OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA.

Inaugural Lecture Series No. 160

PARASITES, PREDATORS AND PATHOGENS OF INSECTS

By

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Professor of Plant Science
(Entomology)

FOR LEARNING AND CULTURE

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Introduction

Mr. Vice-Chancellor, Sir, it is with a deep sense of gratitude to Almighty God, and a modicum of sense of history that I deliver this 160th Inaugural Lecture of the Obafemi Awolowo University entitled: "Parasites, Predators and Pathogens of Insects". Seven years ago, I was scheduled to deliver this lecture, but at that time I happened to be settling to a Sabbatic at the University of Stellenbosch, South Africa. I do believe that it was by Divine appointment that the lecture can now incorporate my South African experience.

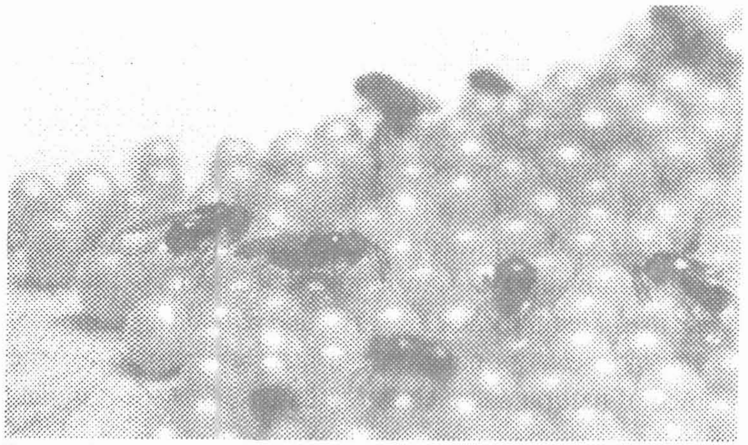
This Inaugural Lecture, in the tradition of academia, is designed to lay some theoretical framework for the subject matter, present an account of my foray into the world of beneficial insects and the causal agents of the maladies of insects, and outline my modest contributions to the discipline. As much as possible, I would attempt to outline the genesis of teaching and research in the field of Insect Pathology and Biological Control of Insects in this University and relate everything to the economy.

Definition of Terms

At this juncture, Mr. Vice-Chancellor, attempt will be made to define the key words in the topic of my lecture i.e. "Parasite", "Predator" and "Pathogen", all of which are collectively known as "Natural Enemies". It is worthy of note that as the knowledge of entomology (the study of insects) particularly entomophagy (the consumption of insects or their parts) advanced, the use of natural enemies arose, and controlling populations of pest insects using predators, parasites, and later pathogens demonstrated the importance of natural enemies as regulators of insect population abundance.

Parasite/Parasitoid

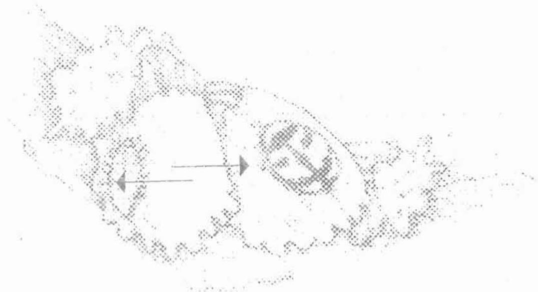
"Parasite" in this context, defined after Coppel and Mertins (1977) refers to an insect which lives on or in a larger insect, the host to reach maturity. When the insect parasite of an arthropod is parasitic only in its immature stages, destroying its host in the process of its development, and free-living as an adult, it is referred to as a "Parasitoid". The entomophagous Hymenoptera are parasitoids (Fig. 1). Some of them attack the egg stage while others attack the larval stage (Fig. 2). Thus parasitism is a qualitative term which refers to a kind of symbiosis in which one party (the parasite) lives at the expense of the other (the host). The parasite contributes nothing to the relationship and frequently destroys the host in the process. The food sources of the adults of parasitic insects usually differ from those of the immature stages. According to Steinhaus and Martignoni (1970), the parasite obtains nutriment from the living substance of the host, thus depriving it of useful substance, or exerting other harmful influence upon it.



Hymenopterous egg parasitoids laying their eggs in the eggs of a Pentatomid.

Predator

"Predator" is defined as "an animal which feeds upon other animals (prey) that are usually smaller and weaker than itself, frequently devouring them completely and rapidly". Predators have been described as nature's first line of defence against insect pests (Whitcomb, 1987). A predator most often is required to seek out and attack more than one prey to reach maturity. The food sources of the adults and immature stages are often the same. However, no sharply defined line of demarcation can be drawn between the parasite and the predator. For there is great divergence in feeding habits of the adults and the larvae or nymphs of a few species that have parasitic or predaceous larvae, yet the adults are strictly phytophagous and are classed as crop pests. In referring to a species or group as being parasitic or predaceous in habit, it should be borne in mind that it is the immature stages which are usually referred to. In general, parasites and predators had formed the subject of extensive reviews including those of Sweetman (1958), Thompson (1971), Clausen (1972), Coppel and Mertins (1977), U.S.D.A. (1978), Van Huis (1991), Greathead (1991), Feener and Brown (1997), and Hawkins (1993).



Adult Beetle and Larval predators preying on the Cottony cushion scale

Pathogen

"Pathogen" is defined after Steinhaus and Martignoni, (1970) as "a specific cause of disease. A microorganism capable of producing disease under normal conditions of host resistance and rarely living in close association with the host without producing disease. A pathogen could be any microorganism, virus, substance, or factor causing disease".

Bucher (1973) defined a pathogen very briefly as a parasitic microorganism, or less briefly as a microorganism that is capable of growing, multiplying, or developing within or upon a host organism and that by so doing causes the individual host some demonstrable harm. In order to prove that a pathogen is the cause of disease, that causal organism must be taken through Koch's postulates. For those pathogens that are not culturable *in vitro* (viruses and microsporidia, etc.) the step, isolation, identification and growth in pure culture must be circumvented while retaining the basic idea of the postulates. Even some of the pathogens are known to be fastidious and

(Mummified nymphs and adults of *Zonocerus variegatus* infected with *Entomophaga grylli fungus)*

not readily amenable to *in vitro* culture (e.g. some entomopathogenic fungi). Hence the pathologist may face some problems in attempting to

determine whether or not a microorganism is a pathogen. Specifically, Insect Pathology is that branch of Entomology or Invertebrate Pathology that embraces the general principles of pathology as they may be applied to insects. Different classes of pathogens of insects had been reviewed extensively by Bulla,Jr. (1973), Cantwell (1974), Roberts and Strand (1977), Burges (1981), Roberts and Aist (1984), Wilding (1983), Matanmi (1989), Evans and Prior (1990). The first insect pathogen of which we have record was a *Cordiceps* fungus on a Noctuid moth, reported and illustrated by De Reaumur in the year 1726.

Scope of the Lecture

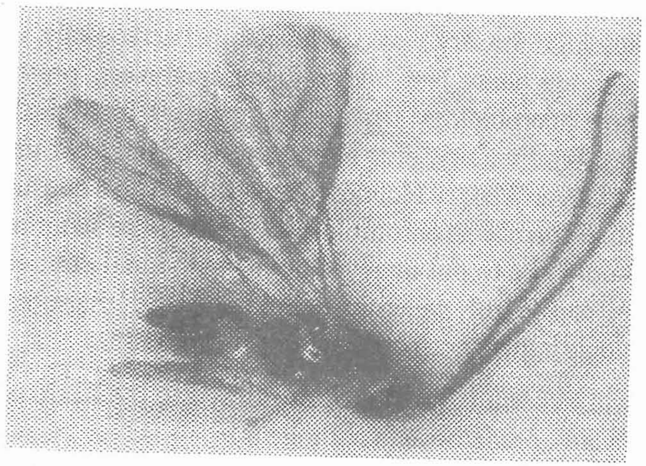
Entomology, over the ages, has greatly affected man's health and food supply and has played an important role as religious and cultural symbols. The subject is rather broad, covering certain essentials of several disciplines including: pathology, systematics, morphology, ecology, sericulture, physiology, ethology, forestry, virology, mycology, bacteriology, veterinary and public health, apiculture, horticulture, forensic pathology, protozoology, instrumentation, microbiology, nematology, genetics, biological control, biotechnology, biodiversity, etc. The vastness of the field must have prompted one Oliver Wendell Holmes to reply quickly to a question asked him: "I suppose you are an entomologist? " Not quite so ambitious as that, Sir. I should like to put my eyes on the individual entitled to that name. No man can be truly called an entomologist, Sir; the subject is too vast for any single human intelligence to grasp".

The lecture will, accordingly, focus on my foray into the world of natural enemies (parasites, predators and pathogens).

A foray into the world of natural enemies

Parasites

About three decades ago, as a pioneer Master of Philosophy student in the Department of Plant Science of this University, I investigated the biology, taxonomy and control of Tephritid fruit flies attacking Cucurbits in Ile-Ife environs. That study eventually yielded, among other things, 4 Dacine Tephritids from different melons. The flies were found to be parasitised consistently by *Opius phaeostigma* Wilkinson and *Opius sp.* (Hymenoptera, Braconidae) and to show considerable promise as biological control agents of melon fruitflies. The field and laboratory investigations, and ensuing thesis, (Matanmi, 1971), constituted part of the requirements for the award, in 1971, of the first Master of Philosophy (Plant Science) degree of this University. Since then, other parasitoids/parasites have been encountered and investigated as follows: Larval parasitoids, *Apanteles syleptae* Ferriere and *Bracon* sp.; larval-pupal



(Larval/Pupal Opiine Parasitoid of the Bean fly, *Ophiomyia spencerella.)*

parasitoids, *Xanthopimpla* sp.(Hymenoptera :Ichneumonidae); and *Carducia auratocauda* Curran (Diptera:Tachinidae) from *Sylepta derogata* F. (Lepidoptera:Pyralidae), a serious pest of okra, *Hibiscus* sp. and cotton , *Gossypium* sp. in Nigeria . Our results showed that a combination of *A. syleptae* and *C. auratocauda* appeared to offer promise as biocontrol agents of *S. derogata* ; the 3 major parasites recorded a mean percent parasitization of 18.3, 25.5, and 3.6 respectively (Ebe and Matanmi, 1978). Similarly, in spite of the impressive defence mechanism of *Acraea eponina* , a key pest of *Corchorus olitorius* (Linnaeus) (Lepidoptera, Nymphalidae), *Charops sp.* (Hymenoptera: Ichneumonidae) and the parasitic fly, *Carcelia (Caricellia) normula* Curran (Diptera, Tachinidae) were recorded as natural enemies of *A. eponina* (Matanmi and Hassan, 1987). In an earlier study, Matanmi (1980) recorded the sarcophagid, *Blaesoxipha filipjevi* Rohd. consistently from the variegated grasshopper, *Zonocerus variegatus* (L) (Orthoptera, Pyrgomorphidae) in different locations in South-Western Nigeria. The parasitised males and females contained between 1 and 7 larvae per host, representing 6.9 percent parasitization, and this resulted in some degree of population reduction . (Fig. 3 shows a generalized sarcophagid adult .)

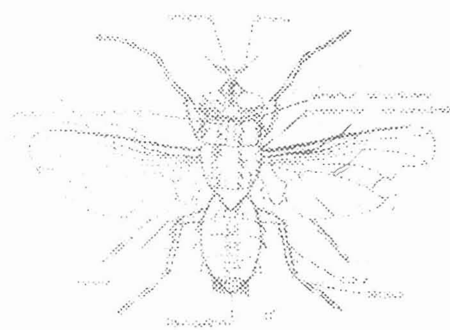
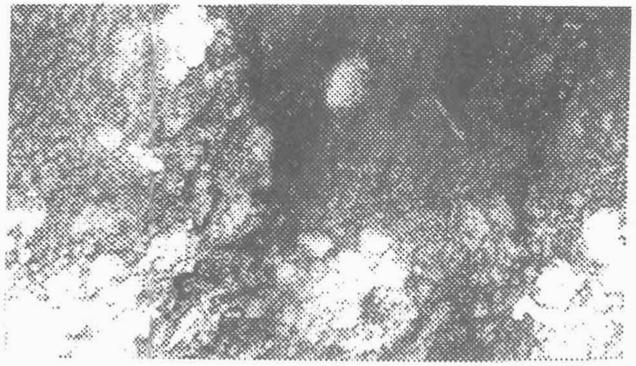


Diagram illustrating a Sarcophagid e.g. *Blaesoxipha sp.* parasite of *Zonocerus variegatus*

It is worthy of note that this parasite was formally exported to an interested research collaborator, Dr. Norman Rees, of the Rangeland Insects Research Institute, U.S.D.A. , Montana State University, Bozeman, Montana, U.S.A. who subsequently reported rearing success. Hawkins (1993) has remarked that the parasitoids represent one of the most speciose and important ecological groups on the planet i.e. parasitoid-host systems do represent species-rich communities , in which large numbers of parasitoid species often co-exist on individual host species.

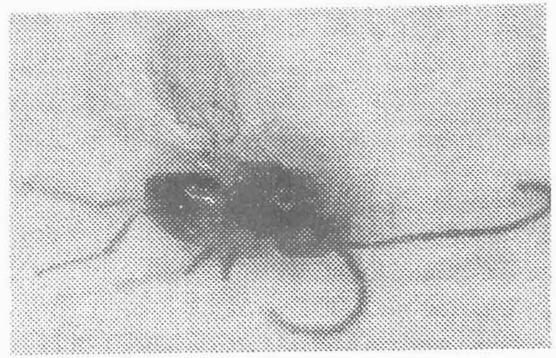
Confined animal housing as is used for poultry production is known to create an artificial protected environment for the rapid build -up of various filth fly species such that one finds even more flies in and around confined housing than the climatic zones would suggest. (Fig. 4)



(Manure deposit in deep litter poultry housing, predisposes to heavy fly breeding)

Quite a few Hymenopterous parasitoids from the Pteromalidae, Chalcididae and Diapriidae have been recorded from field surveys and laboratory investigations of synanthropic filth flies in caged layer poultry production systems in Ile-Ife environs, and high rise intensive poultry production systems in the Western Cape Province of South Africa.

(Matanmi, 1990; Matanmi and Giliomee, 1998). (Fig. 5)



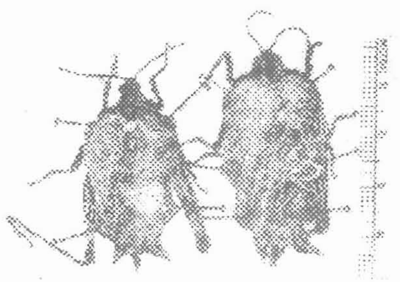
Chalcidid parasitoid of filth flies.

Also, parasitoids from various families in the Hymenoptera have been reported as natural enemies of bruchid beetles in different parts of the world. It is therefore little wonder that Van Huis (1991) advocated increased attention paid to research on the introduction and conservation of natural enemies, and the combination of an overall pest management strategy. There is also a positive trend in research in some advanced laboratories with established insectaries to investigate hybridization in primary parasitoids and possibly direct heterosis to favour certain desirable parasitoid traits. Until recently, a helpful senior colleague, and accomplished leader, Emeritus Professor E.F. Legner of the Division of Biological Control, University of California, Riverside, California, was very active in this novel area.

On the home front, as a follow-up to research findings emanating from the efforts to exploit natural enemies of synanthropic flies of public health importance, comprehensive proposals for the mass production of parasitoids in insectaries are being completed . Hopefully, this should lead eventually to the development of cottage industry in the mass-production of natural enemies of pestiferous flies.

Nematode Parasites

Recorded observations of workers e.g. Nickle (1972) and Poinar, Jr. (1975) would show that Mermithids are the commonest nematode parasites of the Acridoidea apart from the Spiruridea which may also utilize them as intermediate hosts. As far back as 1979, Matanmi encountered and reported on *Mermis sp.* (Nematoda: Mermithidae) as a parasite of the notorious defoliator, *Zonocerus variegatus* (Linnaeus) (Orthoptera : Pyrgomorphidae) (Fig 6). In this study, it was found that parasitization at different locations in Ile-Ife, Akure, Gbongan, Ilesa and Osogbo ranged between zero and 7.58 percent. Although the parasite constituted an important mortality factor for *Z. variegatus,* it was not efficient as a potential biological control tool.

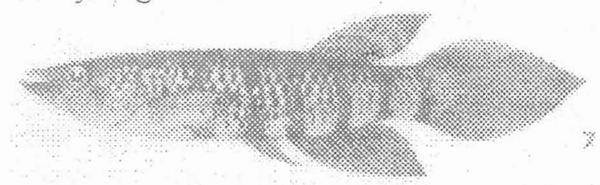


Adult *Z. varigatus* loaded with *Mermis sp.* nematode parasites.

Predators:

There are different kinds of predators viz. Vertebrates e.g. Fish (Fig. 7), Epiplatys sexfasciatus (Cyprinodontidae) which is a very common species throughout West Africa. They bask a lot near the water surface, the body is elongated, and the oblique mouth is suited to exclusive diet of insects and larvae.

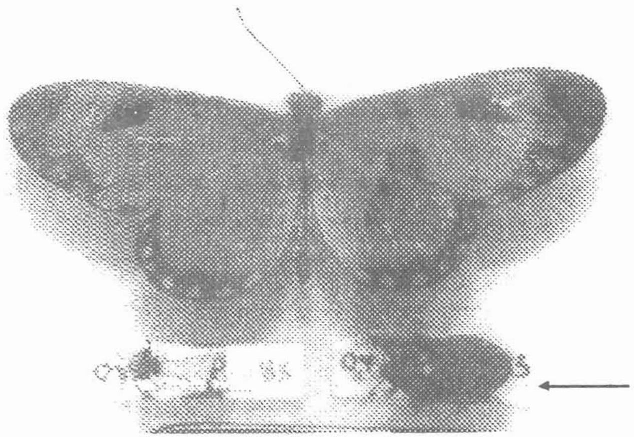
The common names are: toothed carps, top minnows, killifishes, or panchax (Holden and Reed, 1972). Other fishes include *Tillapia zilli,* which is also common and feeds readily on insects and larvae. But it is known to prey on its own young.



Epiplatys sexfasciatus (Cyprinodontidae), toothed carps, or top minnows, are good predators of mosquito- and other larvae.

Predaceous Heteroptera

In an earlier study, Matanmi and Hassan (1987) reported on *Afrius figuratus* (Germar) (Heteroptera ,Pentatomidae), *Rhinocoris bicolor* (Fabricius) and *Rhinocoris sp.* (Heteroptera, Reduviidae) as predators of *A. eponina.* These predators, by means of their powerful sucking mouthparts called "beak" suck body fluids from their prey larvae while the latter are suspended in the air (Fig. 8).



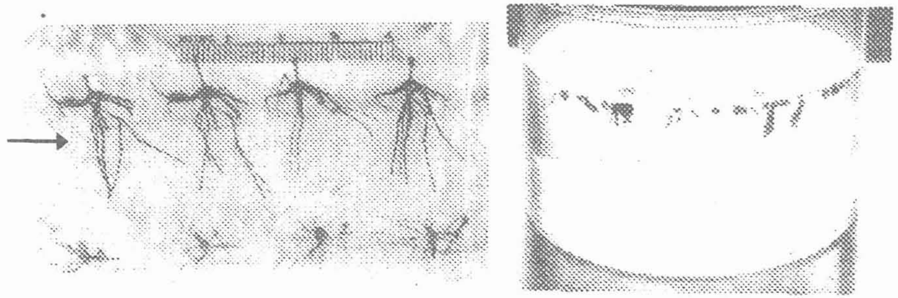
Afrius figuratus (Pentatomidae) preys upon larvae of *Acraea eponina*

The intimate association between predators and their prey or parasitoids and their hosts means that population density changes in one group may well effect complementary changes in the other group. It is believed that pest population suppression may be accomplished by somehow increasing the numbers or effectiveness of the natural or introduced enemies associated with it.

Predaceous Mosquitoes

The large mosquito, *Toxorynchites brevipalpis conradti* is rather spectacular. The adults are non-bloodsuckers, but the larvae are powerful predators of other mosquito larvae and pupae such as *Culex (Lutzia) tigripes* which is itself another predator of other mosquito larvae, and other container-breeding mosquitoes. In our study of 1989 at Ife, Matanmi found *T. brevipalpis* (Fig. 9) to exhibit a compulsive cannibalistic behaviour in laboratory colonies. Cannibalism rarely occurred in nature, but is thought to have an advantage for species survival in the absence of alternate food.

Predaceous mosquitoes had been used successfully against container-breeding mosquitoes in different parts of the world.



The giant mosquito, Toxorhychites brevipalpis, as larvae, are effective predators of mosquito larvae

Predaceous Beetles

Our studies at Ife and also in the Western Cape Province of South Africa showed that *Carcinops troglodytes* and *Hister sp.* were effective predators of eggs and early instar maggots of flies in the poutry manure Matanmi and Giliomee (1998).

Pathogens

Fungi

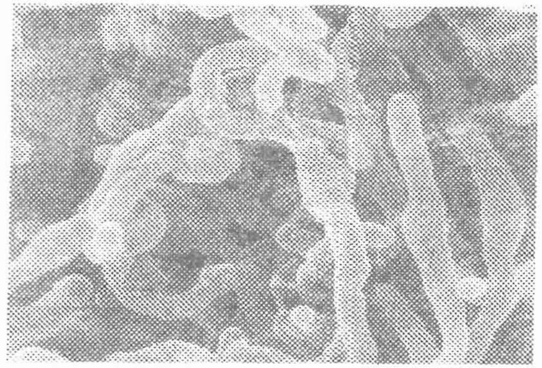
Fungi are eukaryotic, non-vascular, heterotrophs lacking plastids and photosynthetic pigments. Many fungi are parasites of domestic animals and insects, plants, humans, while others are chiefly saprophytes. Fungi usually possess filamentous vegetative structures which may be amoeboid, or unicellular and typically consist of many fine, thread-like hyphae collectively referred to as a mycelium.

Entomopathogenic fungi, bacteria, protozoa, viruses, etc. have formed the subject of extensive research investigations. The use of fungi in pest management has a number of merits viz:

1. Their cosmopolitan distribution and the fact that they induce natural epizootics amongst several orders of insects.
2. The method is ecologically sound, sustainable, and compatible with Integrated Pest Management.
3. They are generally safe in terms of human or mammalian pathogenicity.
4. Ingestion of spores by the host is not a prerequisite for infection.
5. The method is amenable to cottage industrial production; local production is relatively easy and needs relatively low investment.

The fungi that infect insects are the oldest of the recognized insect pathogens. Agotino Bassi (1835) established the germ theory of disease with a fungal disease of silkworms, having submitted his thesis to the University of Pavia in Italy in the year 1834. That was 30 years before Louis Pasteur provided other supporting evidence with a protozoan parasite of the same insect. The value of fungal pathogens of insects as population regulatory agents is most evident in naturally-occurring epizootics which could sometimes be impressive and conspicuous. As far back as 1974, I reported on my isolates of *Entomophthora virulenta Hall and Dunn* and *Conidiobolus coronatus* (Constantin) Batko obtained from naturally-occurring epizootics in Wisconsin, U.S.A. That research verified the occurrence of these entomogenous fungi in Wisconsin, and constituted the first record of the fungi from adult cabbage and seed-corn maggots. The fungi formed the subject of my Ph.D. thesis which included Scanning Electron Microscopy that highlighted the surface fine details of the conidia and resting spores and justified the removal of *C. coronatus* from the

genus *Entomophthora*. Other fungal isolates have since been recorded and reported upon at Ile-Ife including *Entomophthora apiculata* (Thaxter) Gustafs from Calypterate flies, and *Entomophthora gryll* Fres. from *Z. variegatus*. (Matanmi, 1979, 1980). These two isolates have also been re-named *Batkoa apiculata* (Thaxter) Humber. Nov. and *Entomophaga grylli* (Fres) Batko respectively following subsequent taxonomic reviews (Figs. 10 and 11). On the basis of cultural and other desirable properties, a promising mycopesticide against grasshoppers is now *Metarhizium flavoviride*, while *Metarhizium anisopliae* is known to pose quite some promise for subterranean termites (Hall, R. 1992, Zoberi, 1995). *Beauveria bassiana* is still recognized as one of the most widely occurring entomogenous fungi. In our laboratory at Ife, it had been isolated from Lepidopterous larvae, Diptera, Coleoptera etc. (Matanmi, Unpublished data).



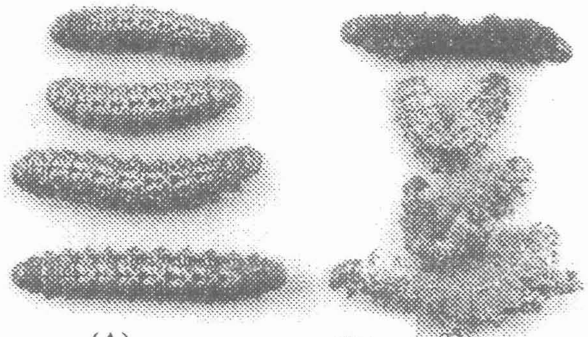
Scanning Electron Micrograph of *Batkoa apiculata* (Thaxter) Humber, nov. fungus, a pathogen of Calypterate flies

The principal target insect groups for entomopathogenic fungi are Culicidae (mosquitoes), Aphidae (aphids), Delphacidae (planthoppers), Cicadellidae (leafhoppers) , Cercopidae (spittlebugs), Aleyrodidae (whiteflies), Coccoidae (scales), Thysanoptera (thrips), Coleoptera (beetles), and

Lepidoptera (caterpillars) (Roberts and Humber, 1984) . It is probably worthy of note that during September of 1976, immediately after the First International Colloquium on Invertebrate Pathology at the Queen's University, Kingston, Ontario, Canada, the following eleven people from six countries participated in the first ever World Entomophthora Foray : Dr. Irena Majchrowicz, Poland; Professor G. Remaudiere, France; Dr. Donald M. MaCleod, Canada; Dr. G.Latteur, Belgium; Dr. Neil Wilding, England; Dr. Jean P. Latge, France; Dr. Babajide A. Matanmi, Nigeria;

Dr. Richard A. Humber, U.S.A.; Dr. Gary G. Newman, Brazil (USAID);

Dr. Richard S. Soper, U.S.A.; and Dr. Jacqueline Pelsneer – Coremans , Belgium. The group surveyed parts of Maine, New Hampshire, Massachussetts, Pennsylvania, etc., areas where legendary Professor Roland Thaxter of Harvard had made his original fungal collections on which he based the classic of 1888 on the Entomophthoraceous Fungi. Several Entomophthoraceous fungi were then collected. The group visited the tombstone of Professor Thaxter at Kittery Point, Maine.



(A) (B)

Gonimbrasia sp. (Saturnidae) infected by *Metarhizium sp.* fungus

Bacteria

Bacteria are minute (0.2-5 um), unicellular plantlike, organisms which differ mainly from higher plants in that they lack chlorophyll and do not contain organelles. They may be classified according to shape into four main groups: Bacilli, Cocci, Spirilla and Actinomycetes, branched organisms. In general, insects infected with bacteria exhibit decreased mobility, loss of appetite, and oral –rectal discharges. Usually, the bacterium invades the bogy cavity of the insect, multiplies, and then invades other tissues causing a septicemia (Cantwell, 1974). A microbial insecticide, (Sporeine), based on *Bacillus thuringiensis* (BT) was first commercialized in France in 1938. Today, BT is the most widely used microbial control agent. According to Agrow estimates, worldwide sales of biopesticides based on BT have been growing at an annual compounded rate of about 20 percent over the past several years and now exceed US $ 125 million. Other biopesticides account for less than US $10 million.

Bacillus thuringiensis (BT) is a well known biological (= biorational) pesticide, with its best qualities being its safety and ease of application, inexpensive cost of overall production due to facilitated registration, and effectiveness on key insect pests. Of great importance is the fact that it is very amenable to improvement through Genetic Engineering , which is expected to boost its potential market share. Since its discovery, BT has received considerable attention in the research community. Ecogen has been focusing its efforts on the genetic engineering of BT (Walters, 1994).

The mode of action of BT is through an internal crystalline protein , which, when ingested by a susceptible insect, solubilizes in the gut, causes a swelling and rupturing of the mid-gut epithelial cells, and the host itself quickly stops feeding and dies of starvation and disrupted haemolymph conditions. The disruption of the mid-gut epithelium also allows passage of BT spores into the haemolymph which may contribute to toxicity by septicemia.

Dulmage *et al.* (1981) demonstrated that BT strains active against lepidopteran larvae differ considerably in potency and insecticidal spectra. Goldberg and Margalit (1977) discovered BT strains that were potent in Diptera. Thus BT has been efficacious in *Simulium* (Blackfly) control. Lutwama and Matanmi (1988) found BT subsp. *Kurstaki* formulated as Dipel and Thuricide to be effective at the rate of 0.5 and 1.0 Kg/ ha for the control of *Helicoverpa armigera* and other lepidopterous larvae on tomato in South-Western Nigeria. It was also found to be compatible with a virus formulation and adjuvants in the spray tank.

We have also had field and laboratory experience with BT in the control of mosquitoes.

Matanmi *et al.* (1990) demonstrated the recycling potential of *Bacillus sphaericus*, a mosquitocidal bacterium, in dairy wastewater lagoons at Kasbergen Dairy, Mira Loma, California. Spores could be recovered in surface water after reflooding. The insecticidal activity of the formulations remained high from 3 days (BSP-2 at 4.48 kg/ha to 2 weeks (ABG-6184) at 2.24 kg/ha).

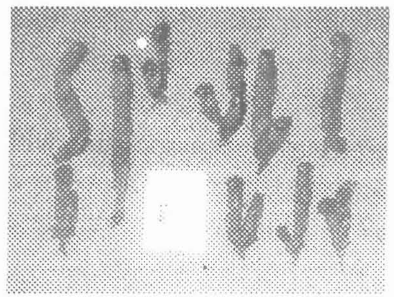
As far back as 1977, the lecturer was appointed on the First Scientific Working Group for the Biological Control of Vectors of Disease at the instance of World Health Organization. At the maiden meeting in Geneva, he was elected as Honorary Vice- Chairman. Thereafter he participated in collaborative studies and bioassays even under stiff operational difficulties back home.

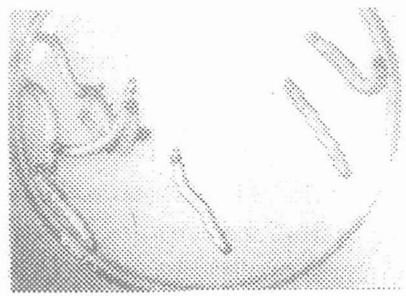
Viruses

The study of virus diseases of insects began with the investigation of the diseases of the commercial silkworm, *Bombyx mori*, and the honey bee,

Apis mellifera. The viruses pathogenic for insects are classified according to the criteria established for other animal viruses. The viruses containing DNA as the Nucleic Acid include the Occluded viruses, Nuclear Polyhedrosis, Granulosis and Entomopox viruses.

The nonoccluded viruses include the Iridescent and Densonucleosis viruses. Infected larvae are typically suspended from tree bark, or hung from the foliage or petioles by the prolegs or terminal segments after succumbing to a nuclear polyhedral virus infection. The larva becomes flaccid, the body contents liquefy, and the integument becomes extremely fragile. Thus any slight touch causes a rupture of the cadaver and dissemination of polyhedra-laden fluids. The larva may turn brown and then black. Some larvae are known to shrivel and dry up. During our investigation of *Epicerura pulverulenta*, , a Notodontid defoliator of Indian Almond, (*Terminalia catappa* L.) virosis of the larvae was recorded (Fig.12) .





Virus-infected , dead, and heathly larvae of *Epicerura pulverulenta*

A large variety of entomopathogenic viruses representing over 20 groups are reported from insects (Lacey and Goettel, 1995). The CPVs are reported from 4 insect orders, mostly from Lepidoptera and Diptera. Over six hundred insect species , including Lepidoptera, Hymenoptera, Coleoptera, Diptera and species from several other insect orders have been reported infected by viruses in the Baculoviridae. The baculovirus virion consists of an enveloped rod shaped nucleocapsid containing circular , supercoiled double-stranded DNA. Lutwama and Matanmi (1988) applied *Baculovirus heliothis* formulated as Elcar , to suppress *Helicoverpa armigera* (Hubner) (Noctuidae and other lepidopterous larvae on tomato in Ile-Ife. Elcar was applied at the rates of 1.0 Kg/ha, 0.5 Kg/ha, and 0.25 Kg/ha alone or in combination with BT or other adjuvants. The results showed that under the field conditions of the experiment, there was no benefit derived from combining BT with the virus . Also, there was no significant reduction in infestation and damage of *H. armigera* larvae when either Elcar or BT was applied with the adjuvant, Gustol or alone. A recent breakthrough has been the discovery that certain optical brighteners, in addition to providing protection from UV light, significantly enhance the activity of NPVs. It has been speculated that the brighteners facilitate virus infection (Lacey and Goettel, 1995).

Reminiscence

Mr. Vice-Chancellor, Sir, since I entered into close association with the Department of Plant Science of this University, I had gained a lot of spiritual insight from *Zechariah 4 : 10 a (AMP)* : "Who (with reason) despises the day of small things?".

Even without trying to be immodest, I would say that I have contributed my own bit towards the development of an exemplary academic unit. I have consistently worked with others to fulfill the mission of the Department and pursue the common goal, excellence. I have taught a number of courses at the undergraduate as well as postgraduate levels, and developed, from scratch, two postgraduate courses: "The Biological Control of Insect Pests", and "Insect Pathology". It is a matter of record

that, throughout Black Africa, the two courses had not been offered hitherto at that level. In the distant past we had, for some years, accommodated on our Departmental Programme, the teaching of "Medical Entomology" to some students from the Faculty of Health Sciences. Through inter-institutional research collaboration, study leave, or sabbatical placement, we had tried to place the Department on a world map, and get connected with the best anywhere. We had always believed in the concept of meaningful marriage between "the town" and "gown" , as well as mutually-beneficial partnership between the University and Industry.

Some Food For Thought

Mr. Vice-Chancellor, Sir, undoubtedly, the role of natural enemies in the management of pest populations in agriculture and forestry, and the abatement of insect vectors of medical and veterinary importance have expanded considerably with the discovery of new agents or the improvement of old agents or their formulation and delivery . The need exists for some sober reflections.

The integrated pest management (IPM) strategy, in which natural enemies (parasites / parasitoids, predators and pathogens) of pest arthropods and other alternative measures play significant roles in crop protection and animal /public health, is one aspect of sustainable agriculture and environmental sanitation that attempts to minimize negative environmental impact and other deleterious effects on the national landscape.

Since the successful control of the cottony-cushion scale, *Icerya purchasi* Maskell, in California with the imported vedalia beetle, *Rodolia cardinalis* (Mulsant), from Australia in 1888, hundreds of attempts at classical biological control have taken place throughout the world. For over a century, scientists from industrialized countries as well as from developing countries have appropriated natural enemies from different parts of the world. Up to 1981, developing countries donated 353 species of natural enemies to the industrialized countries, whereas the developing countries only received 263 natural enemy species from the industrialized countries. According to Altieri (1991), Western Europe, Africa, Asia, and Latin America stand out as net contributors. There has been strikingly little exchange between developing countries. There is also the issue of political economy of classical biological control. By and large, the costs and benefits of biological control have traditionally been analyzed using biological criteria ; economic criteria were seldom used. Owing to such a political-economy approach, it would appear that biological control programmes judged "agronomically successful" may not be so in social terms. Hitherto , biological control has been evaluated on whether it resulted in economic control , higher crop yields or environmental benefits. Rarely has it been evaluated on whether it meets the needs of the rural poor, or in terms of social justice and equity, in resource and benefit distribution. Another dimension to the problem is that : with the emergence of biotechnology, potential inequalities are likely to arise. As interest in genetically-engineered biological control agents increases, it is not unlikely that developing countries will be caught in purchasing "patented natural enemies" at a high cost.

I align myself with the sentiment of Altieri that developing countries should recognize that natural enemies (including plant genetic resources and biocontrol agents) contained within their boundaries constitute their national property, for which they should be compensated in the event of exchange of biological control agents.

On that note, Mr. Vice-Chancellor, Distinguished Guests, and Members of the University Community, I thank you sincerely for your patience and support.

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