



DOCTOR OF PHILOSOPHY (PhD) IN ENTOMOLOGY

INTRODUCTION AND RATIONAL

The African Regional Postgraduate Programme in Insect Science (ARPPIS) West African Sub-regional Programme was initiated on the recommendation of the Academic Board of ARPPIS based at the International Centre of Insect Physiology and Ecology (ICIPE) in Nairobi, Kenya. ARPPIS is a collaborative network project involving, ICIPE Kenya, some African universities as well as donor agencies for the training of Insect Scientists (capacity building) to solve Africa's numerous insect pest problems.

At the University of Ghana, Legon, the programme is administered as an inter-school course between the Schools of Agriculture and Biological Science both of the new College of Basic and Applied Sciences (CBAS), with the departments of Crop Science and Animal Biology and Conservation Science as the collaborating departments.

The Insect Science Programme at the University of Ghana has for the past twenty years provided a platform for the training of entomologists at the masters Degree level not only for the West African Regional Centre but some non West African Countries as well.

The ARPPIS Centre has come of age after 20 years and is now in a position to offer a PhD in Entomology/ Insect Science. The Centre will however continue to collaborate with ICIPE drawing on the pool of scientists at ICIPE for logistic support, teaching and thesis research supervision.

The programme draws its strengths from several sources including a teaching and research faculty of some 17 full and part time professional entomologists, chemical ecologists, toxicologists, geneticists, agronomists and animal scientists as well as some 20 other entomologists and researchers from partner institutions and other national institutes and agencies; and a full range of laboratory and field equipment for teaching and research.

ENTRY REQUIREMENT

An MPhil degree in Entomology or related fields and candidates must have taken a basic course in Entomology in their previous postgraduate studies.

DURATION OF PROGRAMME

The PhD. Entomology programme is a four year programme embodying course work in the first year plus one year of experiential learning and two years of extensive research relating to thesis on an approved topic.

Year 1 - In the first year, a number of core and elective courses plus a series of seminars will be taken by students.

Year 2 - Students will be attached to an institution, an external project or a department project for experiential research learning.

Years 3&4 will be devoted to research, seminar presentations, thesis writing, and submission.

REQUIREMENTS FOR GRADUATION

Course Work: (Year 1): 18-24 credits

Seminar1, Seminar 11 Seminar 111 & Seminar IV (Years 2, 3 & 4): 12 credits

Thesis: 45 credits

Total: 75-81credits

STRUCTURE OF PROGRAMME

Year 1 - COURSE WORK

Semester 1

CORE COURSES

| COURSE CODE | COURSE TITLE | CREDITS |
|--------------------|------------------------------------|----------------|
| FASC 701 | Science and Society | 3 |
| ENTO 701 | Advances in Entomological Research | 3 |
| TOTAL | | 6 |

Students with no background in Insect Systematics will have to take ENTO 601

ELECTIVES COURSES

| COURSE CODE | COURSE TITLE | CREDITS |
|--------------------|---|----------------|
| FASC 700 | Special Topics in Science | 3 |
| ENTO 703 | Commercial Insects | 3 |
| ENTO 705 | Urban Entomology | 3 |
| ENTO 707 | Behavioural and Chemical Ecology of Insects | 3 |
| ENTO 709 | Insect Disease Vector Management | 3 |
| ENTO 711 | Chemical Control of Plant Pests | 3 |
| TOTAL | | 18 |

(Students are to select a minimum of 3 credits and a Maximum of 6 credits)

Semester 2

CORE COURSES

| COURSE CODE | COURSE TITLE | CREDITS |
|--------------------|---------------------------------------|----------------|
| FASC 702 | Advanced Qualitative Research Methods | 3 |
| ENTO 702 | Insects and the Environment | 3 |
| Total | | 6 |

ELECTIVE COURSES

| COURSE CODE | COURSE TITLE | CREDITS |
|--------------------|---|----------------|
| ENTO 704 | Forest Entomology | 3 |
| ENTO 706 | Aquatic Insect Ecology and Conservation | 3 |
| ENTO 708 | Biology of Haematophagous Insects | 3 |
| ENTO 712 | Insect Molecular Biology and Immunology | 3 |
| FASC 710 | Teaching Science at the Tertiary Level | 3 |
| Total | | 15 |

(Students are to select a minimum of 6 credits and a Maximum of 9 credits)

Year 2 – INTERNSHIP/EXPERIENTIAL LEARNING

| COURSE CODE | COURSE TITLE | CREDITS |
|-------------|--|---------|
| ENTO 700 | Thesis | 45 |
| ENTO 710 | Seminar 1 (Research Proposal) | 3 |
| ENTO 720 | Seminar II (Experiential Learning Seminar) | 3 |

Years 3&4 – THESIS RESEARCH

| COURSE CODE | COURSE TITLE | CREDITS |
|-------------|---------------------------------|---------|
| ENTO 730 | Seminar III (Progress Report 1) | 3 |
| ENTO 740 | Seminar IV (Final Results) | 3 |

COURSE DESCRIPTIONS

FASC 700: SPECIAL TOPICS IN SCIENCE

3 Credits

The course examines historical and contemporary issues in science, relating to the student's area of specialization and relevance. Such topics are expected to challenge the students into exploring current and relevant research trends/discoveries in scientific approaches. The course will enable students explore scientific knowledge in modern science, and add on to their depth of information in their chosen areas of specialty. It is expected that, the course will compliment other courses on the PhD flagship of the various departments in the Sciences and elsewhere. Additionally, it will expose students to current trends of presentations, and foster stronger confidence-building attitude that will enable enhanced international academic competitive spirit.

FASC 701: SCIENCE AND SOCIETY

3 Credits

This course will enable students gain insights in the practice of science as a discipline including major scientific concepts like inductivism are examined as well as the history of science and science itself, an overview of current approaches to research and an understanding of research partnerships, networks and appropriate methods of communicating science depending on audience.

The aim of the course is to help students to fit their research to relevant trends and directions for national development. Course content will cover topics such as the basis for the scientific method; conceptual frameworks; the philosophy of science; ethics in research; pure versus

applied science debates; approaches to research; science for development and the merit of broader impact criteria; north south/south south collaboration and partnerships; research networks; communicating science to the policy make, lay audience and to media.

FASC 702: ADVANCED QUANTITATIVE RESEARCH METHODS **3 Credits**

The course will serve as a step up for students who need to add up to their knowledge in quantitative methods of research techniques and analyses. Topics to be covered include: Sampling distributions and hypothesis testing. Sample size determination. Categorical data and chi-square, Non parametric tests. Principles of Design of Experiments. Analysis of variance and its assumptions.

Experiments with single and multiple factors. Orthogonal and multiple Comparisons. Completely Randomized, Randomized Complete Block, repeated measures, cross over and Latin square designs. Nested designs. Fixed, random and mixed effects models. Factorial designs. Confounding. Fractional factorial designs. Split plot designs. Incomplete block designs. Analysis of covariance. Regression models: basic concepts; Regression Model Diagnostics. Categorical data analysis. Logistic regression, univariate and multivariate. Confounding and collinearity in logistic regression. Model selection in logistic regression.

FASC 710: TEACHING SCIENCE AT THE TERTIARY LEVEL **3 Credits**

It is anticipated that many of the students who go through the PhD programme in the Sciences may nurse special interest in teaching and academia. Focusing on group discussions, this course is expected to equip students with the requisite knowledge in overall management of students at the tertiary level. The course will focus on teaching the methodologies and techniques in handling Science-teaching at the undergraduate level. Topics such as laboratory supervision and safety, grading issues, special needs students, lecturing and tutoring techniques, examination preparation, teacher/student relationship, tertiary education management, will be discussed through reading, class/group discussions as well as presentations.

ENTO 701: ADVANCES IN ENTOMOLOGICAL RESEARCH **3 Credits**

This course will focus on new approaches and advancement in entomological research. Topics will cover the latest research developments ranging from molecular biology to applied pest management. This course is intended to cover a range of aspects of modern entomology, including emerging pest management technologies, insect-plant interactions and insecticide

toxicology, to emerging technologies in pest management; functional ecology (advances in molecular ecology), behaviour and ecology (the responses of insects to global warming), molecular biology (use in evolution to trace evolutionary history), emerging pest management strategies and technologies, Pesticide toxicology and insecticide resistance management, forensic entomology. Entomophagy (insects as food and feed), entomopathogens (the use of pathogens as a management option), extension services (setting up insect diagnostic labs, insect ID database, radio farms).

ENTO 702: INSECTS AND THE ENVIRONMENT**3 Credits**

This course will focus on the role insects play in the environment and how insects live in their environments. It is intended to enable students understand how insects help the environment; insect behavior and role in the environment; importance of insects in environmental impact assessment; environmental benefits of insects as food and feed; contributions of insects to food security, livelihoods and the environment; harmful insects and the environment; social insects and the environment; climate change and its role in insect distribution in the environment; adaptation of insects to different environments; adaptation of insects to environmental change, seasonal adaptation of insects; ecological and environmental physiology of insects; insects as bioindicators of environmental change.

ENTO 703: COMMERCIAL INSECTS**3 Credits**

This course will equip students with the requisite knowledge and skills needed to establish and manage beekeeping (apiculture) and silk farming (sericulture) enterprises as alternative income generation options. Topics to be treated include: Introduction to sericulture, silkworm seed technology, silkworm pathology, biology, breeding and agronomy of mulberry plant, cultivation and management of food plants and other host plants of wild silkworms, postharvest technology of silk, sericulture development, economics of sericulture, Fundamental aspects of bee keeping and rearing, beekeeping equipment and apiary management, bee forage plants, bee pests, predators, diseases and their control, bee products and their marketing.

ENTO 704: FOREST ENTOMOLOGY**3 Credits**

This course deals with the forest types in Ghana, General description of the major groups of forest insects pests: Defoliators and woodborers of living plants, Life history, damage and management of serious pests of living plants, Special reference to pests of commercial and economic plants, Pests of flowers, fruits and seeds of high value tree species and exotic plants,

Biology and management of pests of logs, lumber and other forest products. Detailed treatment of the biology and management of termites in forest ecosystems: nutrient cycling, water penetration, soil aeration, soil formation and profile management.

ENTO 705: URBAN ENTOMOLOGY**3 Credits**

The various groups of urban insect pests will be looked at considering their identification, description, biology, damage symptoms and management practices. Insect pests of humans, in and around buildings, insect pest problem associated with urbanization and in recreational and food vending areas, pests of stored food products, fabrics, paper, pets, house plants will be focused on. Nuisance pests on ornamentals, pests of urban agricultural systems and miscellaneous pests associated with the urban environment. Damage symptoms, biology and management of urban insect pests. The role of the pest control operator in the community.

ENTO 706: AQUATIC INSECT ECOLOGY AND CONSERVATION**3 Credits**

The biology and ecology of aquatic invertebrates and their use in monitoring environmental conditions in aquatic habitats will be the focus of this course. Topics to be treated include: Identification and classification of major groups of aquatic insects, ecology and biology, food habits, role in food chains, description of the physical and chemical characteristics of aquatic habitats, adaptations that enable aquatic insects occupy different aquatic habitats, techniques involved in aquatic insect sampling, water chemistry, environmental toxicology, the use of aquatic insects as bio-monitors for quality of aquatic habitat, environmental impact and risk assessment.

ENTO 707: BEHAVIOURAL AND CHEMICAL ECOLOGY OF INSECTS**3 Credits**

A broad overview of how insect behaviour is modulated by chemicals and the mechanisms involved in insect host interactions will be addressed by this course. It is intended to enable students understand and explain insect behaviour based on function, evolution, causation and development. Emphasis will be placed on discussions on: Insect behaviour and communication using tactile, acoustic, visual and chemicals and also mimicry and migration. Demonstration of how insects use various types of semiochemicals to aid in their feeding and mate finding behaviours; principles and dynamics of insect olfaction, insect-host interactions, chemistry and application of novel insect control techniques and chemical ecology studies.

ENTO 708: BIOLOGY OF HAEMATOPHAGOUS INSECTS**3 Credits**

This course is designed to enable students appreciate the diversity, evolution and importance of insect haematophagy to disease transmission and the utilization of such knowledge in the development of novel vector-borne disease control tools. The main topics Include: General introduction to haematophagous insect groups and their medical importance. Evolution of haematophagous behaviour. Feeding preferences in haematophagous insects; host choice and species complexes. Host location. Ingestion of the blood meal. Blood meal management. Vertebrate host–insect interactions. Transmission of parasites by blood-sucking insects.

ENTO 709: INSECT DISEASE VECTOR MANAGEMENT**3 Credits**

This course is aimed at equipping students with the requisite knowledge and skills in vector management towards the control of vector-borne diseases. They will be exposed to be laboratory and field Identification techniques for medically important disease vectors. Disease vectors incrimination techniques. Estimation of disease transmission parameters. Sampling strategies for vectors.

Development and management of insecticide resistance. Determination of insecticide susceptibility or resistance levels. Vector control strategies. Principle and role of integrated vector management strategies in control of vector borne diseases.

CROP 711: CHEMICAL CONTROL OF PLANT PESTS**3 Credits**

Students will be taught techniques for safe and effective application of pesticides for plant pest control. Topics will include: the National Pesticide regulatory programme (Ghana)- registration , enforcement); Types of pesticides approved for Ghana; Pesticide properties, storage and sale of pesticides, disposal and decontamination of pesticides; types of spraying equipment; Types and selection of nozzles; Calibration of sprayers and calculations involved in the application of pesticides; safety in the use of pesticides.

ENTO 712: INSECT MOLECULAR BIOLOGY AND IMMUNOLOGY**3 Credits**

This course is designed to allow students comprehend the potential insect molecular biology holds in the development of innovative ways of managing vector-borne diseases and enable them to employ the knowledge and skills gained in planning and developing efficient control of

medically important diseases. Topics to be discussed include: Introductory microbiology: DNA and other nucleic acid replication, Proteins and protein synthesis, Regulation of gene expressions. Insect genomics: Genome sequencing and analysis, Proteomics and structural genomics, Metabolomic and systems biology. Molecular mechanisms and biological role of micro-RNAs. Molecular modification of insects. Insect immunology; Basic concepts and development of innate immunity.

ENTO 710 SEMINAR I **3 Credits**

Each student will present a formal research proposal seminar in the first semester of the second year of the programme. This will include justification or relevance of the study including objectives and methodology.

ENTO 720 SEMINAR II **3 Credits**

Students are required to give a seminar and submit a report to the department in the second semester of the second year. The seminar would be based on experiential research learning by attachment of the student to a departmental or external project. Invitation is to the general University community. Also as a mini project, students will also be required to collect one hundred different species of insects from at least ten different families of ten insect orders. Students will be required to make a presentation on the different species collected.

ENTO 730 SEMINAR III **3 Credits**

In the third year, each student will present a progress report on his/her research to the department. The University community will be invited.

ENTO 740 SEMINAR IV **3 Credits**

This will be a presentation of the final results of the research in the fourth year before the thesis is finally presented to the University. Invitation is open to all.

YEAR 2: EXPERIENCIAL LEARNING

PROJECTS TO WHICH STUDENTS WILL BE ATTACHED FOR EXPERIENCIAL LEARNING

There are several on-going projects at the Centre being run by local experts with international collaborators to which students will be attached. Students will also be attached to institutions and

organizations working on various aspects of insect science. This aims to give students the opportunity to learn outside of the classroom to gain hands-on experience in organizations which are involved in the application of various aspects insect science.

PROJECT 1

INTEGRATED MANAGEMENT OF *PLUTELLA XYLOSTELLA* AND *LEUCINODES ORBONALIS* ON VEGETABLES IN THE VOLTA REGION

Prof. Kwame Afreh-Nuamah & Prof. Ebenezer O. Owusu

This is a collaboration between the Council for Scientific and Industrial Research-Plant Genetic Resources Research Institute (CSIR-PGRRI), Bunso, and ARPPIS.

Project Description: The 3-year project seeks to develop an integrated pest management (IPM) strategy consisting of the use of healthy seedling production practices, use of pest tolerant cabbage and garden eggs cultivars, sex pheromone trapping of adult male moths for pest population monitoring, prompt removal and destruction of DBM damaged plants (cabbage), and *L. orbonalis* damaged shoots and fruits (eggplant) at regular intervals, and withholding of broad spectrum pesticide use in favour of biorational pesticides such as *Bacillus thuringiensis* to allow for the proliferation of local parasitoids for enhanced pest population suppression on cabbage and garden eggs in the Volta region.

PROJECT 2

PROMOTION OF NEEM-DERIVED PESTICIDES IN WEST AFRICA

Prof Daniel Obeng Ofori & Prof. Kwame Afreh Nuamah

This is a collaboration between UNIDO Centre for South-South Industrial cooperation (UCSSIC), India, and Regional Network for Pesticides in Asia and the Pacific (REMPAP), India, Ministry of Food and Agriculture of Ghana (MoFA), Leventis Foundation Farmers' Training Programme, Institute of Agricultural Research, UG, Legon, Livestock and Poultry Research Centre (LIPREC), Legon, Forest and Horticultural Research Centre (FOHCREC), Kade and Soil and Irrigation Research Centre (SIREC), Kpong.

Project Description: This is a three year programme aimed at promoting the use and development of eco-friendly and cost-effective pesticide derived from neem kernels in three countries of West Africa-Ghana, Nigeria and Sierra Leone.

This would be achieved through neem-shed area development, transfer of appropriate technology, South-South institutional linkages, skill enhancement and training at the village level for rural development, agric-business and micro-industries promotion, poverty alleviation and employment generation, while at the same time strengthening environmental protection and elimination of health

hazards by providing a low-cost bio-efficient alternative to toxic POPs and non-biodegradable chemical pesticides, and supporting organic food production. The project also aims at eventually establishing a regional network on pesticides in West Africa of initially three countries (namely Ghana, Nigeria and Sierra Leone), modelled on and linked to RENPAP.

PROJECT 3

DEVELOPMENT OF COMMUNICATION STRATEGIES FOR THE MANAGEMENT OF FRUIT FLIES IN GHANA.

Professor Kwame Afreh-Nuamah & Dr Maxwell Billah

This is a collaboration between the National Fruitfly Management Committee, Plant Protection and Regulatory Services Division of MoFA and ARPPIS, UG, Legon

Project Description: Fruit and vegetable cultivation is one of the fastest growing agricultural sectors in Ghana. This sector presents many opportunities for rural economies and improved livelihoods for smallholder farmers. Production of these crops is constrained with several factors notably among them is the attack by insect pests, but none has gained greater attention than the fruit flies. The devastation caused by these pests' results in the loss of fruits and vegetables for export markets or in trade disruption

This is a three year project that seeks to empower fruit and vegetable growers with adequate skills and knowledge in fruit fly management to ensure the production of acceptable quality produce which will enhance their competitiveness in both export and domestic markets. This will also build capacity of Agricultural Extension Agents (AEAs) and other stakeholders in the horticultural industry in relation to the management strategies that are environmentally sound and economically viable. Indiscriminate use of chemical pesticides for the management of fruit flies will be put in their perspective so that Maximum Residue Levels (MRLs) are adhered to.

PROJECT 4

PLANT HEALTH DIVISION OF ICIPE

icipe's mission is to help alleviate poverty, ensure food security and improve the overall health status of peoples of the tropics by developing and extending management tools and strategies for harmful and useful arthropods, while preserving the natural resource base through research and capacity building.

The work of *icipe* in plant health contributes to improving sustainable food security and environmental health through developing IPM options for pre- and post-harvest pests, and for parasitic weeds (such as striga). All technology development involves farmer participation to ensure farmers' needs are met. The agenda of plant health research covers four domains: **Staple Food Crop Pests**, which is covered by the *Habitat Management (HM)* and the *Noctuid Stemborers Biodiversity* (in collaboration with the Institut de recherche pour le développement) programmes; **Horticultural Crop Pests**, which is dealt with by the *Fruit Fly, Leafminer, Thrips* and *Red Spider Mites* research programmes; **Locusts and Other Pests**, which deals with African and Malagasy migratory locusts and the armyworm; and the **IPM in Legumes** research.

Further activities at *icipe* plant health analyse the economic impact of the developed technologies and assess factors associated with their success or failure. Finally, the economic impact of good agricultural practices and international standards on export crop production is assessed as well as the dynamics in farmer training and technology transfer

PROJECT 5

ENHANCING VEGETABLE PRODUCTIVITY IN THE ACCRA PLAINS THROUGH INTEGRATED CROP MANAGEMENT

Dr. Ken Okwae Fening & Prof. Kwame Afreh-Nuamah,

Funded by the University of Ghana Research Fund (UGRF) and managed by Office of Research, Innovation & Development (ORID)

This is a collaboration between the University of Ghana and Agricultural Extension Agents (AEAs), MoFA, and vegetable farmers in the catchment area.

Project description: This is a two year project that seeks to use integrated crop management (ICM) approaches involving the use of different quantities and combinations of organic materials (bio-char from rice and poultry manure) to improve soil physico-chemical properties and nutrient uptake by crops, intercropping cabbage with onion, plus application of botanicals, to manage insect pests and diseases, adopting good agronomic and cultural practices that support vigorous and healthy growth of crop and establishing the cost-effectiveness of the ICM package developed. These on-station trials will be undertaken during the minor and major cropping seasons of 2014/15 and 2015/16 at the Soil and Irrigation Research Centre, Kpong. A survey will also be undertaken during the period to solicit baseline information on vegetable crop production and technologies already utilised by farmers in the Accra plains.

PROJECT 6

SUSTAINABLE FOREST CONSERVATION AND ALTERNATIVE COMMUNITY LIVELIHOODS THROUGH SILK FARMING FOR POVERTY ALLEVIATION IN GHANA.

Dr. Ken Okwae Fenning and Prof. Daniel Obeng-Ofori (UG, Legon); Prof. S.K. Raina and Dr. E. Nguku, (Commercial Insects Programme- African Insect Science for Food and Health, ICIPE, Nairobi, Kenya.)

Initial funding from UGRF- managed by ORID, and Capacity Building and Institutional Development, ICIPE, Nairobi, Kenya.

This is a collaboration between the University of Ghana, Legon, Sericulture Promotion and Development Association, Mampong-Akwapim and Commercial Insects Programme- African Insect Science for Food and Health, ICIPE, Nairobi, Kenya.

Project description: This is a four year project that seeks to develop an innovative package that will invigorate silk farming (both domesticated and wild) in Ghana as a major income generation activity for resource-poor rural communities to fully participate in forest conservation by engaging in silk farming activities in a sustainable manner. The study will be participatory involving all stakeholders (silk farmers, University of Ghana (UG), ARPPIS Students, Sericulture Association of Ghana, Ministry of Food and Agriculture, Forestry Commission, Ministry of Environment, Science and Technology and the CSIR-Industrial Research Institute-IRI and the African Insect Science for Food and Health in Nairobi). Mulberry cultivars from Ghana, Kenya, Egypt, and India will be screened in the field for their effectiveness in terms of their cocoon quality when utilised to feed the silkworms. These cultivars will be fed to improved silkworm, *Bombyx mori* races from Kenya, Egypt, India and Bulgaria to identify the best races based on the local climate. This study will identify the best mulberry cultivars and silkworm races for multiplication in Ghana in order to conserve the silkworms and their host plants which will improve the forest cover in forests zones for livelihoods. The project will aim at eventually establishing a silkworm grainage in Ghana and the post-cocoon processing of silk cocoons into yarns that will be woven into silk fabric. The UG will remain the core research Centre in all these activities in collaboration with all other stakeholders and donors for a common goal. This study will increase the awareness of communities and national institutions of the ecological and economic importance of insects and their forest habitats.

COLLABORATING INSTITUTIONS

The following National/International Institutes/Agencies will collaborate by providing experts to assist in teaching, supervision and examination of students.

- International Centre of Insect Physiology and Ecology (ICIPE), Nairobi, Kenya
- Council for Scientific and Industrial Research (CSIR)
- Oil Palm Research Institute (OPRI), Kusi, Kade
- CSIR- Crop Research Institute (CRI), Kumasi.
- CSIR – Savannah Agricultural Research Institute (SARI), Tamale
- CSIR- Water Research Institute (WRI), Accra
- Biotechnology and Nuclear Agricultural Research Institute (BNARI), Kwabenya, of the Ghana Atomic Energy Commission.
- Cocoa Research Institute of Ghana, (CRIG), Tafo
- Quality Control, COCOBOD, Tema
- Plant Protection and Regulatory Services Directorate (PPRSD) of the Ministry of Food and Agriculture (MoFA).
- University for Development Studies (UDS), Tamale/ Navrongo campuses
- Noguchi Memorial Institute for Medical Research, University of Ghana, Legon
- UNIDO Centre for South-South Industrial cooperation (UCSSIC), India, and Regional Network for Pesticides in Asia and the Pacific (REMPAP), India.
- Forum for Agricultural Research in Africa (FARA)