UNIVERSITI PUTRA MALAYSIA

FORAGING PATTERN, FUNCTIONAL AND NUMERICAL RESPONSE OF COCCINELLA SEPTEMPUNCTATA (L.) FEEDING ON MYZUS PERSICAE (SULZER.)

MUHAMMAD RAHIM KHAN

FP 2003 11

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UNIVERSITI PUTRA MALAYSIA

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By

MUHAMMAD RAHIM KHAN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in fulfillment of Requirement for the Degree of Doctor of Philosophy

March 2003

To my brother Muhammad Naeem Khan (Late)

Abstract of the thesis presented to the Senate of the Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

FORAGING PATTERN, FUNCTIONAL AND NUMERICAL RESPONSE OF *COCCINELLA SEPTEMPUNCTATA* (L.) FEEDING ON *MYZUS PERSICAE* (SULZER.)

By

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Chairman: **Professor Mohd. Yusof Hussien, Ph.D.**

Faculty: **Agriculture**

The prey searching pattern, fimctional and numerical response of *Coccinella septempunctata* (L.), common ladybird beetle, feeding on *Myzus persicae* (Sulzer), green peach aphid, were studied to evaluate predation potential. Impact of some potential abotic (viz, temperature) and biotic (viz prey size, prey distribution, predations hunger level and physical heterogeneity among host plant species) factors on the above parameters were studied in the laboratory and semi-field conditions. Both larvae and adult of *C. septempunctata* selected from single stock culture were found to detect their prey by physical contact. Their initial search was random which subsequently become prey-oriented. The prey search path indicated three distinct phases of search, viz "extensive search", initially "intensive search" on encountering the prey, and "post-intensive search" following ingestion of a prey. The intensity of search rate significantly increased following first prey intake stimulus. Predators, hunger level also influenced search pattern. Both prey size and prey densities influenced prey consumption of the predator.

The rate of successful encounter and ultimate consumption also depended on the age/stages of the predator. The fourth instar larvae were found more voracious among larval stages consuming about 69-75 aphids/12 hours. Interestingly, adult females always consumed more aphids than the male counterpart average being 78.5 aphids/12 hours. The interaction among prey density, prey size and predator's age were all significant ($P<0.01$) having profound impact on each other. Functional response curves ranged from linear to sigmoid and increase polynomial. Temperature variation had affected all the components viz. instantaneous attack rate (a'), prey handling time (T_h), given up time etc. of prey searching capacity of the predator. The lower threshold temperature where the predators start feeding was 10°C and with initial increase in ambient temperature the predation rate increased upto a level beyond which the intensity of predation gradually diminished and at the upper threshold (38°C) the predators evantually stopped feeding. The foraging activity took place within the range of 10-40°C, and maximum was between 20-23°C (predicted) and 23-25°C (observed).

The relationship between temperature (within the range of 10-40°C) and intensity (rate) of predation was found to be parabolic (inverted).The minimum (threshold) diet requirement for the initiation of egg production by *C. septempunctata* was 3.5 (4 /aphid /12 hour. The prey, *M. persieae* started to colonize at 8-10°C whereas *C.septempunctata* started to eclose from the hibernating pupae at 14-16°C. Prey population grew exponentially until the predators' numerical response came into effect. Apparently, the predator showed a delayed, although vivid, density dependent numerical response.

The numerical response curve was, however, curvilinear when two factors (viz prey density and temperature) were incorporated, the population decreased with decreasing temperature even at an increasing prey density. The quality of diet (prey species) had a profound impact on the predators' egg production and hence numerical response. When fed with *Brevecoryne brassicae* instead of *M. persicae*, it was marginally accepted by the predator and a minimum number of eggs were laid. Prey searching efficiency of *C. septempunctata* was also found to be affected by the contour of the habitat spectrum.

There was significant difference in prey consumption and search success because of host plant varieties. These differential foraging successes were caused by the (i) differences in the localized (within plant) distribution of the prey as well as the predator, and (ii) variation in the mobility and success of the predators in different morphological stratum. Leaves with thick slippery waxy layers and those with high trichome densities impeded predator's locomotion's greatly. The attack rate while on wheat variety Magala 99, and *B. campestris* were lower (0.987 min/aphid and 0.0730 min/aphid respectively) in comparison with *B. oleracea* (9.45 min/aphid) and *B. juncea* (7.24 mins/aphids).

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

CORAK MENCARI MAKAN, RESPON FUNGSIAN DAN NUMERIK *COCCINELLA SEPTEMPUNCTATA* (L.) YANG MEMAKAN *MYZUS PERSICAE* (SULZER.)

Oleh

MUHAMMAD RAHIM KHAN

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Corak pencarian mangsa, respon fungsian dan numerik *Coccinella septempunctata* (L.), kumbang ladybird, yang memakan *Myzus persicae*, kutu daun peach hijau, telah dikaji bagi menilai potensi pemangsaan. Impak beberapa faktor berpotensi abiotik (viz., suhu) dan biotik (viz., saiz mangsa, taburan mangsa, tahap kelaparan pemgsa dan heterogeneiti fizikal antara spesies pokok perumah) terhadap parameter di atas telah dikaji di dalam makmal dan keadaan separa-lapangan. Kedua-dua larva dan dewasa *C. septempunctata* yang telah dipilih dari satu kultur induk didapati mengesan mangsanya secara sentuhan fizikal. Pencarian permulaan adalah secara rawak yang mana kemudiannya menjadi teraroh-mangsa (berpedomankan mangsa). Jejak pencarian mangsa menunjukkan tiga fasa pencarian yang berbeza, viz. "pencarian meluas", pada mulanya "pencarian tumpuan" apabila bersemuka dengan mangsa, dan "pencarian pos-tumpuan" berikutan menelan mangsa. Tumpuan kadar pencarian meningkat dengan bererti berikutan rangsangan memakan mangsa pertama. Tahap kelaparan pemangsa juga mempengaruhi corak pencarian. Kedua-dua saiz mangsa dan kepadatan mangsa mempengaruhi daya pemakanan pemangsa.

Kadar kejayaan bersemuka dan daya pemakanan terakhir bergantung kepada umur/peringkat pemangsa. Larva instar keempat didapati lebih pelahap di antara lain-lain peringkat larva dengan memakan 69-75 kutu daun/12 jam. Yang menariknya, dewasa betina sentiasa memakan lebih banyak kutu daun berbanding pihak jantan, purata ialah 78.5 kutu daun /12 jam. Tindakbalas di antara kepadatan mangsa, saiz mangsa dan umur pemangsa kesemuanya menunjukkan impak yang bererti ($P<0.01$) dan berkesan. Keluk respon fungsian berjulat dari linear kepada sigmoid dan meningkat polinomial. Variasi suhu telah memberi kesan kepada kesemua komponen, viz. kadar serangan cepat (a'), masa menangani mangsa (T_h), masa menyerah, etc. bagi keupayaan mencari mangsa oleh pemangsa. Ambang suhu rendah di mana pemangsa mulai makan ialah 10°C, dan dengan peningkatan suhu sekitar kadar pemangsaan meningkat hingga ke suatu aras selebih mana pemangsaan beransur merosot dan berhenti makan pada ambang tertenggi (38°C). Aktiviti mencari makan berlaku di antara julat 10-40°C, dan aktiviti maksimum adalah di antara 20-23°C (ramalan) and 23-25°C (pemerhatian).

Perhubungan di antara suhu (di antara julat 10-40°C) dan keamatan (kadar) pemangsaan didapati parabolik (songsang). Ambang minimum keperluan diet bagi memulakan peneluran oleh *C. septempunctatum* ialah 3.5 (4/kutu daun/12 jam). Serangga mangsa, *M. persicae*, mula merebak pada suhu 8-10°C manakala *C. septempunctatum* mula menjelma dari kepompong pada 14-16°C. Populasi mangsa berkembang secara eksponen hingga respon numerik pemangsa mula bertindak. Agak jelas, pemangsa menunjukkan respon numerik kepadatan tertakluk yang tertunda. Keluk respon numerik, bagaimanapun, adalah lengkung linear apabila dua faktor (viz. kepadatan dan suhu) digabungkan; populasi menurun dengan pengurangan

suhu walaupun kepadatan mangsa meningkat. Mutu diet (spesies mangsa) memberi impak berkesan terhadap pengeluaran telur pemangsa dan oleh itu adalah respon numerik. Sebaliknya, apabila diberi makan *Brevecoryne brassicae* dan tidak *M. persicae*, ia tidak berapa diterima oleh pemangsa dan bilangan telur yang dihasilkan adalah minimum. Kecekapan pencarian mangsa oleh *C. septempunctata* juga didapati dipengaruhi oleh kontur spektrum habitat.

Terdapat perbezaan bererti bagi daya pemakanan mangsa dan kejayaan mencari oleh sebab varieti pokok perumah. Pembezaan kejayaan mencari makan disebabkan oleh (i) perbezaan dalam taburan setempat (dalam pokok) bagi mangsa dan juga pemangsa, dan (ii) ubahan dalam pergerakan serta kejayaan pemangsa dalam morfologi stratum yang berlainan. Dedaun dengan permukaan berlilin dan licin serta kepadatan trikom yang tinggi menghalang pergerakan pemangsa. Kadar serangan apabila pada varieti gandum Magala 99 dan *B. campestris* adalah lebih rendah (masing-masing 0.987 min/kutu daun dan 0.073 min/kutu daun) berbanding *B. oleracea* (9.45min/kutu daun) dan *B. juncea* (7.24 min.kutu daun).

ACKNOWLEDGEMENTS

The author wishes to acknowledge the guidance and assistance given by the supervisory committee, Professor Mohd. Yusof Hussein (Chairman), Faculty of Agriculture, Professor Syed Tajuddin Syed Hassan, Faculty of Science and Environmental studies, Associate Professor Dr. Yusof Ibrahim Faculty of Agriculture (UPM) Dr. Muhammad Abdul Matin Director (PRMC) National Agricultural Research Centre (NARC) Islamabad. Their criticism and suggestions have been of tremendous significance during the study and preparation of the Thesis.

The author is grateful to the Malaysian Technical Cooperation (MTCP) for providing the financial assistance to pursue the Doctoral Degree Program.

Special thanks are extended to the staff of Plant Protection Department (UPM) especially the Bio- control Laboratory for providing facilities and assistance.

The author highly appreciate the cooperation provided by Dr. Ather Rafi Senior Scientific officer and his Laboratory staff at IPMI, NARC, Islamabad Pakistan.

The author likes to acknowledge his wife and the kids for their patience in tolerating preoccupation with this research work.

Lastly the author would like to express his deepest gratitude to his beloved mother and father for their prayers and encouragement during the entire study period.

Thanks are extended to brothers and sisters for their sincere love and good wishes. This work is profoundly dedicated to his late brother Muhammad Naeem Khan who was keen in this study but unfortunately departed from us before his dreams comes true.

I certify that the Examination Committee met on 24th March 2003 to conduct the final examination of Muhammad Rahim Khan on his Doctor of Philosophy thesis entitled "Foraging Pattern, Functional and Numerical Response of *Coccinella septempunctata* (L.) Feeding on *Myzus persicae* (Sulzer.)"in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommends that the candidate will be awarded the relevant degree. Members of the Examination Committee are as follows.

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DECLARATION

I hereby declared that this thesis is based on my original work except few quotations and citations, which have been duly acknowledged. I also declared that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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Date : 11 APR 2009

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GLOSSARY AND ABBREVIATIONS

Abaxial	:The upper surface of the leaf
Adaxial	:The lower surface of the leaf
ANOVA	:Analysis of Variance
BB	:*Bravicoryne brassicae*
Cohort	:An initial number of insects recoded from the same birth
CRD	:Completely randomized design
CS	:*Coccinella septempunctata*
DAP	:Date after planting
D:L	:Dark and light period
D_b	:Beeline distance
Ds	:Straightness of the search path
Dwiculture	:More than two crops grown in either side by side or
Di-culture	:Inter cropping in the same unit area.
Functional Response	:The number prey eaten/ predator/unit time
Hunting track	:The path followed by Predator searching the Prey
ILL	:Incipient limiting level
IPM	:Integrated Pest Management
IPMI	:Integrated Pest Management Institute
Kick back	:Aphid's reaction to the Predator when Encountered
LSD	:Least significant difference between the Variables
MP	:*Myzus persicae*
N.A.R.C	: National Agriculture Research Center of Pakistan
Numerical Response	:Increase in number of Predators
PRD	:Prey Recognized from Distance
PEN	:Prey Encountered