

PERSONAL PROFILE - FEBRUARY 2013

Name: Canute Pancras Mutebi Khamala, B. Sc. (Liverpool), Ph.D. (Univ. of E. Africa), FRES (Lond.), FKNAS, EBS, PROFESSOR OF ZOOLOGY.
Address: School of Biological Sciences, University of Nairobi
 P. O. Box 30197 – 00100 Nairobi
E-mails: khamala@uonbi.ac.ke & khamala_m@yahoo.com



Joined the University of Nairobi on 1st October 1965, then University College, London University, as Research Assistant with Department of Zoology and rose through the ranks to Professor of Zoology in 1982. Received in 1969 an International Atomic Agency Fellowship tenable at University of Bonn, Department of Zoology, Germany, where I conducted research for four months on the safe use of radio-isotopes for entomological research. 1971 awarded USA State Department Fulbright Fellowship tenable at the Department of Zoology, University of Iowa, USA, where I taught *Invertebrate and Marine Zoology* for a year and conducted a tropical marine biology field course for them at the Florida Keys in Florida USA. Renowned worldwide leader in Medical Entomology through research on the taxonomy and biology of African *Culicoides* (Ceratopogonidae: Diptera) (Fly biting midges) for which I was recognised by the Royal Entomological Society of London by published my works as a separate volume: *Trans.R.ent.Soc.* **123** (1), 1-95, April 1971. Chairman of former Department of Entomology, University of Nairobi 1976, with the late Professor T. R. Odhiambo, developed pioneer syllabi and launched 1st postgraduate taught-course programmes for Master of Science degrees in Medical and Agricultural Entomology. Published over 50 scientific research papers in peer-reviewed journals, Proceedings on entomology and Books. Singularly, as first supervisor, has successfully supervised more than 15 Ph.D. and 45 M.Sc. degrees. Currently retired, but still serving on contract teaching main core courses: *Arthropod Morphology and Classification*, *Management and Control of Arthropod Vectors and Parasites of Human Diseases*, *Principles of Insect Pathology*, *History and Philosophy of Biology and Evolutionary Biology* to both undergraduate and postgraduate students.

Non-academic National service:

Chairman, Kenya Science Teachers College Board of Governors for 12 years

Chairman Board of the National Environment and Management Authority (NEMA) 2003–2006 by Office of the

Founder Member of the International Centre for Insect Physiology and Ecology (ICIPE) to which recently was appointed Member on its Governing Council;

Founder Fellow of the Kenya National Academy of Sciences (KNAS).

Awards: Fellow of the Royal Entomological Society of London

Fellow of the Kenya National Academy of Science

Order of “Elder of the Burning Spear” (EBS) (Presidential Award)

Publications: Titles and Abstracts of Completed Research Programmes

A. RESEARCH PUBLICATIONS (In Peer-reviewed Journals):

1. **1971** Khamala, C.P.M. and Kettle, D.S., “The *Culicoides* Latreille (Diptera: Ceratopogonidae) of East African.” *Tran. Roy. Ento. Soc. Lond.* **123**: 1-95. (My entire Ph.D. Thesis).

Abstract:

An account is given of 61 species of *Culicoides* collected, largely with light traps, in East Africa along a NW - SE transect from the Queen Elizabeth National Park near the Congo border to Mombasa on the Indian Ocean. The taxonomic characters of *Culicoides* are discussed, and the East African species are arranged in 16 species-groups. Twenty-five of these species are described as new, and the hitherto unknown female of *kibatiensis* and the males of *trifascietus*, *expectator*, *brucei*, *quinquelineatus*, *albopunctatus*, and *adersi* are described for the first time. Separate keys for the identification of males and females are included. (In view of the importance of this work, it was accepted and published as a separate issue of the *Transactions of the Royal Entomological Society of London*, **123** (1), pp. 1-95, 417 figs., 1971).

2. **1971** Khamala, C.P.M. “Ecological distribution of East African *Culicoides* as shown by light trap.” *Bull ent. Res.*, **60**: 459-559.

Abstract: Sixty-one *Culicoides* spp. were collected in Kenya, Uganda and Tanzania between January 1966 and December 1967 using light-traps at 35 stations on a NW-SE transect from the Indian Ocean to central Uganda to evaluate the distribution of *Culicoides* spp. among ecological zones. Most species were confined to one or at least very few similar habitats. The largest number of species (30) occurred in the forest zone, probably because of the many suitable breeding sites, whereas only three species were recorded from the dry bushland zone. Forests also contained more exclusive *Culicoides* spp., whereas savanna species showed a wider distribution, suggesting that the forest species are less adaptable than others. The disease vectors *C. grahamii* Aust. and *C. pallidipennis* C, I. & M. were among the most abundant and widely distributed species.

3. **1971** Khamala, C.P.M. and Buschinger, A. “Effect of temperature on food-transmission activity of three ant species as shown by radioactive tracers.” *Zt. angew. Ehto.* **67**:337-342.

Abstract:

Investigations into the effect of temperature and seasonal changes on the food-transmission activities of three ant species (*Formica polyctena* Forst, *Lasius niger* L. and *Myrmica ruginodis* Nyl.) using radioactive P³² were carried out at Bonn, West Germany, between May and July 1969. One donor and fed on radioactive food was given to 20 hungry ones for 30 minutes at 15°, 20° 25° and 30°C at constant humidity. It was observed that in May the three species behaved more or less the same, each being moderately active (see Figure). In June, however, they began to differ greatly with *F. polyctena* being the most active (more than in May) followed by *L. niger* and *M. ruginodis* showing the least activity. This difference between species increased to a considerable magnitude in July with *F. polyctena* showing the greatest activity followed by *L. niger* and *M. ruginodis* being the least active.

4. **1972** Khamala, C. P. M. "The biting flies of the Kano Plains, part II: Larval habitats of common mosquito species." *Bull. Ent. res.* **61**:299-307.

Abstract: The larval habitats of *Culicoides* species were determined by examining a total of 1,476 samples collecting from different ecological environments in various parts of Kenya. Immature stages were collected from suspected breeding habitats and adults were reared. Adults were also captured in emergence traps and then identified. To determine species preferences, if any, the materials yielding *Culicoides* were analyzed for pH, organic matter and water content.

Fifty-seven percent of the sampls yielded a total of 26 species of *Culicoides*. Sites in which *Culicoides* occurred were classified into eleven habitats grouped into four major systems, namely, aquatic, transitional, terrestrial and general systems. Most species were found breeding over a wide pH range in site which were wet at least part of the time. A few species appeared to select breeding habitats with a high organic matter content.

5. **1972** Khamala, C. P. M., Ecology of *Echinometra mathaei* (Echinoidea: Echinodermata) at Diani Beach, Kenya. *Marine Biol.*, **2**: 167-172.

Abstract

"Studies were carried out on the inner and outer coral reefs at Diani Beach on the Kenyan cost to assess the distribution, density and behavior of *Echinodermata mathaei* (DE BLAINVILLE). Transects 1 m wide were run on the two reefs in April, June and September, 1970. Test measurements on representative samples from the animal populations on both reefs were also taken. Direct observations on specimens of *E. mathaei* in selected rock pools on the outer reef were made to determine their movement, gregariousness, homing and feeding behavior. Population density was higher on the inner reef furthest from the sea at low tide than on the outer reef. On the submerged inner coral reef at low tide, *E. mathaei* occurred mainly exposed on the seaweeds, but on the exposed outer reef, its main niches were crevices on the inner reef and larger ones on the outer reef. The growth rate of *E. mathaei* was estimated from the positions of modal values, calculated from size-frequency distributions. No gregarious or homing behavior was observed and, once settled in a suitable crevice, *E. mathaei* showed little movement."

6. **1972** Dingle, H. and Khamala, C.P.M. "Seasonal changes in insect abundance and biomass in an E. African grassland with reference to breeding and migration of birds." *Andea*: **59**: 287-294.

Abstract:

In this paper we address two problems concerning the ecology of birds in tropical Africa with reference to the availability of insect food. The first concerns seasonal breeding especially by insectivorous species and graminivorous species which feed their young on insects. The second problem concerns the possible use of local environmental cues as triggers for the northward migration of overwintering palearctic species.

Sweep samples were taken of the ninsec fauna of the Athi Plains grasslands near Nairobi, Kenya. Samples were taken during both wet seasons and both dry seasons. Some increase in insect numbers and a large increase in insect biomass occurred at the time of the "long rains" in April-May. These data support Owen's contention that major fluctuations in insect faunas occur near the equator in East Africa. It is not possible to ascertain whether fluctuations in insect numbers or biomass are in fact used as cues to trigger bird migration, but they are probably large enough to be so used. Most savanna and dry country birds breed during the long rains; the breeding is correlated with a major increase in the availability of insect food.

7. **1973** Khamala, C.P.M. The generic identify of *Ceratopogon imperfectus* (*Culicoides imperfectus* Geot.), *Entomol. mon. mag.*, **108**:107-108.

Abstract:

8. **1975** KHAMALA, C.P.M. "Breeding habitats and biting activities of *Culicoides* (Diptera: Ceratopogonidae) at Lake Nakuru National park, Kenya, with special reference to *C. trifasciellus* Goet.", *E. African Med. J.*, **152**:405-512.

Abstract:

9. **1975** Khamala, C.P.M. "Investigations of seasonal and environmental influence on biting and immature populations of *Culicoides cornutus* De Meillon in Kenya." *E. Africa. Med. Res. J.*, **2**:283-292.

Abstract:

Adult female and immature stages of *Culicoides cornutus* De Meillon were collected in the field from March 1971 through August 1972 to determine seasonal environmental influences on the populations. Records of temperature, humidity, rainfall, wind velocity and light conditions were made during the study. There was a direct correlation between the biting intensity of the flies and the seasonal and environmental factors. The biting numbers rose considerably in the rainy season corresponding with a fall in air temperatures and a rise in air humidities. Likewise in the dry season, there was a direct relationship between the decrease in biting fly numbers and the decrease of air humidities and increase in air temperature.

The daily biting cycles were also influenced in a similar manner during months with favourable conditions. Slight wind and short drizzling rain had no effect on the biting activity. However, very bright conditions when there was little clouds coverage and heavy rain reduced the biting activity. There was less variation in the immature population which tended to be high during the periods the adult population was low suggesting that the insect population was in developmental state at this time. The occurrence of immature stages throughout the year confirmed that it was not the lack of suitable breeding habitats which reduced the biting population in the dry seasons, but that other environmental factors were involved.

10. **1976** LUBEGA, R. AND KHAMALA, C.P.M. "Larval habitats of *Culicoides* species in Kenya." *Bull. ent. Res.*, **66**: 421-425.

Abstract:

The larval habitats of *Culicoides* species were determined by examining a total of 1476 samples collected from different ecological environments in various parts in Kenya. Immature stages were collected from suspected breeding habitats and adults were reared. Adults were also captured in emergence traps and then identified. To determine species preferences for breeding habitats, if any, samples the materials yielding *Culicoides* were analysed for pH, organic matter, and water content. Fifty-seven percent of the samples yielded a total of 26 species of *Culicoides*. Sites in which *Culicoides* occurred were classified into eleven habitats grouped into four major systems, namely, aquatic, transitional, terrestrial, and general systems. Most species were found breeding over a wide pH range in sites which were wet for at least part of the time. A few species appeared to select breeding habitats with a high organic content.

11. **1980** KHAMALA, C. P. M. AND OKEYO-OWUOR, J. B. "Pigeon pea (*Cajanus cajan*) (L.) Millsp. varietal response to insect podborer infestations in Kenya." *Kenya J. Sci. and Tech.*, **1** (B): 11-18.

Abstract:

Experiments were designed to investigate the response of four pigeon pea varieties in Kenya to insect podborer infestations. Two parameters, damage to pods and final seed yield, were used to determine varietal differences. Early flowering determinate varieties suffered more seed damage by the podfly *Melanogromyza obtusa* Mall. than the determinate varieties. Although these results are not conclusive, there is evidence that pigeonpea varieties vary in susceptibility to specific pests and the development and use of cultivars resistant or tolerant to one or more pests would permit a more flexible approach to pigeonpea pest management than is now practiced in Kenya.

12. **1980** OKEYO-OWUOR, J. B., KHAMALA, C.P.M., "Insect podborer infestations and their influence on developing pods and final seed yields by Pigeon pea (*Cajanus Cajan*) (L.) Millsp." *Kenya J. Sci. & Tech.*, **1** (B): 79-86.

Abstract:

In Kenya, eight insect species were found to be common borers into developing pigeonpea pods and feeding on developing seeds and reducing seed yield. They were *Heliothis armigera* Hub., *Maruca testulalis* (Geyer), *Pardesena virgulana* Mall., *Exelastis atomosa* Weise, *Lampides boiticus* (Treit), *Catachrysops cnejus* F., *Melanogromyza obtusa* Mall., and *Etiella zinckenella* (Treit). Of these, *H. armigera*, *P. virgulana* and *M. obtusa* were the most serious. Seed yield losses due to insect podborers ranged from 25.7% to 62.7%

13. **1980** MAILU A.M. AND KHAMALA, C.P.M., "Population dynamics of Pine Woolly Aphid, *Pinus pini* Adelgidae) in Kenya". *Bull. ent. Res.*, **70**:483-490.

Abstract:

The population dynamics of the aphid *Pineus pine* (Gmel.) was examine in two locations in the Kenya Highlands where the mean annual precipitation ranges from 620 to 1400 mm. Variations in population densities were related to rainfall. Generally, there was a marked decrease in population during the three months of heavy rainfall in March to May and a significant increased dry weather from August to October. This was followed by a slight decrease in the rate of population build-up, until the long rains in April again resulted in another population collapse. Nine species of predatory insects were identified, and population fluctuations of the most common of these, *Exochonus* spp. was studied. Predators seemed to remove about 12% of the aphid population. Other mortality factors included heat and crawler dispersion. The greatest mortality occurred early on the life-cycle and was mainly due to eggs and crawlers being washe off the host-tree by rain.

14. **1981** KHAMALA, C.P.M., AND NG'ANG'A, P. P. "Resistance of cowpea varieties to the legume bud Thrip *Megalurothrips sjostedti* (Tryb.) (Thysanoptera: Thripidae) in Kenya.", *Kenya J. Sci. & Tech. Series B.*, **2**: 3-7.

Abstract:

Ten promising cowpea varieties were tested in the field to compare their resistance to flower thrips. Thrips were randomly obtained from cowpea flowers by picking one flower from every fifth plant in a row until 10 flowers from each sample plot had been taken. Thrips damage to flower buds expressed as a percentage of injured flowers was used as the major criterion for determining resistance. Varieties VITA 3 and Katumani 1 were the most susceptible, whereas varieties ER 1-1 and ER 7 were the most resistant. Although it was difficult to identify the mechanisms of resistance, field observations suggested tolerance. However, observed seed yield differences between varieties indicate that resistance could be due to many other unknown factors, for example, different varietal yield potential and environmental factors.

15. **1981** KHAEMBA, B. M. AND KHAMALA, C.P.M. "Relation of pod age to the expression of resistance in cowpeas *Vigna unguiculata* (L.) Walp. to common pod-sucking bugs *Riptortus dentipes* F. and *Anoplogmemis curvipes* F. (Hemiptera: Coreidea).", *Kenya J. Sci. & Tech.* **2** (2): 47-52.

Abstract:

Studies on the relation of pod age to the expression of resistance in cowpeas to the common pod-sucking bugs *Riptortus dentipes* (F.) and *Anoplocnemis curvipes* (F.) were conducted at the International Institute for Tropical Agriculture, Ibadan, Nigeria. Cowpea pods aged four, six, eight, 10 and 12 days were fed to the bugs for varying durations. The insects were confined to cowpea pods of the variety Ife Brown (Tvu 3629) and the experiments arranged in complete randomized block design with six replications for both *R. dentipes* and *A. curvipes*. Damage was assessed by pod measurements and counts of damaged seeds of the harvested crop. Cowpea pods aged one week and below sustained significant damage expressed by shriveled pods and damaged seeds caused by the feeding activities of the bugs. However, older pods were least affected by the bugs during equivalent feeding durations indicating that pod age at the time of bug infestation was a critical factor in cowpea pod expression of resistance to these common serious pests.

16. **1982** MAILU, A.M., KHAMALA, C.P.M. AND ROSE D.J.W. "Sampling techniques for Populations of Pine Woolly Aphid *Pineus pini* (Gmelin) (Homoptera)", *Kenya Sci. & Tech.*, (B) **3**:9-18.

Abstract:

Procedures for sampling populations of all stages of the pine woolly aphid, *Pineus pini* (Gmel.) (Adelgidae) on its host tree are given. The distribution pattern of the aphids within the tree crown benches is described; and its tables are presented giving the numbers of trees to be sampled, to estimate population with known precision, either by measurement of pine needle lengths or by counts of aphids present. A highly significant negative regression of needle lengths on aphid numbers, suggests that the measurements of needle lengths alone are adequate to estimate intensity of aphid infestations.

17. **1982** MAILU, A.M., KHAMALA, C.P.M. AND ROSE D.J.W., "Establishment of Pine Woolly Aphid *Pineus pini* (L) (Homoptera: Adelgidae) on some host trees". *Kenya J. Sci. Tech.* **3 (B)** :61-68.

Abstract:

The establishment of *Pineus pini* (Gmelin) on six common *Pinus* species is examined with references to possible causes for observed differences in the rates of infestations on the different host species. Pine woolly aphid crawlers are positively phototactic, but do not settle onto surface exposed to strong light. They appear negatively phototactic to strong light and consequently tend to settle in hidden and tight crevices. The undersides of lateral branches which receive only moderate light tend to harbor a higher concentration of aphids than the upper surfaces. Possibly, positive thigmotaxis and negative phototaxis operate together, tending to bring crawlers into situations satisfying feeding and thigmotactic instincts. *Pinus halepensis* Mill. is shown to be the most favourable species for a fast infestation build-up and a higher adult aphid survival. Three other host species, namely; *Pinus elliottii* Engelm, *Pinus caribae* var. *hondurensis* Barr and Golf and *Pinus oocarpa* Schiede that seem favourable and appear to evoke an appropriate response from aphids with regard to orientation, feeding and oviposition are recommended for use where maximum efficiency in pine woolly aphid build-up is required.

18. **1983** KHAMALA, C.P.M. AND NG'ANG'A, P.P., "Insecticide evaluation against the Legume bud Thrips *Megalurothrips sjostedti* (Tryb.) (Thysanoptera: Thripidae).", *Kenya J. Sci. & Tech.* **(B) 4 (1)**: 35-42.

Abstract:

Studies on three insecticides, namely; Thiodan 35% EC, Sevib 85% WP and DDT 25% EC, commonly used against the legume bud thrips *Megalurothrips sjostedti* Trybom.) and other insect pests on field cowpeas were conducted to determine their efficiency. Cowpea variety VITA 3 was selected for use because it was reported to be susceptible to *M. sjostedti* attack. Four insecticide sprays were applied from the onset of flowering at weekly intervals. Although all the three insecticides depressed thrips population in both short and long rain seasons, Thiodan maintained the lowest population value. Seasonal weather changes did not appear to influence thrips population directly.

19. **1984** P. NG'ANG'A MUKAMI. AND CANUTE P.M. KHAMALA, "Population dynamics and seasonal incidence of the legume bud thrips *Megalurothrips sjostedti* (Trybom.) (Thysanoptera: Thripidae) in cowpea fields in Kenya.", *Kenya J. Sci. & Tech.:(B) 5 (1&2)* 15-25, 1984.

Abstract:

Population dynamics and seasonal incidence of the legume bud thrips *Megalurothrips sjostedti* Trybom. were conducted at the Coast Agricultural Research Station, Mtwapa. All experiments were randomized block design in plots that measured 3 m x 3 m. Thrips populations were estimated from random samples of 10 flowers per plot in the replicates. Population levels varied with season with significantly more thrips occurring during the long rainy season. Rapid thrips population build-up appeared to correspond with the peak flowering period of the cowpea crop. In general, population levels were influenced by cumulative number of flowers in each season. Daily weather changes, for example, rainfall, relative humidity and temperature, did not appear to influence thrips population directly. With sufficient information on population trends, population dynamics, and seasonal incidence, it is possible to develop a thrips pest management programme that can at least lead towards a reasonable increase in cowpea seed yield.

20. **1986** MEBRAHTU, Y., BEACH, R.M. HENDRICKS, L.D. AND KHAMALA, C.P.M. "Occurrence of *Simulium (Edwardsellum) damnosum* s.l. Diptera: Simuliidae in nine river system in Kenya.", *Journal of Medical Entomology*, **23**:111-112.

Abstract:

Six systems in Kenya were found to harbor *Simulium damnosum* Theobald s.l. Two CDC light traps, during 12-h overnight collections at the Isiukhu and Nzoia rivers, caught 3 and 116 adult *S. damnosum* s.l., respectively.

Searches for aquatic stages of *S. damnosum* s.l. in the 9 river systems produced 15 species of *Simulium*. *Simulium damnosum* s.l. is reported here for the 1st time from the Lusumu (0°19'N, 34°35'E) and Nzoia (0°35N, 34°48'E) rivers

21. **1986** MEBRAHTU, Y., BEACH, R.F. KHAMALA, C.P.M. AND HENDRICKS L.D. "Characterization of *Simulium (Edwardsellum) damnosum* s.l. populations from six river systems in Kenya by cellulose acetate eletate electrophoresis.", *Trans.R. Soc.Trop. Med & Hyg.* **80**: 914-922.

Abstract: Isoenzyme characterization of the *Simulium damnosum* Theobald sibling species complex from two widely separated geographical areas in Kenya is presented based on 10 enzymatic loci. Four river systems in Western and Nyanza Provinces, namely, the Yala, Lusumu, Isiukhu and the Nzoia harbouring *S. damnosum* s.l. were compared among themselves and with *S. damnosum* s.l. collected from the Thiba and the Nyamindi river systems in the Mt. Kenya area. The two populations were easily separable using PGM, HK and, more than 73% of the time, with PGI. Using the first two enzymatic loci, PGM and HK, all the western Kenya *S. damnosum* s.l. belong to the same population while those from Mt. Kenya areas belong to a different population. In both geographical zones there was less than 20% qualitative and quantitative polymorphism within infraspecific forms in any given breeding area of *S. damnosum* s.l. Three enzymes, ME, XDH, and G-6-PDH had isomorphic mobilities for both the Mt. Kenya and western Kenya populations. Four other enzyme/substrate systems tested had no satisfactory resolution as a diagnostic value.

22. **1987** Mebrahtu, Y., Khamala, C.P.M. Hendricks, L.D. and Beach, R.F. "Mermithidae (Nematoda) infection of the aquatic stages of *Simulium (Edwardsellum)* from the nine river systems in Kenya.", *Proc. Helminthol. Soc. Wash.*, 54 (1): 156-157.

Abstract:

23. **1988** LUCIE, M. ROGO, KHAMALA, C.P.M., AND MUTINGA, M.J. "Biochemical identification of *Phlebotomus (Larroussius) pedifer* and *Phlebotomus (Larroussius) elegonensis*.", *Bioch system. & ecol.*, **16** (1/8): 655-659.

Abstract: Females of the vector of *Leishmania aethiopica*, *Phlebotomus pedifer*, have previously been morphologically indistinguishable from the non-vector, *P. elegonensis*. The present studies have biochemically separated these two species. Differences were observed in the mobility of four enzymes, GPI, HK, ICD and PGM on thin-layer starch gel electrophoresis. Using the isoelectric focusing technique, the two species could be differentiated by one enzyme, GPI.

24. **1995** Khamala, C. P. M., *et al.* "Relationships between *Plasmodium falciparum* transmission by vector populations and the incidence of severe disease at mine sites on the Kenya Coast.", *Am. J. Trop. Med. Hyp.*, **52** (3): 201-206.

Abstract: The transmission of *Plasmodium falciparum* was studied in relation to the incidence of severe malaria infections at nine sites in the Kilifi District in Kenya. Intensive mosquito sampling during a one-year period yielded *Anopheles gambiae* s. l., *An. funestus*, *An. coustani*, *An. squamosus*, *An. nili*, and *An. pharoensis*. *Anopheles gambiae* s.l. was the predominant vector, comprising 98.4% of the total anophelines collected. Overall, 3.5% of 2,868 *An. gambiae* s.l. collected indoors and 0.8% of 261 collected outdoors contained *P. falciparum* sporozoites. Transmission was detected during 10 months, with peak periods from June to August and December to January. In eight of the nine sites, entomologic inoculation rates (EIRs) averaged only four infective bites per year (range 0-18); an annual EIR of 60 was measured for the site with the highest intensity of transmission. The incidence of severe malaria infections, ranging from 8.6 to 38.1 per 1,000 children (0-4 years), was not associated with EIRs. At these sites on the coast of Kenya, a high incidence of severe disease occurs under conditions of very low levels of transmission by vector populations. With respect to conventional approaches for vector control in Africa, decreases in transmission, even to levels barely detectable by standard approaches, may not yield corresponding long-term reductions in the incidence of severe disease.

25. **2010** Mutisya, D.L., C.W. Kariuki and C.P.M. Khamala (2010). “Growth and development of cassava predatory mite under different relative humidity regimes.”, *E. Afr. agric. For. J.*, **76**: (1 & 2) 97-102.

Abstract: The effect of relative humidity regimes on the development and growth of the various development stages of the predacious mite *Typhlodromalus aripo* (Acari: Phytoseiidae) was studied in the laboratory at a constant temperature of $27 \pm 2^\circ\text{C}$. The mite was raised on its natural diet of phytophagous cassava green mite, *Mononychellus tanajoa* Bondar, reared on cassava apices of young stems. Development was measured as the life history of the mite (the total duration from egg to egg) whereas growth was determined as the duration of days it took each immature stage to change into the next stage. Results of the study showed a negative correlation between the mite development period and relative humidity. Similarly, there was a negative relationship between the number of offspring (eggs) produced by individual female mites with respect to relative humidity regimes. These findings facilitate better understanding of the predatory mite population dynamics, in different environmental conditions and as a biological control agent of cassava pest *M tanajoa*.

26. **2012** Mutisya, D.L., E.M. El-Banhawy, C.W. Kariuki, C.P.M. Khamala, K.K.M. Fiaboe and M.M. Kungu. “Effect of the cassava green mite *Mononychellus progresivus* Evans on the development and reproduction of the introduced predatory mite *Phytoseiulus longipes* (Acari: Tetranychidae = Phytoseiidae).”, *Systematic and Applied Acarology* **17**: (4): 378-383.

Abstract: The cassava green mite (CGM) *Mononychellus progresivus* Doresta allowed for a limited development of the predatory mite, *Phytoseiulus longipes* Evans at three experiments temperatures. When the predators were confined with the motile stages of CGM, at 10°C , only 10% of the larvae reached maturity after 16 days. At 24 and 32°C , the development on the same prey was improved, however less than 50% that reached maturity, were not able to produce eggs. At the same temperatures, on the tomato spider mite (TSM), *Tetranychus evansi* Baker & Pritchard, the developmental periods of *P. longipes* were shorter and mortality lower. *P. longipes* consumed less number of CGM when compared to TSM and about double the number of TSM prey when compared to CGM. Feeding only on CGM produced insignificant number of eggs with high rate of female mortality. Combination of both CGM and TSM at different ratios substantially improved reproduction and lowered mortality of *P. longipes* females.

27. **2013** MUTISYA, D. L., C.P.M. KHAMALA, E.M. EL BANHAWY, C.W. KARIUKI, S.RAGWA. “Cassava variety tolerance to spider mite attack in relation to leaf cyanide level”, *J. Biol., Agric. & Health*. **3**: (5), 24 – 30.

Abstract: Cassava *Manihot esculenta* Crantz is grown in the tropics as an important staple root crop. The major herbivore pest is the cassava green mite (CGM) of the *Mononychellus* species. The pest mite *Mononychellus progresivus* Doresta collected from the coastal Kenya lowlands was used to evaluate spider mite tolerance of nine cassava varieties grown in three regions of the country; eastern lowlands, western midlands and the humid coastal lowlands. Mite population build-up of 10 individual motile stages of *M. progresivus* reached peak densities on 39th day of the most susceptible varieties and by the 54th day attacked leaves had wilted in $20.0 \pm 2^\circ\text{C}$ and $63 \pm 4\%$, climatic conditions. For the most tolerant varieties it took 47 days to reach peak densities and for one variety (MM97/3567) the mite population did not cause highest damage score even by the 55th day. Equating visual damage score with actual leaf biomass loss (%) enabled indication of the level of photosynthetic leaf area loss due to pest mite attack. Higher leaf cyanide (HCN) content led to higher biomass loss (%) up to HCN 20 mg/Kg. Spider mite density increase was similarly positively correlated to the subsequent biomass loss on cassava varieties. This information is beneficial to cassava breeders when developing varieties tolerant to CGM attack and safe for human consumption.

28. **2014:** DANIEL L. MUTISYA, E, M. EL BANHAWY CHARLES W KARIUKI, CANNUTE P, M. KHAMALA *Typhlodromalus aripo* de Leon (Acari: Phytoseiidae) development and reproduction on major cassava pests at different

temperatures and humidities: an indication of enhanced mite resilience.
Acarologia 54(4): 395-407

Abstract

Both prey type and biotic conditions limit performance of phytoseiid predators. The exotic predatory mite, *Typhlodromalus aripo* developed and produced when maintained on eggs and active stages of the cassava green mite (CGM) *Mononychellus progresivus* at three different temperatures. At the highest temperature of 33⁰C and the lowest at 12⁰C, mite survival was less than 15% over a period of ten days with low fecundity. At 12⁰C, immature took longer to reach maturity, while at 33⁰C high mortality (>80%) occurred. The best performance was recorded at 27⁰C and 75% relative humidity. *Typhlodromalus aripo* was able to feed, develop and reproduce on the crawlers' stage of the whitefly, *Bemisia tabaci* and the nymphal stage of the mealybug, *Phenacoccus manihoti*., though a low survival rate (<10%) was observed for the stages of protonymph, deutonymph and adults. Normal life stage development and egg hatchability were recorded at 27⁰C and 75%RH. The egg stage exhibited high drought tolerance (70% hatching at 40% RH). *Typhlodromalus aripo* females consumed less than 3 crawlers and produced less than one egg/day when fed with *B. tabaci* and *P. manihoti* at 75% RH. The study indicated that for successful utilization of *T. aripo* in biological control of CGM, it would be important to introduce the predator at low prey density whether in absence or presence of alternative prey on cassava. In conclusion, results revealed *T. aripo* to have drought resilient survival attributes which enhances this phytoseiid as an effective biological control agent.

29. **2014:** DANIEL L. MUTISYA, E. M. EL BANHAWY CANNUTE P, M. KHAMALA, CHARLES W KARIUKI, MIANO DW Determination of Damage Threshold of Gassava Green (Acari: Tetranychidae) on Different Cassava Varieties *Journal of Plant and Pest Science* 1, (2): 79-86.

Abstract

Density threshold has been least considered in efforts to control cassava green mite (CGM) of the *Mononychellus* species. Nine cassava varieties of varied cyanogenic contents were evaluated for CGM density threshold. Mite population of the 10 introduced individual active stages of *Mononychellus progresivus* reached peak densities on 39th day of the most susceptible varieties, and by the 54th day attacked leaves had withered at 20.0 ± 2⁰C and 63 ± 4% test climatic conditions' Mite threshold was determined to be ≥ 27 mites / leaf, cassava leaf variety cyanogens potential content was between 8.5 to 20.0 mg/kg on the nine varieties evaluated' variety high cyanogens potential led to higher CGM density growth and subsequent biomass loss. similarly, high leaf cyanide (HCN) content led to higher biomass loss (%) up to HCN 20mg/Kg as a result of high CGM infestation. This information is beneficial to cassava breeders, when developing varieties tolerant to CGM damage and safe for human consumption where cyanogens levels <10mg/kg showed the least leaf damage by CGM. Likewise farmers and crop Protection agents can use the determined threshold to decide when to implement control measure for CGM on cassava crop.

30. **2015.** DANIEL L. MUTISYA E.M, EL.BANHAWY, C.P.M. KHAMALA, C,W. KARIUKI Management of cassava green mite *Mononychellus progresivus* (Acari: Tetranychidae) in different agro-ecological zones of Kenya *Systematic & Applied Acarology* 20(1): 39-50

Abstract

The cassava green mite (CGM), *Mononychellus progresivus* Doreste, causes serious leaf damage on cassava leading to low root yield in the dry savannah regions of Africa. A study to compare effectiveness of other predatory phytoseiid *Typhlodromalus aripo* (De Leon), an acaricide abamectin, an insecticide chlorpyrifos and fertilizer in management of CGM was carried out in various agro-ecological zones of the eastern dry low-midlands at Katumani (LM4), Kiboko (LM5), the cool upper midlands at Embu (UMZ) and the warm-humid coastal lowlands at Mtwapa (CL3) of Kenya. The acaricide abamectin was found most efficacious in controlling CGM at all agro-ecological zones. Further, the results revealed that the exotic phytoseiid *T. aripo* was effective in suppressing population densities of CGM by 45% in the dry-hot midlands (Kiboko) and 64% in the warm-humid coastal climatic zone, but the predator could not persist in the cool midlands. However, in the same cool midlands, high amounts of rain fall led to low CGM density of less than 20 mites per leaf, amid the presence of the indigenous phytoseiid *Euseius fustis* (Pritohard & Baker). Increase in CGM density was positively correlated to the warm and hot dry environment at the plots at Kiboko and Katumani. In the irrigated and wetter

sites, T ariipo increased with the increase in relative humidity in the environment at Kiboko and Mtwapa. Abamectin spray was the best option in s in the dry lowlands zones. Similarly, soil fertility input led to higher yield in the sandy soils of low coastal and eastern midlands. High CCM densities did not result in low yield as other environmental factors such as soil fertility and temperature influenced the final root yield. These findings give insight on the management options of the CCM pest in the different agro-ecological zones in Kenya and similar regions of Africa

B. M.Sc. and Ph.D. Supervised Degree Publications)

Topic 1 (1976). Biology of *Pachypasa papyri* Tams and *Gonometa podocarpi* Aurivillius (Lepidoptera: Lasiocampidae) defoliators of Pulpwood forests in Kenya. (M.Sc. Thesis)

Objective:

To determine in the field and laboratory the life cycles, enemies and alternative host plants of the common lepidopterous insect defoliators of forest pine trees in Kenya.

Abstract:

P. papyri and *G. podocarpi* are among the most destructive insect pests attacking vegetative parts of pine trees in Kenya. Field and laboratory experiments were carried out to study the life cycles, natural enemies and alternate host plants of these insects. The life cycle studies revealed that *G. podocarpi* passes through two generations in a year while *P. papyri* attains two but sometimes three to four generations. The conditions under which three to four generations are possible were not elucidated.

Mortality during laboratory rearing was very high in *P. papyri* due to the high incidence of a nuclear polyhedral virus. *G. podocarpi* had a low mortality and was well adapted to laboratory rearing contrary to Ochong's (1972) observations. The nuclear polyhedral virus disease described by Harap *et. al.* (1966) on *G. podocarpi* was not recorded during the course of these studies. A cytoplasmic polyhedrosis was present. The two species, though polyphagous are predominantly tree species. When a host preference experiment using 1st instar and 5th instar larvae were presented with leaves of *Pinus patula*, *P. rasiata*, *Acacia mearnsii*, *Cupressus lusitanica* and *Eucalyptus saligna*, *G. podocarpi* fed on all the plant species while *P. papyri* showed a strong preference for *A. mearnsii*.

Parasitization of field insects was very high. The most infected stages were the larvae. Two parasites *Trocicus ovatus* and a tachinid *Exorista sorbillans* were important on *P. papyri* while another tachinid *Palexorista gilvodes* caused significant mortality on *G. podocarpi*.

Topic 2 (1976). Biology and morphology of *Cirrospilus variegatus* (Hymenoptera: Eulophidae), an ectoparasite of the Coffee Leaf Miner moth in Kenya. (M.Sc. Thesis)

Objectives:

1. To determine the biology of the hymenopteran *Cirrospilus variegatus* (Masi) an ectoparasite of the lepidopteran Leaf-miner *Leucoptera meyricki* Ghesqueire.
2. To determine the behavior of the hymenopteran *Cirrospilus variegatus* (Masi) an ectoparasite of the lepidopteran Leaf-miner *Leucoptera meyricki*.
3. To evaluate the efficacy of the ectoparasit *Cirrospilus variegates* to control the notorious coffee pest Leaf miner moth *Leucoptera meyricki* in Kenya

Abstract:

Cirrospilus variegatus is an ectoparasite of the larval stages of the coffee leaf miner moth *Leucoptera meyricki*. The immature stages are described and their life history given. Under field conditions with temperatures between 19^o C and 21^o C, developmental period was 25 to 40 days from egg to adult. Percentage hatchability was frequently above 80 % but larval feeding stages had the least percentage survival rate. Almost all the pupae emerged into adults with little mortality. Temperatures above 20^o C tended to reduce the duration period of these developmental stages and longevity of adults but increased mortality.

All the development of *C. variegatus* and its mode of parasitism occurred within leaf mines created by the feeding activities of *L. meyricki* larvae. After determining the location of *L. meyricki* larva within a mine the female *C. variegates* first paralyzed the host with its ovipositor before ovipositing its eggs beside it. One to eight eggs were singly deposited. Hatched *C. variegates* larvae attached themselves to *L. meyricki* larvae and fed continuously from the exterior. They detach from the hosts before they pupated. To emerge adults ate a hole through the crust of the mine for escaping.

Mating was preceded by courtship and took place within the first 3 to 10 minutes after emergence. Pre-oviposition period varied from 3 to 5 days. Eggs laid before mating produced males only. Mated females laid more eggs which produced both sexes in variable ratios. There was a positive correlation between sex ratios and brood sizes. Percentage parasitism attributable to *C. variegatus* varied from 30 to 50 and its correlation with the sex ratio was also positive. Nine to eleven overlapping generations of *C. variegatus* in a year were found. The phenomena of hyper-parasitism and cannibalism were also observed in this parasite. It appeared that host *L. meyricki* larvae were actually killed by the paralyzing action of the adult *C. variegatus* female and that the larvae of the latter merely fed on already dead hosts. If and when, therefore, *C. variegatus* were to be utilized as a biological control agent against *L. meyricki*, focus must be made on the adults.

Topic 3. (1976). Investigations on the influence of some of the common pesticides used on the coffee crop against the populations of *Leucoptera meyricki* Ghesquiere the coffee Leaf Miner moth (Lepidoptera: Lyonetiidae) in Kenya.

Objective:

To determine the influence of copper fungicides and persistent insecticides on the populations of eggs and larvae of the coffee leaf miner moth *L. meyricki* in coffee ecosystems in Kenya.

Abstract:

Topic 4 (1976-1979). "Pest Management of Grain Legume Crops in Multiple Cropping Systems."

Objectives: (M.Sc. Thesis)

1. To survey and collect insect pests of grain legume crops in Kenya.
2. To gain a better understanding of the phenology of grain legume varieties and the pest complex interactions in mixed cropping systems.
3. To assess the pest status of insect species attacking grain legumes in mixed systems in order to guide pest protection programmes.
4. To elucidate the ecological factors and utilization of chemical, biological and cultural control practices to reduce the overall pest populations in mixed cropping systems.
5. To select the most insect-resistant but acceptable grain legume market varieties (See publications).

Abstract:

Topic 5 (1980). A comparative study on development of the bean beetle *Acanthoscelides obtectus* (Say) in bean, cowpea, and pigeon pea seed diets. (M.Sc. Thesis)

Objective: To compare the performance in population growth, life cycle, adult emergence pattern, oviposition preference, larval food of the bean beetle *Acanthoscelides obtectus* (Say) in three pulses.

Abstract:

Results indicated that the differences in the numbers of beetles developing in beans, pigeon peas, and cowpeas were statistically significant at the third generation level. The average life cycle in a generation was shorter in beans and cowpeas than in pigeon pea. Adult emergence pattern curves showed that beans and cowpeas were better food media for *A. obtectus* than pigeon peas. Likewise, beetles reared in bean and cowpea seeds had a longer lifespan than those reared in pigeon pea seeds. Ovipositing *A. obtectus* tended to lay more eggs among bean seeds than among cowpea and pigeon pea. In terms of these studies, it was clear that bean seeds are more suitable as host to *A. obtectus* than cowpea and pigeon pea.

Topic 6 (1981). Studies on Population densities and some aspects of Control of the common Maize Stalkborer *Chilo partellus* Swinhoe, *C. Orichalcocililla* Strand. and *Sesamia calamistis* Hmps.

Objectives: (M.Sc. Thesis)

1. To determine the population densities of the common maize stalkborers in maize field crops in the Coast Province of Kenya.
2. To elucidate the efficiency of selected insecticides for the control of maize stalk-borers.
3. To determine the susceptibility/residence levels of maize varieties grown in the Coast Province of Kenya to stalkborers.

Abstract:

The population densities of the three coastal maize stalkborers, *Chilo partellus* Swin. *C. orichalcoiliella* Strand. and *Sesamia calamistis* Hmps. were estimated during the long rains of 1979, 1980 and 1981, showed the occurrence of two population peaks of different magnitudes during the years studied. There was an interchange in the pest status by the two *Chilo* species in different years during the experimental seasons. *S. calamistis* was found to be less important than the *Chilo* species, but became important during the reproductive stages of the maize crop particularly in the coastal hinterlands, e.g., Taita/Taveta District. Attempts made to screen in the field a number of insecticides applied in the funnels of maize plants to control the stalkborers showed that Thiodan and Dipterex granules applied at the rate of 12.0 kg/ha. and 4.4. kg/ha., respectively, were superior to other insecticides tested. The method of evaluating insecticidal performance was based on damage symptoms on leaves. Tests carried on resistance/susceptibility of maize varieties grown at the Coast showed that the backcrosses of the coast composite variety with '405' variety were less susceptible than other materials tested, indicating that the '405' variety contained resistance values since its partner was very susceptible to infestation by the stalkborers.

Topic 7 (1984). Insect pests of Cowpeas *Vigna unguiculata* (L.) Walp. and studies on Cowpea yield assessment under different chemical spray regimes and minimum use of insecticides against the dominant insect pest species at Katumani Dryland Research Station, Kenya. (M.Sc. Thesis)

Objectives:

1. To determine the major cowpea insect pests in Kenya.
2. To assess cowpea yields under different inset chemical control regimes.
3. To determine the minimum insecticidal use for control of the dominant cowpea insect pests.

Abstract:

Studies to identify major insect pests attacking cowpea, *Vigna unguiculata* (L) Walp., in the field and to assess cowpea yields under different chemical control regimes were conducted at Katumani, Kenya during the short and the long rainy seasons of 1978 and 1979 respectively. From materials collected in unsprayed plots, the cowpea crop was found to be attacked by a total of 43 species of insects which were classified into seven orders: Diptera (1), Coleoptera (10), Heteroptera (4), Homoptera (3), Lepidoptera (8), Orthoptera (4), and Thysanoptera (2). Only a few of these were considered major pests, namely, *Acanthomia horrida* Germ, *Agrotis segetum* D and S, *Anoplocnemis curvipes* F., *Aphis craccivora* Koch, *Callosobruchus maculatus* Fab., *Heliothis armigera* Hb, *Lagria villosa* Fab., *Maruca testulalis* Geyer, *Megalurothrips sjostedti*, Trybom, *Nezara viridula* L. Maximum seed yields were obtained from cowpea plots sprayed with gamma BHC insecticide after flowering. There were no significant difference in yields between plots sprayed with insecticide before flowering and those of the untreated plots. Insecticidal treatments applied four times after flower at 14 days interval, starting at the appearance of first flowering, gave significantly higher yields than spraying two times after onset of flowering at 45 days apart. Mean seed yield of the ten varieties of cowpea used differed significantly between treated and untreated cowpea plots. The local varieties KAT 1, KAT 2 and KAK 1 constantly performed well producing higher yields than the exotic varieties except VITA 4. Aphids which were one of the most important pests of cowpea at Katumani preferred to colonize prostrate varieties to erect ones in growth habit. When gamma BHC insecticide was applied to plots attacked with aphids there was no correlation between insecticide application and cowpea varietal yields.

Topic 8 (1985). Mechanisms of Sorghum resistance to the spotted stalkborer, *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae). (Ph.D. Thesis)

Objectives:

1. To determine the methods of measuring sorghum resistance to the spotted stalkborer, *Chilo partellus* (Swinhoe).
2. To elucidate the relationships of *C. partellus*' oviposition preferences and larval development and feeding to the damage caused to the sorghum crop

Abstract:

The spotted stalkborer *Chilo partellus* is one of the most notorious pests in Kenya of cereal crops especially maize and sorghum particularly in semi-arid areas. These studies showed that ovipositing maize stalkborers have distinct preferences for certain sorghum cultivars. Cultivar IS 2205 was the least preferred while IS 18363

was the most preferred. Experiments to identify the factors responsible were inconclusive. Evidence pointed to both biochemical and biophysical factors. First instar larval establishment studies were also inconclusive even though it was demonstrated that larval establishment was different among the cultivars used. The only definite evidence for poor establishment in some cultivars was biophysical. Different cultivars were significantly different in their susceptibility to leaf damage. The tendency to form deadhearts was also significantly different. Cultivars were not significantly different in their susceptibility to tunnelling even though they had different amounts of fibre, lignin and sucrose. The single most important factor for the different cultivar susceptibilities was in their different tolerance to *C. partellus* attack. Tillering, in particular, was demonstrated to play an important role in compensation for damage. The ability to flower and to produce seed in spite to having a high infestation of stalkborers were also very significant. Susceptible cultivars dried up before they had flowered. Others still flowered but could not form seed. Using tolerance as a criterion for resistance showed IS 18520 to be the most resistant. Formation of multiple heads was also shown to be an important factor as a result of stalkborer infestation. Different cultivars had varying effects on the development of *C. partellus* (antibiosis). However, the antibiotic effect was either insignificant or only just significant statistically. The use of the resistant crop varieties to insect pests is one of the best and environmentally sound methods in pest management.

Topic 9 (1985). Estimation of the survival rates of field populations of malaria vectors in Kenya

Objectives: (Ph.D. Thesis)

1. To test the applicability to Kenya malaria transmitting mosquito species of new techniques for the estimation of the average survival rate and to modify and improve such techniques where necessary.
2. To determine the average survival rates at different seasons of the years of the four mosquito species that transmit malaria in Kenya.
3. To rank the various malaria vector populations studied according to their relative vectorial capacity on the basis of average longevity.

Abstract:

Results revealed that the average survival rates between the dry and the wet seasons mosquito populations of individual species was possible in *An. gambiae s. str.* The survival for this species was higher during the dry than the wet season. Overall, the highest survival rate was of the short rains population of *An. merus*, while *An. gambiae s.l.* had the lowest. *An. arabiensis* had the second lowest survival rate. By expressing the vectorial capacity of each population as a ratio of the lowest calculated, the short rains *An. merus* had the highest capacity, followed in, descending order, by dry season *An. gambiae s. str.*, long rains. *An. gambiae s. str.*, *An. gambiae s.l.*, and lastly, *An. arabiensis*. The most hardy and long surviving mosquito disease vector is more dangerous than that which has a short lifespan.

Topic 10 (1989). Evaluation of resistance to insecticides in the mosquito larvae of *Anopheles gambiae* Giles and its control by microbial bacterial pathogens. (M.Sc. Thesis)

Objectives:

1. To investigate the occurrence of resistance to various insecticides in larval *Anopheles gambiae s.l.* from Ahero and Mwea Tebere Rice Irrigation Schemes.
2. To evaluate the potential of some of the bacterial pathogens as an alternative to chemical insecticides in the control of malaria vectors.
3. To determine and compare lethal values of two bacterial pathogens, namely, *Bacillus thuringiensis* and *B. sphaericus* to *An. gambiae s.l.* larvae under laboratory and field conditions.
4. To provide additional data on the biology of these malaria vectors in Kenya that would lead to designing and developing better malaria control strategies.

Abstract:

It was found that resistance factors of mosquito larvae were near unity for dieldrin, and 2 to 3 times for Malathion at both Ahero and Mwea, and 2 times for DDT at Ahero. These low resistance factors indicated little or no resistance by the mosquitoes to these insecticides. However, resistance factors to fenitrothion at Ahero of times 30.5 and at Mwea of times 5.4, and to DDT at Mwea of 16.5, were high indicating resistance to these insecticides. This was explained by the fact that these 2 insecticides have been regularly used for rice pest control, and therefore, the mosquitoes had become used to them. Comparative bioassays showed that younger active larval instars were most susceptible to these bacterial pathogens as determined by both spore counts

compared to international toxic unit system methods for measuring toxicity of the bacterial isolates. Although the toxic activity of the bacterial formulations was reduced under field condition, it was concluded that this method of control could be an effective alternative for the management of malaria vector mosquitoes in rice irrigation schemes.

Topic 11 (1990). The dynamics of *Anopheles arabiensis* Patton and *Anopheles funestus* Giles larval densities in relation to small-scale rice cultivation practices in Western Kenya. (M.Sc. Thesis)

Objectives:

1. To assess the relationships between small-scale irrigated rice farming and densities of *Anopheles* mosquito species.
2. To determine the seasonal distribution of these malaria mosquitoes in the small-scale irrigated rice fields and in undisturbed breeding grounds.
3. To determine the preferred breeding habitats of the Anopheline mosquitoes.
4. To determine the predators of the immature stages of the Anopheline mosquitoes.
5. To elucidate the physical and biotic factors in the breeding habitats of Anopheline mosquitoes so as to assist in designing successful control measures against the malaria vector species.

Abstract:

A two-year study was conducted on the densities of *Anopheles arabiensis* Patton and *Anopheles funestus* Giles larvae in two rice cultivation sites with divergent farming practices, at the Ahero Irrigation Scheme, Kenya. The study site was situated in a malaria endemic area where *An. arabiensis* and *An. funestus* are the principal vectors. Sampling of mosquito larvae and predators was carried out fortnightly from selected rice paddies, nurseries and irrigation canals. The results of the study showed a relationship between the farming practices and the breeding of the two mosquito species. There were distinct differences in the stability of breeding sites, vegetation heights, and water depths, due to the differences in cultivation practices. The associated larval density fluctuations and the temporo-spatial distribution of the two malaria vectors showed that certain practices can affect the level of breeding of the two vector species as well as lead to the exclusion of *An. funestus*.

Topic 12 (1992): Factors affecting malaria transmission by vector mosquito populations in Western Kenya, with special reference to altitude. (Ph.D. Thesis)

Objectives:

1. To monitor the seasonal population densities, age structure and vectorial capacity of malaria mosquito vectors along a longitudinal transect traversing over various altitudinal levels in order to determine the malaria incidence and its transmission patterns in western Kenya.
2. To examine variation in anopheline mosquitoes' blood feeding patterns, biting peaks, and man-biting rates in relation to the intensity of malaria transmission at selected altitudinal sites.
3. To determine the *P. falciparum* sporozoite rates and the concomitant inoculation rates in geographically distinct areas of western Kenya situated at different altitudes.
4. To examine the seasonal pattern and ecology of the sibling species of the *An. gambiae s.l.* complex and their relationship to sporozoite rates and infectivity at the same sites.
5. To determine seasonal and environmental factors, including, temperature and relative humidity, that affect sporozoite rates, blood feeding preferences, survivorship and infectivity of the anophelines at the same sites.
6. To determine the overall influence of the above entomological factors to the intensity and epidemiological variation of malaria transmission in western Kenya.

Abstract:

Five populations of *Anopheles* mosquito vectors of malaria from different altitudes along a transect in Nyanza Province of western Kenya were studied over a period of two years, January, 1989 through December, 1990. Each population was sampled by two methods: the pyrethrum-spray-sheet collection (PSC) technique for the indoor day-resting, and the human-bait technique (WHO 1975; Service, 1976) for the biting population. The following parameters were determined: (1) species composition; (2) the relative density of indoor day-resting populations in inhabited houses; (3) the relative density of the biting populations; (4) the man-biting rates and biting cycles between 19.00 and 07.00 hours, and for a full 24 hour day cycle; (5) blood feeding preferences; (6) parity rates; (7) sporozoite rates; and (8) entomological inoculation rates, i.e. man-biting rate x sporozoite rate. In the PSC technique, a total of 192 house searches were carried out by

sampling once monthly from eight human-inhabited houses at each altitude. The anophelines were identified morphologically with the aid of keys. Siblings of the *An. gambiae* complex were separated by the cytogenetic identification of polytene chromosomes as described by Coluzzi & Sabatini (1967). Bloodmeal types were identified by the blood meal enzyme-linked immunosorbent assay (ELISA) technique (Service, 1986). The human-bait catches were performed at three different altitudinal sites located at 1219 m (Ahero), 1350 m (Rota) and 1524 m (Oriwo). The procedure involved hourly catches for 12 hours of the night, and on six occasions throughout the 24 hours covering day and night by a team comprising two collectors seated indoors and two others seated outdoors with their legs exposed, and collecting mosquitoes from themselves using test-tubes with the aid of torch lights. The data was used for the analyses of the man-biting rates, biting cycles, and longevity and parity rates. Sporozoite rates were determined by the ELISA technique described by Burkot *et al.* (1984) and Wirtz *et al.* (1985) and also by dissection for comparison; and were used to calculate the entomological rates. All the parameters were correlated to altitude, seasonal and climate changes.

The anopheline composition along the transect varied in species diversity and reduced in population abundance with rising altitude. Member species of the *An. gambiae* complex *An. gambiae s.str.* and *An. arabiensis* were caught at all altitudes. *An. funestus* was not found in collections above 2100 m above sea level. At the lower altitude of 1219 m (Ahero), *An. arabiensis* existed as a homogeneous population, whereas at higher altitudes this species and *An. gambiae s.str.* existed as sympatric (mixed) populations, with the latter tending to be predominant. Small numbers of *An. zeimanni*, *An. pharaoensis* and *An. coustani* were also captured. The man-biting rates reduced with rising altitude from a peak of 108 bites/man/night for *An. arabiensis* at 1219 m, through 28.3 bites/man/night in a sympatric population, to less than 0.1 bites/man/night in a homogeneous population of *An. gambiae s.str.* at 1524 m. The man-biting rate for *An. funestus*, also reduced from 69.3 bites/man/night to 65.1 bites/man/night and less than 0.1 bites/man/night at the respective altitudes. Altitude and seasonality affected the parity rates and age composition. *An. arabiensis* at 1219m had a lower parity rate than *An. gambiae s.str.* at higher altitudes. However, the parity rate for *An. funestus* at 1350 m was higher than that of the same species at 1219 m. Age-composition studies showed that the percentage of age-groups at each gonotrophic cycle differed with altitude, with the duration of the gonotrophic cycle of the three vectors being longer at higher altitude.

Although sporozoite rates were bound to differ with species, it was evident that altitude affected sporozoite development in a given species. While the mean sporozoite rate in *An. arabiensis* from 1219 m was 0.3%, it was significantly higher 5.3% at 1350 m and 5.5% at 1524 m in its closest relative, *An. gambiae s.str.* The sporozoite rates in *An. funestus* also showed an increasing trend, from 1.9% at 1219 m to 4.2% at 1350m and 4.0% at 1524 m. These differences occurred also in day resting populations, notably *An. gambiae s.str.* whose sporozoite rates increased from 3.7% at 1524 m to 5.3% at 1829 m and 12.5% at 2134 m. Irrespective of altitude, no sporozoite infections were detected in *An. zeimanni*, *An. pharaoensis* and *An. coustani*. In contrast to the sporozoite rates, the entomological inoculation rate (EIR) reduced with increasing altitude. The EIR was intermittent and unstable at 1524 m, medium at 1350 m and intense at 1219 m. This phenomenon was consistent with parasitemia rates observed in school children during the same period. A comparison of the three vectors revealed that *An. funestus* consistently had a higher entomological inoculation rate at each altitude than the other two vectors.

Bloodmeal analysis for pooled samples of the three vectors showed that at 1524 m feeding was predominantly on humans in contrast to both human and bovid feeding exhibited at 1350 m and 1219 m. Human feeding by *An. arabiensis* was only 28.8% in contrast to 63.5-72% for bovid feeding. However, human feeding was above 90% in both *An. gambiae s.str.* and *An. funestus* without significant variation in altitude. It is concluded that altitude, besides seasonal, ecological and climatic factors, has a significant effect on malaria epidemiology. In particular, malaria transmission albeit very low and intermittent, occurred also at the high altitudes, formerly popularly known as the "White Highlands", contrary to the long held notion that malaria did not occur in these areas of Kenya. The practical implications of these observations are that malaria control strategies against the mosquito vectors must be carefully selected in relation to altitude and their ecological diversity.

Topic 13 (1994) Dynamics of Malaria Transmission and its Epidemiology among Children Populations of Kilifi District, Coast Province, Kenya. (Ph.D. Thesis)

Objectives:

1. To determine anopheline species composition and abundance in relation to malaria transmission intensity and illness at two ecologically distinct sites in the Kilifi District in the Coast Province of Kenya.

2. To evaluate entomological risk factors for severe malaria in households with children suffering from severe malaria as compared with households with children having mild malaria.
3. To determine the blood-feeding and biting behaviour of anophelines in Kilifi District.
4. To determine the best sampling procedures for anophelines in areas of low vector abundance but high severe malaria incidence.

Abstract:

The transmission of *Plasmodium falciparum* was studied in relation to the incidence of severe malaria infections at nine sites in the Kilifi District in Kenya. Intensive mosquito sampling during a one-year period yielded *Anopheles gambiae s. l.*, *An. funestus*, *An. coustani*, *An. squamosus*, *An. nili* and *An. pharoensis*. *Anopheles gambiae s.l.* was the predominant vector, comprising 98.4% of the total anophelines collected. Overall, 3.5% of 2,868 *An. gambiae s.l.* collected indoors and 0.8% of 261 collected outdoors contained *P. falciparum* sporozoites. Transmission was detected during 10 months, with peak periods from June to August and December to January. In eight of the nine sites, entomologic inoculation rates (EIRs) averaged only four infective bites per year (range 0-18); an annual EIR of 60 was measured for the site with the highest intensity of transmission. The incidence of severe malaria infections, ranging from 8.6 to 38.1 per 1,000 children (0-4 years) was not associated with EIRs. At these sites on the Coast of Kenya, a high incidence of severe disease occurs under conditions of very low levels of transmission by vector populations. With respect to conventional approaches for vectors in Africa, decreases in transmission, even to levels barely detectable by standard approaches, may not yield corresponding long-term reductions in the incidence of severe disease.

Topic 14 (1996). Mosquito species (Diptera: Culicidae) and associated entomofauna breeding in tree holes and artificial containers in three adjacent forests in Western Kenya. (M.Sc. Thesis)

Objectives:

1. To determine the mosquito species and associated entomofauna that utilizes natural tree holes and artificial containers for breeding.
2. To compare the frequency with which mosquitoes utilize tree holes and artificial objects for breeding.
3. To determine the horizontal and vertical distribution of mosquito species along transects within and among the three forests.
4. To determine patterns of interspecific association in breeding sites among mosquito species.
5. To determine seasonal variation among the common mosquito species.

Abstract:

Results revealed 17 mosquito species of which 13 occurred in Kakamega forest and 11 each in the Kaimosi and South Nandi forests. *Aedes africaus* (Theob.) occurred in all the zones in Kaimosi forest but was more abundant in the closed canopy zone. Knowledge gained from these studies could assist in the understanding of the potential distribution of some of the common arboviruses harboured and transmitted by the incriminated vector mosquito species.

Topic 15 (2000): Study of the Efficacy of Chilli (*Capsicum* spp) and Onion (*Allium* spp) Aqueous Extracts as natural Pesticides for the control of insect pests of Tomato with emphasis on African Bollworm *Helicoverpa armigera* (HB) Lepidoptera: Noctuidae. (M.Sc. Thesis)

Objectives:

1. To evaluate the field efficacy of Chilli and Onion preparations for the control of tomato pests.
2. To evaluate under laboratory conditions the effects of Chilli and Onion preparations on *Helicoverpa armigera* (HB) larvae.
3. To assess the possible side effects of *Capsicum* spp and *Allium* spp when sprayed on natural enemies, beneficial insects and also on the vegetation in the field.

Abstract:

The African Bollworm *Helicoverpa armigera* (HB) is one of the major insect pests of agricultural importance. The larval stages of this insect causes direct reduction and quality losses of tomato yields, and also through the high cost of insecticides that must be used against it.

Two field experiments, i.e., (September 1999 – January 2000 and January – June 2000) were carried out. The field experiments were of randomised complete block design. Similarly, two experiments were conducted in the

laboratory. These investigations were initiated to determine the efficacy of the extract solutions from chilli and onion plants as control strategies against this notorious pest. The population of *H. armigera* in the tomato field plots was determined by weekly sampling during the two experiments of 1999 and 2000 respectively. The pest intensity values were used in conjunction with yield data to estimate crop loss with respect to the reduction in market value of the tomato fruits due to the lowering of their quality by damage caused by the *H. armigera* larval borers.

Effects of the Chilli and onion aqueous extracts in a mixture of soap solution was determined by leaf-dipping experiments on which the larvae were allowed to feed which assessed the optimum dose of the solution. The soap solution was used to act both as a solvent and/or carrier.

The mean larval intensity during the first experiment was not significantly different ($p > 0.5$) between treatments and did not greatly affect the yield of marketable tomatoes that were harvested. On the other hand, the second experiment in 2000 revealed that larval intensity was highly significant ($p > 0.001$) between treatments.

Comparisons of the effect of field sprayed chilli solutions revealed that the difference between them was not significant. This was in contrast with the effect of chilli when leaves were dipped into it and fed on the larvae. The difference between treated and untreated leaves was significantly high at $p > 0.001$. This indicated that the chilli solutions contained insecticidal repellents that prevented the larvae from feeding freely. The mortality rates of larvae among the treatments in which they were totally immersed in chilli, onion and mixtures of chilli and soap solutions as compared to the control treatments were highly significant at $p > 0.001$. This confirmed that there were insecticidal activity properties in chilli and onion solutions. Therefore, the use of these plant materials can contribute to the enhancement of the IPM implementation programmes.

Topic 16 (2002): Responses of the spotted maize stemborer moth *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae) to the bacterium bioinsecticide *Bacillus thuringiensis* Berliner formulations in Kenya. (M.Sc. Thesis)

Objectives:

1. To quantify the effects of geographic isolation (allotropy) and altitude on the three widely distributed populations of the spotted maize stemborer moth *C. partellus* by determination of their responses to various strains of the bacterium bioinsecticide *Bacillus thuringiensis*.
2. To determine the genetic variations between the three *C. partellus* allopatric populations using the Random amplified polymorphic DNAs (RAPDs).

Abstract:

This study sought to quantify the effects of geographic isolation (allotropy) and altitude on three widely distributed populations of the spotted stemborer *Chilo partellus* (Swinhoe) a pest maize crops by determining their response to various strains of the bioinsecticide *Bacillus thuringiensis* (Bt). The findings would serve to illustrate the perception since the Darwinian ages that geographic isolation and temperature variations due to altitude are some of the important factors that cause speciation and thereby promoting the evolutionary process. These factors are said to bring about genetic changes in individual organisms, which are then spread through its population or are eliminated.

Three populations of *C. partellus* were selected from widely separated locations approximately 500 km apart, namely, Muhaka in the Coast Province, Katumani in Eastern Province and Mbita in Nyanza Province. Although the localities differ ecologically, they all are suitable for maize crop farming and hence harbour the stemborer insect species under study.

The bioassay technique which depend on the quantal or all-or nothing response to quantify the biological activity of serially diluted samples was performed using various concentrations of Dipel (a commercial Bt formulation from Abbot Laboratories) and a local Bt isolate named ICPE 023. For these Bt serial dilutions, the quantal response sought from the test insect *C. partellus* was genetic variations between the three populations as revealed by percentage mortality and determined by random amplified polymorphic DNA (RAPD) analysis.

Results with Dipel 0.250 g/l showed that there were significant differences at $\alpha 0.05$, with a calculated F-value of 6.11 against a critical F-value of 3.27. According to Tukey's groupings analysis, the source of genetic variation between the populations was from the Mbita sample. Similarly, at dose of 0.375 g/l Dipel, there were significant differences in the genetic composition of the three *C. partellus* at a lower calculated F-value of 4.77 against the same critical F-value of 3.47 and the source of variation was again the Mbita population. But the variations in the genetic make up of the populations were not significant at the highest dose of 0.500 g/l Dipel.

Due to these significant genetic variations, it was inferred that the geographically isolated *C. partellus* populations contained enough variation to warrant distinctive races or even sub-species. This observation was supported by the Nei's diversity estimate test for the genetic material of each population, which also revealed significant genetic diversity in Muhaka populations of $H=0.3724$, followed the Katumani population of $H=0.3069$, while the least diversity was found the Mbita population with a mean diversity estimate of $H = 0.2716$.

However, the notion of distinctive races was not supported by the analysis of the same data using molecular variance (AMOVA). This method gave the percentage of variations within populations as much as 91.67% and that between populations as little as 8.33%. Clearly, this showed that there was very little difference between the genetic composition of the three allopatric populations suggesting some gene flow between them. The Nei's genetic distances grouped together into the same cluster the Mbita and Katumani populations while the Muhaka one formed a separate cluster of its own. This indicated that the populations at Mbita and Katumani are more closely related.

Overall, these investigations revealed that although there was varied genetic diversity between the three *C. partellus* populations in Kenya, allopatry was not responsible. Likewise, this diversity may not be enough indicator for the formation of distinctive new species. However, there is a strong indication that genetic factors are responsible for *C. partellus* tolerance to Bt as evidenced by high percentages of mortality probably due to the genetic diversity narrowed down by possible environmental bottlenecks which were not accounted for in this study.

Topic 17 (2005): A study of the factors influencing Aphids (Homoptera: Aphididae) vectors of viral diseases of Kale and Cabbage (*Brassica oleracea*) vegetables in Kenya.
(M.Sc. Thesis)

Objectives:

1. To elucidate the factors which influence the ability of different aphid species to transmit viral diseases to brassican plants in Kenya.
2. To determine the efficiency of aphid species in transmitting viruses to brassican plants in Kenya.
3. To determine the effect of the age of brassican cabbage plants on aphid virus transmission.
4. To determine the persistence of transmission of viruses on brassican cabbage plants by the three common vegetable aphids species in Kenya.
5. To establish the relationship between aphid population dynamics and virus plant diseases.

Abstract:

Insect Aphids (Homoptera: Aphididae) are important crop pests because of their ability to carry plant viruses and the effect of their fluid sucking damage from plants thereby affecting plant growth. Some of the factors influencing aphids as vectors of plant viral diseases were investigated in the laboratory and field using kale and cabbage plants of the family Cruciferae in genus *Brassica*.

A laboratory experiment was designed to determine the effect of aphid species and host plant ages on viral transmission. Three aphids *Brevicoryne brassicae* L., *Myzus persicae* Sulz. and *Lipaphis erysimi* Kalt. species were used to transmit two viruses Cauliflower mosaic caulimovirus CaMV and Turnip mosaic Potyvirus TuMV to kale plants that were three, seven and eleven weeks old. No significant difference in the efficiency of transmission of CaMV and TuMV was observed between the aphid species. Similarly, the plant ages did not influence virus transmission.

In the second experiment designed to determine the persistence of transmission of CaMV and TuMV by the 3 aphids by exposing kale plants at one-true-leaf stage to and individual viruliferous aphids showed that *M. persicae* and *L. erysimi* than *B. Brassicae* transmitted the viruses. These differences were however insignificant at $p < 0.5$.

Field experiments to determine the effect of aphid population dynamics on virus incidences in November 2000 to March 2001 and in June to October 2001 at more than one site each showed that aphid scores in straw mulched plots were significantly lower than the non-mulched plots at $p= 0.028$. The opposite was true for the difference observed for virus infections in the nurseries. The virus incidences were positively correlated with the number of alate aphids which were in turn correlated to aphid populations and rainfall regimes in the experimental period. There was a positive correlation between relative humidity and populations of the aphids *M. persicae* and the opposite was true for the aphid *B. Brassicae*.

Topic 18 (2005): Studies on the potential non-target effects of the bacterium *Bacillus thuringiensis* Berliner *CryIb* toxin on two parasitoids *Cotesia flavipes* Cameron and *Xanthopimpla stemmator* Thunberg of the maize stemborer moth *Chilo partellus* (Swinhoe) and the butterfly *Acraea eponina* Cramer. (Ph.D. Thesis)

Objectives:

1. To elucidate the potential risks of adopting the bacterium *Bacillus thuringiensis* (*Bt*) maize on parasitoids of the stemborer *Chilo partellus* and larvae of the butterfly *Acraea eponina*.
2. To evaluate the effects of *Bt CryIAb* toxins on the fitness of the parasitoid wasp *Cotesia flavipes* in the control of the stemborer moth *Chilo partellus* larvae.
3. To evaluate the effects of *CryIAb* toxins on fitness of the parasitoid wasp *Xanthopimpla stemmator* in the control of the stemborer moth *Chilo partellus* pupae.
4. To evaluate the effects of *Bt CryIAb* toxins in *Bt* maize pollen spores on the survivorship of the butterfly *Acraea eponina* larvae.

Abstract:

A risk assessment was used for measuring the harmfulness caused by *Bacillus thuringiensis* (*Bt*) bacterium labelled MON810 maize to parasitoids that feed on maize moth pests in Kenya. The same factor was used for measuring the harm caused to the butterfly caterpillars that accidentally ingest pollen deposited onto their host plants. Experiments were designed using purified *CryIAb* toxin and two stembore wasp parasitoids, *Cotesia flavipes* Cameron (Braconidae) and *Xanthopimpla stemmator* Thunberg (Ichneumonidae). Larvae of the butterfly *Acraea eponina* Cramer (Acraeidae) were used in the studies of *Bt* maize pollen spores on caterpillars. In the experiments on the effects of host-ingested *Bt* toxins on parasitoids, neonate larvae of the stem borer *Chilo partellus* (Swinhoe) (Crambidae) were fed on artificial diet with purified *CryIAb* toxin at 0.005 ml and 0.01 μ /ml. Controls included phosphate buffered saline (PBS) to check for its effect as a solvent for the toxin, and a normal diet. *C. partellus* larvae at the age of 25 days were brought into contact with mated females of *Co. flavipes* and parasitized. Three days old pupae were parasitized by *X. stemmator* in paper straws. Parameters like host weights, developmental time, number of progeny, immature mortalities, egg loads, oviposition rates, longevity and adult sizes were assessed. Experiments on effects of *Bt* maize pollen spores on butterfly larvae involving planting of non-*Bt* maize on plots, while *Waltheria indica* L., a host plant for *Acraea eponina*, were planted in plastic pots. The host plants were arranged at different distances in four directions of maize plots during anthesis. Densities of maize pollen deposited on the host plant leaves were estimated using a 0.25 cm² wire quadrat. The maximum density encountered was 492 grains/cm². These densities were converted to *Bt* toxin concentrations basing on *CryIAb* levels in MON810 variety. The toxins were fed to *A. eponina* 2nd and 4th instar on leaf discs and their mortalities were recorded daily.

The effects of *Bt CryIAb* toxin on *Co. flavipes* included reduction in host weights, production of few progeny, longer development time and higher immature mortality, oviposition of fewer eggs, smaller egg loads, short life span, and small adult size. For the parasitoid *X. stemmator*, the toxin caused reduction in weights of host pupae that suffered high mortality when parasitized by the wasp. The experiments on effects of *Bt* maize pollen spores on *A. eponina* larvae recorded high mortality of both 2nd and 4th instar larvae. The results indicate that introduction of *Bt* maize would harm parasitoids and butterfly larvae. An ecological imbalance may result as a consequence of these effects. More research should therefore be carried out using the actual transgenic plants prior to any introduction of *Bt* maize in Kenya.

Topic 19 (2005): The impact of human land use activities and seasonal changes on dung Beetles (Insecta: Coleoptera) diversity of the Kakamega Forest ecosystem. (M.Sc. Thesis)

Objectives:

1. To study the effects of land use modes and seasonal changes on the abundance, guild structure and species diversity of coprophagous beetles in the Kakamega forest and the surrounding farmlands.
2. To survey and compare dung beetle abundance and guild structure between the primary, the and secondary forests, and ungrazed and grazed grassland pastures bordering the forest to determine the effects of human activity on the guild structure of dung beetles.
3. To correlate differences in the structure of the dung beetle assemblages with the seasonal changes in the forest and the surrounding farmlands to determine the effects of seasonal changes on the beetle guild structure.

Abstract:

Based on quantitative comparative data collected in the Kakamega Forest and adjacent farmlands between October 2002 and August 2003, analyses were made to ascertain the extent of the different modes of land use, and seasonal changes on the beetle guild structure, abundance and their diversity. Data collection methodology included deposition of 10 standard samples of 1 kg fresh cow dung on standard areas in the various habitats in each season at night and during the day to attract the beetles which were then recovered using the floating method.

The 80 samples yielded a total of 21,604 beetles representing the families Scarabaeidae, Hydrphilidae, Staphylinidae and Histeridae. The dominant family Scarabaeidae contained category guild groups of tunnelers, dwellers, and rollers.

The studies revealed that the extensive cattle grazing and forest degradation influenced both the guild structure and abundance of the dung beetles. There was high abundance in the grazed grasslands followed by the ungrazed grasslands. All the studied habitats had a significant conditional effect on the beetle family abundance and their guild structure indicating strong association with different habitat locations. Beetle day dwellers were significantly associated with the primary forest, tunnelers with the secondary forest, while rollers and families Staphylinidae and Hydrophilidae were associated with the ungrazed grasslands.

Dung beetle assemblages were significantly affected by seasonal changes and human activities. More beetles were collected during the rainy than in the dry seasons.

The differences in the beetle guild structure, abundance and species diversity revealed by these studies could be good predictors of susceptibility of habitat degradation for the Kakamega forest by human land uses and seasonal changes.

Topic 20 (2007). Indigenous botanical pesticides for use in integrated pest management (IPM) of insect pests of brassicas by small scale farmers in Kenya.

Objectives:

1. To acquire and evaluate local farmers' indigenous knowledge for the control of insect pests of brassicas.
2. To elucidate the efficacy of the two not yet widely accepted plant extracts namely chilli and marigold against the Diamond-black moth, *Plutella xylostella* L., and the Cabbage aphid, *Brevicoryne brassicae* L., in kale.
3. To demonstrate the potential for the reduction of the frequency of spraying chemical insecticides against insect pests of brassicas by using them in combination with botanical formulations.
4. To illustrate the efficacy of chilli extracts in the laboratory bioassays.

Abstract

A survey of the knowledge of indigenous farmers in the selected locations of Kiambu, Maragua and Machokos districts in Central and Eastern Provinces of Kenya was carried out to determine their understanding of practical aspects of crop pest management procedures and methods. To test the insecticidal efficacy of the syrup concentrations made from the African marigold plant, *Tagetes erecta*, and of the chilli plant, *Capsicum frutescens*, on the diamondback moth (DBM), *Plutella xylostella* L. and the cabbage aphid, *Brevicoryne brassicae* L., quantities of 3200g/l and 50g/l fresh aqueous extracts of these plants were prepared in a laboratory and sprayed after 24 hours in kale crop fields against the DBM and the aphids. Field experiments to determine the effects of reduced frequency use of chemical insecticides were also carried out alternating with chilli aqueous extracts to determine the effects of reduced use of chemicals by 50 percent on crop yields. Laboratory experiments to determine best dose of chilli aqueous freeze-dried extracts were carried out by testing various concentrations of chilli aqueous extracts for their efficacy against the laboratory reared 3rd instar DBM larvae. Anti-feedant effects of the extract were assessed by introducing DBM larvae on a treated food (leaf). It was found that the farmers in the districts studied had time-tested and in-depth knowledge on modern chemical insect pest control issues. Repellent effects and insecticidal properties of liquid concentrations of the African marigold plant and of the chilli plant on the diamondback moth larvae and the cabbage aphids were observed. The field experiments revealed that both DBM larval intensity and cabbage aphids' scores were significant between the treatment. The effects of the treatments on the actual crop yields varied. Results from replicate experiments showed significant differences in yields between the treatments. Treatments with marigold had a negative impact on the kale leaves in that all the plots sprayed with marigold syrup showed leaf scorching which could have contributed to less crop yield compared to all the other treatments. It was also observed that these botanicals had no impact on the natural enemies of the insect pests and on diseases such as virus and bacterial black rot. Results from the second field experiment for the reduction of the frequency use of diazinon insecticide showed that differences in the harvested leaves from the weekly sprayed plots with chemicals were not

significantly different from those of the plots sprayed with chemicals one week and alternated with chilli in the following week. Drastic reduction of food intake of the insect pests in the laboratory experiment was observed as concentration increased. Repellent effects of the chilli extracts were particularly significant as the concentration increased. However, larval mortality was not significant but it was proportional with the increment of the extract concentration. The combination of repellent effects, antifeedant and stomach poisoning of the chilli extract would make chilli products an alternative strategy on the vegetable insect pest control and could reduce the frequent use of chemical insecticides for environmental safety.

Topic 21 (2008): Indigenous botanical pesticides for use in Integrated Pest Management (IPM) of insect pests of Cabbage (*Brassica oleracea*) vegetables by small scale farmers in Kenya. (Ph.D. Thesis).

Objectives:

1. To acquire and evaluate local farmers' indigenous knowledge for the control of insect pests of brassican (Cabbage) vegetables.
2. To elucidate the efficacy of two plant extracts namely, chilli and marigold for the control of the brassican vegetable common insect pests, the Diamondback moth *Plutella xylostella* (L.) and the aphids *Brevicoryne brassicae* L. To demonstrate the potential for the reduction of the frequency of spraying chemical insecticides against insect pests of brassican vegetables by using them in combination with botanical formulations.
3. To illustrate the efficacy of chilli extracts in laboratory bioassays.

Abstract:

A survey of the knowledge of indigenous farmers in the selected locations of Kiambu, Maragua and Machakos districts in Central and Eastern Provinces of Kenya was carried out to determine their understandings of practical aspects of crop pest management procedures and methods. To test the insecticidal efficacy of the syrup concentrations made from the African marigold plant (*Tagetes sp.*) and of the chilli plant (*Capsicum sp.*) on the diamondback moth (DBM) (*Plutella xylostella* L.) and the cabbage aphids (*Brevicoryne brassicae* L.), quantities of 300g/l and 50g/l fresh aqueous extracts of these plants were prepared in the laboratory and sprayed after 24 hours in kale crop fields against the DBM and aphids. Field experiments to determine the effects of reduced frequency use of chemical insecticides were also carried out alternating with chilli aqueous extracts to determine the effect of reduced use of chemicals by 50% on crop yields. Laboratory experiments to determine best dose of chilli freeze-dried extracts were carried out by testing various concentrations of chilli aqueous extracts for their efficacy against the laboratory reared 3rd instars DBM larvae. Antifeedant effects of the extracts were assessed by introducing DBM larvae on treated food (leaf).

It was found that the farmers in the districts studied had time-tested and in-depth knowledge in farming practices and pest control strategies but lacked knowledge on modern (chemical) insect pest control issues. Repellent effects and insecticidal properties of liquid concentrations of African marigold plant and the chilli plant on diamondback moth larvae and cabbage aphids were observed. The field experiments revealed that both DBM larval intensity and cabbage aphids' scores were significant between the treatments. The effects of the treatments on the actual crop yields varied.

Results from replicate experiments showed significant differences in yields between the treatments. Treatments with marigold had a negative impact on the kale leaves in that all the plots sprayed with marigold syrup showed leaf scorching which could have contributed to less crop yield compared to all the other treatments. It was observed that these botanicals had no impact on the natural enemies of the insect pests and on diseases such as virus and bacterial black rot. Results from the second field experiment for the reduction of the frequency use of diazinon showed that differences in the harvested leaves from weekly sprayed with chemicals were not significantly different from those of the plots sprayed with chemical one week and alternated with chilli in the following week. Drastic reduction of food intake of the insect pests in the laboratory experiment was observed as concentration increased. However, larval mortality was not significant but it was proportional with the increment of the extract concentration. The combination of repellent effects, antifeedant and stomach poisoning of the chilli extract would make chilli products an alternative strategy on the vegetable insect pest control and could reduce the frequent use of chemicals for environmental safety.

Topic 22 (2009): Influence of relative humidity on the growth and development of the Mite *Typhlodromalus aripo* De Leon (Acari: Phytoseiidae): Evidence from Laboratory and Greenhouse experiments. (M.Sc. Thesis)

Objectives:

1. To determine the effects and relationships between various relative humidity regimes on growth and developmental stages of the predatory mite, *Typhlodromalus aripo* De Leon.
2. To describe the life cycle and development of *T. aripo* from egg through larval, protonymph, deutonymph and adult at specified relative humidity regimes.
3. To elucidate the relationship between the mortality of the life cycle stages of *T. aripo* and relative humidity regimes.
4. To determine the optimal relative humidity for rearing *T. aripo* in greenhouses in the lower, moderate and upper regimes.
5. To evaluate greenhouse mass rearing of *T. Aripo* in Eastern Kenya at the KARI-Katumani Research Station for release in farmer's fields.

Abstract:

The influence of selected relative humidity regimes on the development and growth of the various immature stages from egg to adult of the predacious mite *Typhlodromakus aripo* de Leon was studied in the laboratory at a constant temperature of $27 \pm 2^\circ \text{C}$. A related greenhouse study where the temperatures and relative humidity fluctuated closely paralleling the outdoor conditions in Eastern Kenya Province was also carried out. *T. aripo* was raised on its natural diet of phytophagous cassava green mites, *Mononychellus tanajoa* Bondar, reared on cassava apices of young stems. Development was measured as the life history of the mite, that is, the total duration of development from egg to egg; whereas growth was determined as the duration in days it took each immature stage to change into the next stage.

A coefficient of correlation between the mite developmental period or life cycle duration and relative humidity showed that there was a negative relationship between decreasing relative humidity and the length of development or duration of the mite's life history. In other words, a decrease in the relative humidity increased the duration length of the life history which also resulted in increased mortalities. Similarly, there was a negative relationship between the fecundity or the number of offspring (eggs) produced by individual female mites with respect to lower relative humidity regimes. In this case the growth period of individual young stages was not affected by either low or high relative humidity levels. The tendency by *T. aripo* motile cohorts to aggregate at the fresh cassava apices than at the older or wilting ones was an indication that they were attracted to areas of high relative humidity regimes usually caused by transpiration. These findings on the relationships between relative humidity regimes and the life cycle durations of the stages of mites allows a better understanding of its population dynamics. In a similar experiment the current study has confirmed these findings. The knowledge gained will contribute to mass rearing methods of this predacious mite in greenhouse for further release in cassava fields for biological control of the cassava green mite pest.

Topic 23 (2011): Assessment of current Malaria transmission levels and Potential behavioural changes of people and adult mosquitoes in Emutete Village, Western Kenya after increased use of Insecticide Treated Nets (ITNs). (M.Sc. Thesis)

Objectives:

1. To assess the current malaria transmission levels and the potential behavioural changes both in man and adult mosquitoes after increased use of ITNs in the Ematete village, Emuhaya County, Western Kenya.
2. To determine the indoor resting malaria vector mosquito densities in the study area.
3. To determine the entomological inoculation rate in the study area
4. To establish the current level of ownership and utilization of the INTs by means of a questionnaire.
5. To determine the occurrence of early biting behaviour in malaria vectors.

Abstract:

A longitudinal study in Ematete village Emuhaya County Western Kenya was conducted in the houses to the collect monthly indoors resting malaria vector mosquitoes for eight months from September 2009 to April 2010. Species were identified both morphologically and by the PCR technique to determine the dominant malaria vector in the area. Infective rates were carried out by use of the Enzyme Linked Immunosorbent Assay (ELISA) method to enable the generation of an entomological inoculation rate. Bednet coverage, utilization and

ownership were monitored through a questionnaire approach administered among the school children and shifts in man-biting rates were determined by use of the CDC light traps bi-weekly for four months.

A total of 142 adult malaria mosquito vectors were collected with *An. gambiae* s. s. as the principal malaria vector. The mean human biting rate for eight months was 0.12, with an infectivity proportion rate for circumsporozoite for *Plasmodium falciparum* being 2.5%. These measurements yielded a transmission intensity of 1.1 infectious bites per person per year. An overall ratio of 71%:95% CI 66-76% of households owned nets of this proportion parents had a proportion of 59.2%; and children below 5 years 42.8% and above five years 35.8%. Of this proportion 87.3% were from the hospital and 12.7% from the shops. There was a significant difference between the proportion of parents who owned nets to that of children below and above 5 years ($p << 0.001$) and the proportions that obtained their bed nets from hospital to those from the shops ($p << 0.001$). Proportions that slept under the bednet the night before the study was 48.6%; those who slept under bednets always 39.6%, and 35.4% sometimes sleep under a bednet and 23.1% never sleep under a bednet. The proportions that slept under bednets the previous night were not significant to those that always slept in the net ($p = 0.0783$), but was significantly so when compared to those sleeping under the net sometimes ($p=0.0078$) or never slept under the net ($p = 0.001$). The early biting rates were higher than the late biting rates for all three mosquito species, however the mean biting rate (2.9) was not significantly higher than the mean late biting rate (2.6: $t = 0.1626$, $df = 4$, $p = 0.8787$).

These results show that the malaria transmission intensities are still reducing after the increased bed net use though the pace could be affected with the effects of the ITNs on the behaviour the people and adult mosquitoes. Thus monitoring should continue on the behaviour of the adult mosquitoes to establish their biting trend.

Topic 24 (2012): Biology and ecology of the coffee berry Fruit flies (Diptera: Tephritidae) on the University of Nairobi Farm, Kabete Kenya. (M.Sc. Thesis)

Objectives:

1. To determine the reproductive biology of fruit fly pests in coffee crops in Kenya.
2. To compare the life cycles of the identified fruit fly coffee pests.
3. To determine the timing of emergence activities of both the larvae and the adults of coffee fruit fly pests from their habitats.
4. To determine the oviposition behaviour of the coffee fruit flies on coffee berries.

Abstract:

Past literature reveals that the basic biological and ecological studies in Kenya on the coffee fruit flies were conducted nearly half a century ago. It is on the basis of this back-drop that these studies were initiated to update knowledge on the biology and ecology of the coffee berry fruit flies in view of the changing farming practices and the climate. The experiments were carried out on the University of Nairobi coffee farm at the Kabete Campus. The specific objectives were to compare the life cycles of the coffee berry fruit flies; to determine the timing of the emergence of the larvae the berries and the adults from the pupae in the soil; and to determine the oviposition behaviour of the flies on coffee berries at different stages of their maturation.

The flies were identified by their morphological features and the three found species were: *Ceratitis capitata* Wied, *Ceratitis rosa* Karsch and *Trirhithrum coffee* Bezzi. Durations taken for maturation of immature stages in each species were determined by the Friedman test based on the hypothesis that there are no differences in the number of days required to complete development between the three species. Timing of emergence activities by the mature larvae and adults from pupae in the soil was contrasted between two groups one studied under controlled conditions in the laboratory at 20°C and the second group observed out-doors in natural conditions in the field. Five berry categories: immature green, mature green, mature green-yellow, mature-yellow-red, and mature-red were established and presented to gravid fruit flies for oviposition. Ovipunctured berries were dissected to recover eggs and larvae. All three species synchronized their oviposition with regard to the most preferred mature-red berries.

By analysis of variance, there were significant differences at $p \leq 0.05$ between preferred berry categories for oviposition by the flies with the mature-red berries being dominant. No eggs were oviposited in the immature green berries. There was no difference between the three species in the egg incubation period. By the Friedman test, variations in the larval and pupal developments were significant at $p < 0.05$. The emergence activities of the fruit flies occurred in the early hours of the day when temperatures were low which by selective pressure would reduce mortality rates and promote adult populations. Overall, the life cycles were similar to the previous

records. Knowledge on synchronization of oviposition by the three fruit fly species would be useful for designing sound cost effective management programmes for the notorious coffee fruit fly pests in Kenya.

**C. SPECIAL PUBLICATIONS, PROCEEDINGS & SCIENTIFIC REPORTS
CONFERENCES:**

1. **1974** Khamala, C.P.M. and Dingle, H. "What tropical Africa can contribute to ecology", UNESCO BULL. SCI. & TECH. Nairobi.
2. **1976** Khamala, C.P.M. "Teaching and practice of Apiculture in Kenya". Opening address at the seminar on "Apiculture Training for Teachers", Farmers Training Centre, Ngong, Min. of Agriculture
3. **1977** Khamala, C.P.M. Insects of medical and veterinary importance associated with water resources and some aspects of their control by water resource management, in: water Resources in Development (Eds. Castelino, J.B. and Khamala, C.P.M., *Kenya National Academy for Adv. of Arts and Sciences*, P. 130-136.
4. **1977** Khamala, C.P.M., and M. O. Odindo, The use of microbes in biological control of insect pests and vectors in Kenya. In: Proceedings of 5th Intern. Confr. on Global Impact of Applied Microbiology, Bangkok, Thailand, 22-29 Nov., 1977.
5. **1978** Khamala, C.P.M., "Organizing aspects Agricultural development: Human aspects in the utilization of Science and Technology", *Proceedings of Founding meeting of the African Association for Advancement of Science and Technology*". Dakar, Senegal, 15-19 July.
6. **1978** Khamala, C.P.M., "Science education for development. In Science and Technology for Development", *Kenya National Academy for Advancement of Arts Sciences*, Nairobi p. 4
7. **1978** Khamala, C. P. M., "Science Policy for Kenya and expectations to an international co-operation". Paper read at the International Symposium in "Basis Research on Technology for Development". Berlin (West Germany) 13-15 December.
8. **1978** Khamala, C.P.M. "Production of capital goods in the Framework of rural industrialisation in developing countries". Paper read at the International Symposium on "*Basic Research on technology for Development*". Berlin (West Germany), 13-15, December.
9. **1978** Khamala, C.P.M. "Pests of grain legumes and their control in Kenya. In: grain Legume Pests: Their Ecology and Control". (Eds.) R.S. Singh, H. van Emden, T.A. Taylor. *Academic Press*, London, P. 127-137.
10. **1978** Khamala, C.P.M., Oketch, L. and Okeyo Owuor, J. B. "Insect species associated with *Cajanus cajan* (L) Millsp. (Pigeon pea) in Kenya and their seasonal occurrence, Kenya". *Kenya Entomology. Newsletter*, **8**: 3-5.
11. **1978** Khamala, C. P. M., and Okeyo-Owuor, J. N., "Studies on Insect pod borer infestations on *Cajanus cajan* (L.) Millsp. (Pigeon Pea) under different insecticidal spraying regimes in the Kenya Highlands, Kenya, *Entomol. Newsletter*, 8:5-7.
12. **1979** Khamala, C.P.M. "Ideas to the United Nations Conference on Science and Technology for Development in the field of information". Paper read at 39th Congress of the International Documentation Federation (FID), Edinburgh, Scotland, 13-19 September and *POST-Kenya*, Vol. **4** (2): 22-23.
13. **1979** Khamala, C.P.M., "Co-ordinated information and documentation services as integral parts of the application of Science and Technology to Development in

- Eastern Africa". Paper read at the World Future Studies Federation Conference on "Science and Technology and the Future". Berlin (West Germany 8-10 May 1979.
14. **1979** Khamala, C.P.M., "Insect and disease control". *POST Kenya*. Vol. 4(2): 7
 15. **1979** Khamala, C.P.M., and Olubayo, F.A., "Comparative study on development of Bean beetle *Acanthoscelides obtectus* (Say) in bean, cowpea and pigeon pea seed diets". Proceedings of symp. on grain legume improvement in E. Africa", Faculty of Agriculture, University of Nairobi, 20-24 Aug. 1979.
 16. **1979** Khamala, C.P.M. and Mabonga, F., "Studies on minimum use on insecticides against major insect pest of cowpeas in Katumani Dryland Research Station, Kenya". Proceedings of Symp. on Grain Legume Improvement in E. Africa," Faculty of Agric. University of Nairobi 20-24- Aug., 1979.
 17. **1979** Khamala, C.P.M. and Khaemba, B. M., "Resistance of cowpeas to common pod sucking coreid Bugs (*Anoplocnemis curvipes* F. and *Riptortus dentipes* F. (Coreidae: Hemiptera). Proceedings of Annual Seminar for Cowpea Research", IITA, Ibadan, Nigeria, 15-19
 18. **1980** Khamala, C.P.M. "The human aspects in the utilization of science and technology for agricultural development". *POST, Kenya* Vol. 5 (3), 5-7.
 19. **1980** Khamala, C.P.M. "A survey of Reading Habits and Preferences among Nairobi and Lower Secondary School Children: Foundation stones for a Notional; Book Policy in Kenya". - A report, Kenya National Academy for Adv. and Arts & Sci., March 1980.
 20. **1980** Khamala, C.P.M. "Promotion of Public understanding for Science and Technology: the Kenyan experience". Paper read at the OAU/ECA/AAAST Symposium on "Culture and Technical Dimensions of African Development", Addis Ababa, 10-15 March, 1980.
 21. **1980** Khamala, C.P.M., "Science and Technology for African Development: An Assessment of their Achievements and prospects". Paper read at the Afro-German Conference on "Higher Education for Development", Education report (Bildungsreport) Nr. 12 Esinborn/ Nairobi, December, 1980.
 22. **1980** Khamala, C.P.M. "The World Dimensions of the Community of the Black Peoples: The role of science and Technology in the cultural development of the Black Community with reference to Africa and its Diaspora". Paper read at First Pre-Colloquium of the 3rd World Black African Festival of Arts and Culture (FESTAC). Dakar, Senegal, 13-15 December, 1980.
 23. **1981** Khamala, C.P.M. "The current situation on Post-Harvest Food losses in Kenya". Paper presented at the Workshop on "Towards self-sufficiency in food production of harvest losses", African Regional Centre for Technology, Dakar, Senegal, and 23-27 November 1981.
 24. **1981** Khamala, C.P.M. "Technology available for fisheries residue and prospects of their utilisation in Kenya, *POST, Kenya*. Vol. 6 (1): 17-21.
 25. **1983** Khamala. C.P.M. "The Role of development aid organizations and their funds in education and training in Africa". Consultancy paper prepared for the International Conference on Education and Training for Agricultural Library and Information Work. 7-12 March 1983, Nairobi.
 26. **1983** Khamala, C.P.M., "The role of Regional organizations and Associations in strengthening research and development in developing countries". Consultancy paper

- prepared for the First World CISTOD Congress on: Interdependence and self-reliance: The Promises and Limitations of Science and Technology and the role of the Non-Governmental Organizations acting concert". 11-15 April 1983, Tunis, Tunisia.
27. **1983** Khamala, C.P.M. "Constraints to fertilizer use in the management of insect and other pest", *POST Kenya*, Vol. 7 (1-8): 10-12.
 28. **1987** Khamala, C.P.M. "Control of Bedbugs in Kenya". *POST Kenya*. Vol. 8:
 29. **1991** Karanja, D. and Khamala, C.P.M. Ecological studies on *Anopheles* mosquitoes in the small scale rice farms at the Ahero Rice Irrigation Scheme in Western Kenya. KEMRI/ KETRI ANNUAL PROC.
 30. **1995** Resources person and Chairman for the Session on "Pests and insect infestations: Desert Locust, armyworms qualea birds and weevils as devastating agents on crops. 3rd African Sub-Reginal Workshop on "Natural Disaster Reduction" Conducted by the UN Department of Humanitarian Affairs; Nairobi, Kenya, August.

D. CONSULTANCY REPORTS:

1. ECA: Study on the impact of local research and development in agriculture and agricultural development: report of a mission to selected African countries: Sudan, Ghana, Cameroon and Zambia. ECA, Addis Ababa (Ethiopia).
2. 1982 African Regional Centre for Technology: Inventory of scientific and technological establishments and equipment in Botswana, Malawi, Madagascar, Mozambique, Kenya and Lesotho. ARCT, Dakar, Senegal.
3. 1983 K.E.M.R.I: Research Programmes and Projects; K.E.M.R.I., Nairobi.
4. 1984: Kenya Wildlife Fund Trustees & Unep Ecological studies in Kakamega Forest as a sample unit in the global strategies of conservation in vulnerable tropical ecosystems with special references to the insect status, K.W.F.T., Nairobi
5. 1984 MIRCEN: Use of microbial genetic resources for controlling insect pests and vectors in developing countries, MIRCEN, Nairobi.

E. BOOKS:

1. 1977 Castelino, J. B. and Khamala, C. P. M. (Eds.). *The Role of Water Resources in Development*, Kenya National academy for Adv. of arts & Science, Nairobi.
2. 1978 Khamala, C. P. M. and Castelino, J.B. (Eds.) *Energy Resources in E.A. Kenya National Acad.*, for Adv. of Arts & science, Nairobi.
3. 1979 Khamala, C. P. M. (Ed.) *Science and Technology for Development*, Proceedings of Seminar, 21-24 March, Nairobi, 215pp.
4. 1979 Khamala, C. P. M., (Ed.). *Science and Technology and the Future. A report on Proceedings of the African Regional Symposium*, 10-12 July, Nairobi, Kenya.
5. 1996 Khamala, C. P. M. *Lecture Notes on History and Philosophy of Biology*.
6. 2015 Mutisya, D., G.P.. Khamala and E.M. El Banhawy "Cassava mite species identification and modelling for pest management" Lambert Academic Publishing Go., Gemany, ISBN 97&3.659-671,1S3, (2015).

F. BOOKS FOR THE SELF-CONTAINED OPEN DISTANCE LEARNERS' PROGRAMME

1. **Khamala, C.P.M. (2007)**. *Evolutionary Biology: Self-contained study manual for the Open Distance Learners Programme (ODL)*
2. **Khamala, C. P. M. (2005)**. *Dictionary of Zoology*

3. **Khamala, C. P. M. (2008).** History and Philosophy of Biology: Self-contained study material for the Open Distance Learners Programme – Lecture Notes for 4th Year Course for the Bachelor of Science (B. Sc.) Degree
4. **Khamala, C. P. M. (2008).** Principles of Insect Pathology: Self-contained study manual for Regular and Distance Learners Programmes - Lecture Notes for 4th Year Course for the Bachelor of Science (B. Sc.) Degree
5. **Khamala, C. P. M. (2009).** Management and Control of Vectors and Parasites of Human Diseases. Self-Contained Manual of Lectures and Practical Exercises for Master of Science (M. Sc.) Degree in Medical Entomology.