 3rd and 4th instar were noticed for *Lipaphis erysimi* than *Aphis nerii* and *Bervicoryne brassicae*. The current results have partial agreements with those of [8]. The total feeding act of adult predators was noted significantly more on *L. erysimi* as compare to grubs. This examination also validated the decision of [9, 10, 11, 12]. The maximum development of pupa was noted for *Bervicoryne brassicae* than *Lipaphis erysimi* and *Aphis nerii*. The *Menochilus sexmaculatus* adults (female and male) were lived longer on *Aphis nerii*. The longest for the length of *Menochilus sexmaculatus* was found in 1st, 2nd, 3rd, 4th instar, and male and female were recorded on *Aphis nerii* than *Lipaphis erysimi* and lowest was recorded on *Bervicoryne brassicae.* The result further depicted that the longest breadth values of *Menochilus sexmaculatus* 2nd, 3rd, 4th instar, pupa, and male were noted on *Aphis nerii* than *Lipaphis erysimi* and lower length values of *Menochilus sexmaculatus*, in 1st, 2nd, 3rd, and 4th instar, pupa and male and female were recorded on *Bervicoryne brassicae.* The feeding efficiency of *M. sexmaculatus* determined on rose aphid, *M. rosae*, in the laboratory at 27±2 °C, and 62±5% RH [13]. The result revealed that the longest consumption was recorded 4th instar larva of *Menochilus sexmaculatus* followed by 3rd, 2nd, and 1st instars, respectively. However, females of *Menochilus sexmaculatus* consumed the longest number of aphids as compare to males. Reported that the total larval period of *Menochilus sexmaculatus* ranged between 7 to 9 days when reared on bean aphid. While the pupal period of the predator was recorded from 2.21 to 4.35 days at varying temperatures [14].

Conclusions

It is concluded that the shortest development period was observed in 1st, 2nd, 3rd and 4th instars, larvae of *Menochilus sexmaculatus* on *A. nerii* followed by *B. brassicae* and *L. erysimi.* respectively. The shortest development period was observed in pupae of *Menochilus sexmaculatus* on *B. brassicae* followed by *A. nerii* and *L. erysimi.* respectively. The maximum adult longevity of female and male of *Menochilus sexmaculatus* were not significantly varied on *A. nerii* and *B. brassicae* as compare to *L. erysimi*. The average maximum length and breadth in larval instars were recorded on *A. nerii* followed by *L. erysimi.* and *B. brassicae*, respectively. However, the maximum length and breadth were observed in pupae and adults (female and male) on *L. erysimi*, *B. brassicae*, and *A. nerii*, respectively.

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