UNIVERSITI PUTRA MALAYSIA

# BIOCONTROL DYNAMICSTTRICHOGRAMMA SPP ASSOCIATED WITH HELICOVERPA ARMIGERA (HUBNER) IN ETHIOPIAN MIXED VEGETATION ECOSYSTEMS

MULUGETA NEGERI TULU.

FP 2005 20

# BIOCONTROL DYNAMICS OF *TRICHOGRAMMA* SPP ASSOCIATED WITH *HELICOVERPA ARMIGERA* (HÜBNER) IN ETHIOPIAN MIXED VEGETATION ECOSYSTEMS

**By**

**MULUGETA NEGERI TULU**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy**

**May 2005**

**To**:

"My beloved Wife, Tigist Tadesse

My Daughter Hawi Mulugeta,

My Son Yomiyu Mulugeta and the rest of my families"

for their much tried patience and support.

*"Success is going from failure to failure*
*without loss of enthusiasm"*
*Winston Churchill.*

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

# BIOCONTROL DYNAMICS OF *TRICHOGRAMMA* SPP ASSOCIATED WITH *HELICOVERPA ARMIGERA* (HÜBNER) IN ETHIOPIAN MIXED VEGETATION ECOSYSTEMS

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**MULUGETA NEGERI TULU**

**May 2005**

**Chairman: Associate Professor Rohani Ibrahim, PhD**

**Faculty: Agriculture**

The natural occurrence of egg parasitoids was assessed by investigating the compatibility of *Trichogramma* spp. associated with the African bollworm, *Helicoverpa armigera* (Hübner) under mixed vegetation ecosystems. Field and laboratory investigations were conducted to study the diversity, species composition, biology and effectiveness of recovered *Trichogramma* spp. and other egg parasitoids on *H. armigera*.

Assessments on the diversity of egg parasitoids conducted on farmers' fields on 50 randomly selected sites from four contrasting agro-ecosystems indicated that there were four main groups of Hymenopteran egg parasitoids. They were the two *Telenomus* spp. (Scelionidae), two *Trichogrammatoidea* spp. nr. *lutea* and nr *armigera* (Trichogrammatidea), two *Trichogramma* spp. nr. *mwanzia* and nr. *bournieri* (Trichogrammatidae) and lastly a number of unidentified species. The natural field parasitism was estimated to be 33%; parasitism of the recovered egg parasitoid species according to locations varied from 27 to 40% while that of different crops (cotton, tomato and pepper) varied from 25 to 57%. Among those recovered

from the surveyed agro-ecological locations, *Trichogramma* sp. nr. *bournieri* was recovered on various canopy structures of cotton, tomato and maize, indicating that it has a broader niche. Egg parasitoid abundance and species composition analyzed by the Czekanowski coefficient and Shannon index indicated that *T.*sp. nr. *bournieri, Telenomus* sp. and *T.*sp. nr. *mwanzia* were widespread in both low (Afar) and high altitude (Guder) agro-ecologies.

The abundance of *H. armigera* egg and its egg parasitoids in two benchmark sites at extreme altitudes (740 and 2034 meter above sea level) during the main and off-seasons on eight crop types varied with respect to crop type, season and altitude. In general, parasitism was higher during the main season. At lower altitudes, the highest count of parasitized eggs was from pigeon peas where the parasitoid *Telenomus* sp. was the most abundant. At higher altitudes, the highest number of parasitized eggs was recorded from tomato. The first appearance of targeted host egg during the off-season at lower altitude was in November and it was the highest number recorded. At Guder, (high altitude) during the off-season, *H armigera* eggs and their parasitoids were recorded from November to January in tomatoes and pigeon peas with the highest parasitism recorded in January in both crops.

Observations revealed that male *T.*sp. nr. *bournieri* emerged 7-12 minutes earlier than the females. The males stood guard around the parasitized eggs awaiting the emerging female for copulation. The overall frequency distribution of the number of adults emerged daily was positively skewed for both sexes. The duration of immature and adult stages for *T.*sp. nr. *bournieri* was 9.25 and 3 days, respectively, whereas for *T.*sp. nr. *mwanzia* it was 9.35 and 2.35 days, respectively.

Suitability and acceptability of *H. armigera* egg for ovipostion of the native *T.*sp. nr. *bournieri*, *T.*sp. nr. *mwanzia* and a *Telenomus* sp. was studied under laboratory conditions. *Telenomus* sp. failed to perform when held under laboratory conditions. The reason for this is not clear. The acceptability and suitability level by the two *Trichogramma* parasitoids varied with age and density of *H. armigera* eggs. In general, severity of parasitism decreased with increasing host egg age while searching or foraging increased with increasing host egg age.

Functional responses studied on various factitious host egg densities exposed to different numbers and combinations of parasitoid species showed the mean rate of parasitism was highest when the host eggs were exposed to an individual species of multiple females of four to eight. The mean parasitism rate increased with increasing number of adults.

The host egg parasitism by *T.*sp. nr. *bournieri* and *T.*sp. nr. *mwanzia* was highly affected at temperature intervals between 10 and 40°C. The number of adult female progeny was greater than the males at different level of temperature. *Trichogramma* sp. nr. *bournieri* had a wider spectrum and its optimum temperature was between 10 and 35°C. The high efficiency of parasitism by *T.*sp. nr. *bournieri* and its superior searching capacity, as revealed by studies done under the controlled conditions of the greenhouse (under cloth mesh cage) and lathehouse (under open air cage) led to the conclussion that it was potentially promising to be exploited as a biocontrol agent against *H. armigera*.

Abstrak Tesis Yang Dikemukakan Kepada Senat Universiti Putra Malaysia
Sebagamemenuhi Keperluan Untuk Ijazah Doktor Falsafah

**DINAMIK KAWALAN BIOLOGI *TRICHOGRAMMA* SPP. BERKAITAN DENGAN *HELICOVERPA ARMIGERA* (HÜBNER) DI DALAM EKOSISTEM PELBAGAI TUMBUHAN DI ETHIOPIA**

**Oleh**

**MULUGETA NEGERI TULU**

**MEI 2005**

**Pengerusi:** **Profesor Madya Rohani Ibrahim, PhD**

**Fakulti:** **Pertanian**

Kejadian semulajadi parasitoid telur telah dinilai secara menyiasat keupayaaan penyesuaian *Trichogramma* spp dengan ulat kapas Afrika, *Helicoverpa armigera* (Hübner) di dalam ekositem pelbagai tumbuhan. Penyiasatan di lapangan dan makmal telah dijalankan untuk mengkaji kepelbagaian, komposisi spesies, biologi dan keberkesanan *Trichogramma* spp. yang ditemui dan lain-lain parasitoid telur ke atas *H. armigera.*

Penilaian terhadap diversiti parasitoid telur di 50 buah ladang yang dipilih secara rawak daripada empat agroekosistem berlainan menunjukkan terdapat empat kumpulan utama parasitoid telur Hymenoptera. Mereka adalah dua *Telenomus* spp (Scelionidae), dua *Trichogrammatoidae* spp .nr *lutea* dan nr. *armigera* (Trichogrammatidae), dua *Trichogramma spp.* nr. *mwanzai* dan nr. *bournieri* (Trichogrammatidae) dan sebilangan speses yang belum dapat dikenal pasti. Parasitisme semulajadi di lapangan telah dianggarkan sebanyak 33%; parasitisme spesies parasitoid telur yang ditemui mengikut lokasi merangkumi 27% hingga 40%

sementara daripada tanaman yang berbeza (pokok kapas, tomato dan chili) merangkumi 25% hingga 57%. Di antara yang telah ditemui dari lokasi aroekologi yang disurvei, *Trichogramma* sp. nr. *Bournieri* telah ditemui di dalam pelbagai struktur sudur pokok kapas, tomato dan jagung, menunjukkan bahawa ia mempunyai niche luas. Limpahan parasitoid telur dan komposisi spesies yang dianalisis secara koefisyen Czekanowski dan indeks Shannon menyatakan bahawa *T.* sp. nr. *bournie*ri, *Telenomus* sp. dan *T.* sp. nr. *mwanzai* adalah tersebar luas di kedua-dua agroekologi altitude rendah (Afar) dan altitude tinggi (Guder).

Kelimpahan telur H.armigera dan parasitoid telurnya di dua tapak tandaras pada altitud lampau (740 dan 2034 masl) pada musim utama dan luar musim ke atas lapan jenis hasil tanaman berbeza-beza mengikut jenis tanaman, musim dan altitud. Secara umumnya, parasitisme adalah tinggi mengikut musim utama. Di altitud rendah, jumlah paling banyak telur yang diparasit adalah dari pigeon peas di mana parasitoid *Telenomus* sp. adalah yang terbanyak. Di altitude tinggi, bilangan tertinggi telur yang diparasit telah direkodkan dari tomato. Kemunculan pertama telur perumah sasaran pada luar musim di paras altitud rendah adalah pada bulan November dan merupakan catatan yang tertinggi. Di Guder (altitud tinggi) pada luar musim, telur *H. armigera* dan parasitoidnya telah dicatatkan dari November hingga pada tanaman tomato dan pigeon-peas dengan parasitisme yang tertinggi dicatatkan pada bulan Januari bagi kedua-dua tanaman.

Penelitian mendedahkan bahawa induk jantan *T.* sp. nr. *bournieri* muncul 7-12 minit lebih awal daripada betina. Induk jantan akan mengawal berhampiran telur yang diparasit sambil menunggu penjelmaan betina untuk mengawan. Keseluruhan taburan

frekuensi bilangan dewasa muncul setiap hari adalah positip berat sebelah bagi kedua-dua jantina. Jangka masa peringkat belum dewasa dan dewasa untuk *T.* sp. nr. *bournieri* adalah masing-masing 9.25 dan 3 hari, manakala untuk *T.* sp. nr. *mwanzia* pula masing-masing 9.35 dan 2.35 hari.

Kesesuaian dan penerimaan telur *H. armigera* untuk dioviposisi spesies asli *T.* sp. nr. *bournieri*, *T.* sp. nr. *mwanzia* dan *Telenomus* sp. telah dikaji di makmal. *Telenomus* sp. gagal bertindak apabila terkurung di dalam keadaan makmal. Sebabnya masih belum jelas. Paras penerimaan dan kesesuaian untuk kedua parasitoid *Trichogramma* dibedakan dengan usia dan kepadatan telur *H. armigera*. Secara umumnya keterukan parasitisme telah menurun dengan peningkatan usia telur sementara pencariannya menurun dengan peningkatan usia telur perumah.

Kajian respon fungsian ke atas kepadatan telur perumah buatan yang telah didedahkan kepada pelbagai bilangan dan kombinasi spesies parasitoid menunjukkan min kadar parasitisme adalah tertinggi apabila telur utama telah didedahkan kepada spesies tunggal dari empat hingga lapan betina. Min kadar parasitisme telah meningkat dengan peningkatan bilangan dewasa.

Parasitisme telur perumah amat dipengaruhi oleh *T.* sp. nr. *bournieri* dan *T.* sp. nr. *mwanzia* amat dipengaruhi oleh suhu di antara 10°C dan 40°C. Bilangan anak betina yang dewasa adalah melebihi bilangan jantan pada aras suhu yang berlainan. *T.* sp. nr. *bournieri* mempunyai spectrum lebih luas dan suhu optimum baginya adalah di antara 10°C dan 35°C. Keberkesanan parasitisme yang tinggi oleh *T.* sp. nr. *bournieri* dan keupayaan pencarian yang unggul, sebagaimana yang telah didedahkan dalam kajian

yang dibuat di bawah keadaan yang terkawal rumah hijau (sangkar kain) dan rumah lapis (sangkar terbuka) telah menjuruskan kepada kesimpulan bahawa ia mempunyai harapan berpotensi untuk diperalatkan sebagai agen pengawalan biologi ke atas *H. armigera.*

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*"Almost everything you do will seem insignificant, but it is very important that you do it anyway." Gandhi*

---

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I certify that an Examination Committee met on 13th May 2005 to conduct the final examination of Mulugeta Negeri Tulu on his Doctor of Philosophy thesis entitled ''Biocontrol Dynamics of *Trichogramma* spp Associated with *Helicoverpa armigera* (Hübner) in Ethiopian Mixed Vegetation Ecosystems" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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Date: 21 JUL 2005

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

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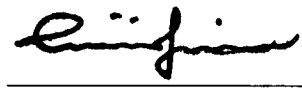

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## DECLARATION

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

**MULUGETA NEGERI TULU**

Date: 7 JUN 2005

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