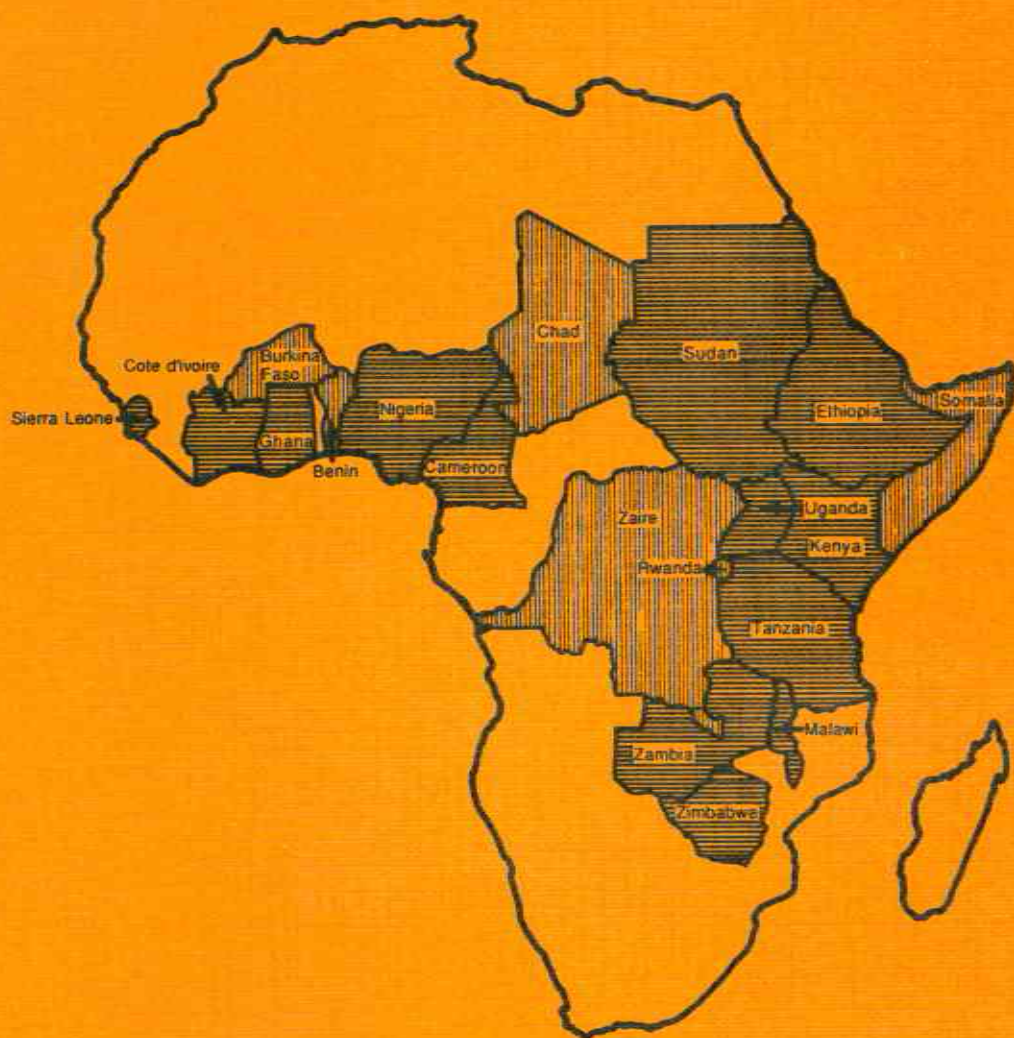
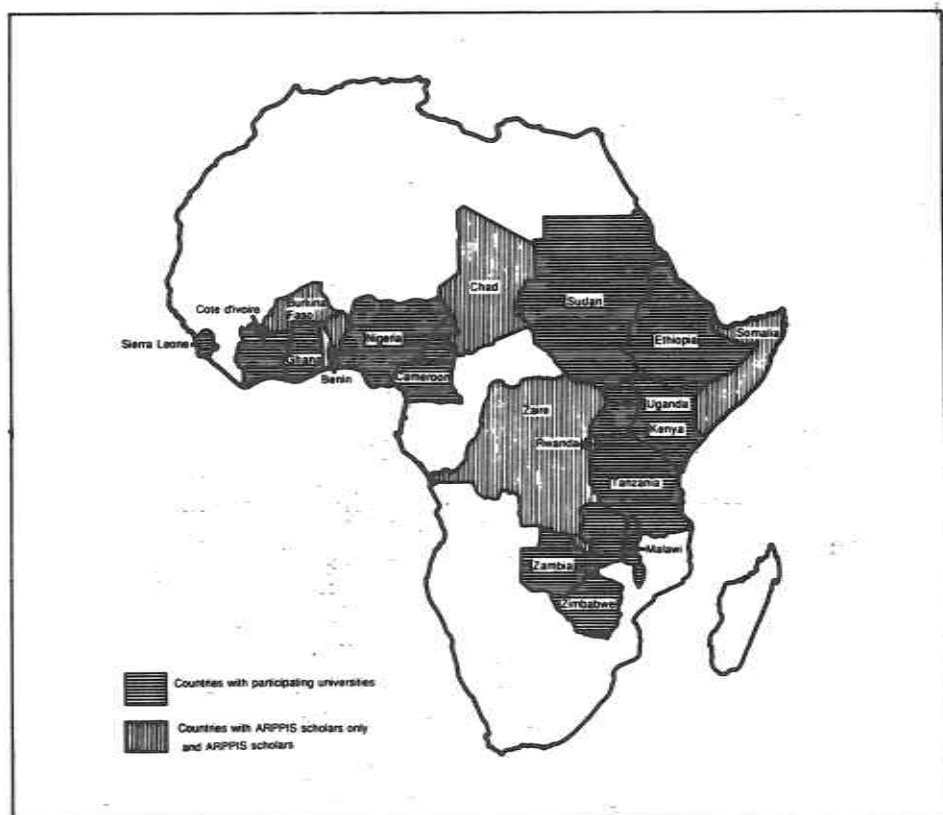


AFRICAN REGIONAL POSTGRADUATE PROGRAMME
IN INSECT SCIENCE (ARPPIS)

ABSTRACTS

PH. D. AND M. PHIL. THESES
SUBMITTED BY ARPPIS SCHOLARS
1983-1987 CLASSES





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APRIL 1991

ICIPE SCIENCE PRESS

“...Creativity is “thinking up new things”; innovation is “doing new things”. In any society, there is no shortage of creativity or creative people; what is in short supply is *innovators*. These scarce people “are the ones who have the know-how, energy, daring, and staying power to implement ideas”. African agriculture now desperately needs the discoverers of new knowledge to give African tropical agriculture the potential for a new quantum jump, and the innovators to set in motion the action-oriented follow-through...”

PROF. T. R. ODHIAMBO

WELCOMING AND OPENING ADDRESS;

Eastern and Southern Africa Agricultural Research Review, The World Bank 1985–1986; Washington D.C. 20433, USA, pp. 101–106, Annex 4.

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Summary Information on ARPPIS, 1983-1990

The African Regional Postgraduate Programme in Insect Science (ARPPIS) was established at an international meeting held in Bellagio, Italy in September 1981 attended by representatives from the International Centre of Insect Physiology and Ecology (ICIPE), African universities and other national and international bodies. It is now a fully functional collaborative graduate training network comprising the ICIPE and 15 African universities, which enables young African scientists to study for a Ph. D or M. Phil degrees in insect science as well as integrated pest and vector management. ARPPIS draws on the strength of a three-year degree programme in which students, registered at a participating university, carry out their research at the ICIPE under the direction and supervision of the University and ICIPE Scientists. Between 10 and 15 students are admitted to ARPPIS each year, giving a student population of up to 45 within the revolving 3-year programme. Since the first class was admitted in March 1983 there have been 8 classes. The 72 Ph. D. and 10 M. Phil. scholars have come from 18 countries (Benin Republic, Burkina Faso, Cameroon, Chad, Ethiopia, Ghana, Kenya, Malawi, Nigeria, Rwanda, Sierra Leone, Somalia, Sudan, Tanzania, Uganda, Zaire, Zambia and Zimbabwe). Forty of them have successfully completed their programmes at the ICIPE, and returned to their countries as lecturers in Universities or as working scientists in research institutions.

It is the intention of ARPPIS that, after their graduation, the students will return to their home countries, and contribute to building the capacity for research in insect science within their national programmes and universities. However, the programme is increasingly aware that Africa is facing a brain drain of its best young scientists, and that unless ARPPIS provides some form of continuing career support, its objectives in training will not be entirely fulfilled. For that reason, an ARPPIS Scientific Network has been established that will foster and sustain the enthusiasm of its scientists.

We are pleased to present to you the Abstracts of Ph. D. and M. Phil. theses of ARPPIS Scholars who conducted their research on insect crop pests and vectors of human and animal tropical diseases, often using a mission-oriented and multi-disciplinary approach. The Abstracts clearly show that the overall contribution of the ARPPIS Scholars to ICIPE research is a distinct benefit to the centre from the graduate programme. ICIPE programme leaders and unit heads all noted the contribution ARPPIS students are making to the achievement of ICIPE's strategic research objectives, and that the ARPPIS scholars are significantly increasing the research output of individual supervisors.

We hope that when you read the Abstracts you will agree with the opinion of the Third Periodic External Review (IPER) Team which reviewed the ICIPE from 15th February to 3rd March 1990. They have assessed that ICIPE's potential in promoting postgraduate education and training for human resource development for scientific leadership in Africa. The team stated that it was impressed by the motivation of the ARPPIS students and by the quality of their research and wished to commend ICIPE for having spearheaded this innovative approach for the practical training of applied entomologists for the ever increasing demand at the national level.

As the ARPPIS is a collaborative programme, I wish to thank participating universities, for their assistance and contribution to this unique regional programme of advanced education.

Professor Thomas R. Odhiambo
Chairman, ARPPIS Academic Board

8 October, 1990
Duduville, Nairobi

***Theses submitted for the
degree of Doctor of Philosophy
(Ph. D.)***

[illegible]

Medical Vectors

STUDIES ON *LEISHMANIAE* OF LIZARDS

WADEEDA S. FORAWI (SUDAN)
1983 CLASS

Lizard *Leishmaniae* have been the subject of very few studies within either the invertebrate or vertebrate hosts. *Leishmania*-infected lizards live in close association with sandfly and rodents while certain sandfly species are both saurian and mammalian (including man) feeders. Considering this fact it is necessary to study the host-parasite relationship of lizard *Leishmaniae* and also the susceptibility of lizards to promastigotes of different origin and conversely that of mammalian hosts to lizard *Leishmaniae*.

Lizards of the species *Mabuya striata* were experimentally infected with the following isolates:

- (i) LIZ/KEN/75/ICIPE 140 (Lizard isolate)
- (ii) MOHM/SU/75/5 ASKH *L. major* (Human isolate)
- (iii) LIZ/RC/84/244 *L. adleri* (Lizard isolate)

The first isolate was found to be biochemically identical to *Leishmania major*. Its life cycle was followed both in lizards and mice and compared to those of the latter two isolates.

Promastigotes were seen in the anterior mid-gut of some *Sergentomyia* sandfly species fed on lizards inoculated with the above-mentioned isolates.

SUPERVISORS:

ICIPE: Dr. J. Kaddu
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Khartoum, Sudan

ECOLOGY OF MALARIA VECTORS IN RELATION TO AN IRRIGATION SCHEME IN BARINGO DISTRICT, KENYA

IFEANYI ANIEDU (NIGERIA)
1985 CLASS

A comparative study of the ecology of mosquito vectors of malaria was carried out in the Perkerra irrigation scheme and the Lobo swamp in Baringo district, Kenya.

The swamp was found to be more productive than the irrigation scheme both in terms of species diversity and the relative abundance of individual mosquito species. Seventeen mosquito species were collected and identified and all of these were found breeding in the swamp, while only 5 species were breeding in the irrigation scheme. Two known malaria vectors, *Anopheles gambiae* Giles *sensu lato* and *Anopheles funestus* Giles were among the 17 species identified. The two were collected in almost equal numbers in the swamp area (1466 and 1475 respectively, between January and December, 1986). *A. funestus* was very scanty in the irrigation scheme, with only 28 collected as against 845 *A. gambiae*, between January and December, 1986.

Peak populations of *A. gambiae* were recorded during the rainy season, April–July, in the swamp and during the cool dry period following the rains, July–September, in the irrigation area. For *A. funestus*, the peak numbers occurred between the end of the cool dry period and the beginning of the dry season (August–September).

Rainfall was the most important factor affecting seasonal population fluctuations at the swamp. However, at the irrigation scheme, other factors, especially farming and irrigation practices, were observed to affect the vector population significantly.

Larval survivorship was similar in both types of habitat and predation seemed to be the major mortality factor during larval development. Adult survivorship was, however, significantly higher in the irrigation scheme than in the swamp. The higher survival rate at Perkerra was probably due to factors related to irrigation, in particular the provision of cooler and more humid microclimates by growing crops and shade trees in the irrigated areas, especially during the long dry season.

The two vector species were strongly endophilic but a degree of exophily was evident among the gravid females, which was stronger in *A. gambiae* (33%) than in *A. funestus* (15%). *Anopheles gambiae* also showed a higher preference for human blood, with a human blood index of 88.6%, than *A. funestus*, with an index of 58.8%.

Malaria accounted for 56% of all sicknesses treated annually in the area. Transmission occurred throughout the year with the peak between April and September. Crude inoculation rates were four times higher in *A. gambiae* than in *A. funestus*, indicating that the former was the more efficient and important vector in the area.

SUPERVISORS

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STUDIES ON FACTORS AFFECTING THE DISTRIBUTION AND ABUNDANCE OF PHLEBOTOMINE SANDFLIES IN A LEISHMANIASIS ENDEMIC FOCUS IN BARINGO DISTRICT, KENYA

MULENDA BASIMIKE (ZAIRE)

1985 CLASS

Factors affecting the distribution and abundance of phlebotomine sandflies were studied during the period 1985 to 1987, in the Marigat leishmaniasis endemic area, located in Baringo district, Kenya. It was found that the relative abundance of *Phlebotomus* species collected from burrows was four-fold that from termite hills, whereas the *Sergentomyia* species recovered from termite hills was twice the number caught in animal burrows. Both termite hills and animal burrows were the main sandfly breeding and resting sites in the Marigat area. The *Sergentomyia* species were predominant in this area, representing 97% of the total sandfly population, while the *Phlebotomus* species constituted only 3% of the population. Considerable seasonal variations were observed in both sites. However, sandfly relative abundance increased in the rainy season and decreased in the dry period. The phlebotomine sandflies were grouped into perennial and seasonal species. *Sergentomyia antennatus* was the most collected sandfly species followed by *S. bedfordi*. *Phlebotomus martini* showed a high capture rate among the *Phlebotomus* species.

Fluctuations in the sandfly population from all breeding and resting sites are discussed, in relation to environmental conditions. The abiotic factors, particularly the rainfall, appeared to have important effects on the distribution and abundance of sandflies. Two major peaks of sandfly abundance were observed in April and August, corresponding to high rainfall. Significant positive correlation coefficients obtained between rainfall and sandfly vectors of leishmaniasis, showed that high incidence of the disease occurred mainly during the rainy season.

Collections of phlebotomine sandflies in different vegetation habitats demonstrated the existence of a high density of flies in large trees. *Sergentomyia bedfordi* seemed to be more closely associated with the vegetation habitats. The studies on sandfly vertical distribution in two different biotopes showed that only *Sergentomyia bedfordi* and *S. antennatus* reached a height of ten metres and beyond. Also, it was observed that two types of sandfly populations occur in the forested areas: the lower species (*Sergentomyia ingrami*, *S. affinis*, *S. adleri*, *S. africanus* and *S. clydei*), mainly flying from the ground level up to five metres, and the species flying beyond six metres (*Sergentomyia bedfordi* and *S. antennatus*). Relating the sandfly density and the height of flight, it was found that the number of both male and female sandflies significantly decreased with the height.

It was possible to relate the increase of phlebotomine sandflies in a particular habitat to the presence of a certain number of chemical and physical soil characteristics. It was found that the growth of the immature stages depended on parameters such as organic carbon, calcium, potassium, sand and clay. However, other features such as sodium were found to have detrimental effects on sandfly abundance.

The identification of bloodmeals determined the range of possible hosts on which each sandfly feeds, and showed the degrees of anthropophily of the local sandflies. The bloodmeal analyses also provided the actual or potential sandfly hosts for the *Leishmania* parasite.

THE BIOCHEMICAL TAXONOMY OF PHLEBOTOMINE SANDFLIES (DIPTERA: PSYCHODIDAE) IN KENYA

HASSANE MAHAMAT (CHAD)

1987 CLASS

Isoenzyme analysis and pattern analysis of cuticular components were used to characterize sandfly species collected from the field and reared in the laboratory. The following sandfly species were used during the investigations: *Phlebotomus duboscqi*, *P. elgonensis*, *P. martini*, *P. pedifer*, *Sergentomyia africanus*, *S. antennatus*, *S. bedfordi*, *S. garnhami*, *S. ingrami* and *S. schwetzi*.

Eighteen isoenzyme systems were assayed to determine which could be of practical use in the identification of sandflies. Identification of the sandfly species was shown to be possible by examining three enzymes, glucose phosphate isomerase (GPI), malate dehydrogenase (MDH) and phosphoglucumutase (PGM) on thin layer starch gel electrophoresis. Phenetic relationships between the species based on the isoenzyme banding patterns gave two groups which corresponded to the genera *Phlebotomus* and *Sergentomyia*. Only *S. garnhami* was grouped in the genus *Phlebotomus*, a peculiarity that needs to be further investigated. Fast system TM IEF was also carried out for various enzymes, but only three isoenzymes, GPI, ME and PGM, were found to give banding patterns capable of distinguishing between sandfly species. Cuticular components of sandflies showed both quantitative and qualitative differences among species. Each species of sandfly had a unique pattern of peaks, which was discernible visually. Classification based on different characteristics of the peaks (e.g. area, width and area percent) was carried out and found equally useful in differentiating species. Peaks of females and males of the same species showed quantitative differences. These results showed that cuticular component analysis could be used as a rapid technique for the identification of sandflies.

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University: Prof. H. Morgan

REGISTERING UNIVERSITY:

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Tsetse

THE INFLUENCE OF MODE OF TRANSMISSION OF *TRYPANOSOMA CONGOLENSE* ON THE STABILITY AND INDUCTION OF RESISTANCE TO SAMORIN

JACK H.P. NYEKO (UGANDA)
1983 CLASS

A series of experiments were performed to determine if the level of drug susceptibility of *Trypanosoma congolense* strains changed during cyclic or syringe passages. It was interesting to note that when a drug-resistant trypanosome strain was maintained through 12 cyclical transmissions in the tsetse flies (in the absence of the drug), no significant reduction in the level of resistance was observed. When the same trypanosome strain was maintained in mice through 20 syringe passages (in the absence of the drug), a significant reduction in the level of resistance was noted after the 15th syringe passage.

In another experimental series, tsetse flies infected with a drug-sensitive *T. congolense* strain were maintained on rabbits that were previously treated with Samorin. It was observed that the infections arising from flies maintained for over 60 days on the drug-treated rabbits needed higher doses to cure. Attempts to induce resistance in the same trypanosome strain by syringe passages of the relapsed infections rapidly produced high levels of resistance.

The course of parasitaemia was studied in both the treated and untreated animals. It was observed that parasitaemia persisted for 2 to 3 days in the treated animals before disappearing. Tsetse flies were fed on parasitaemic but recently treated animals.

Some of the flies were dissected within 6-48 hr after ingestion, and the gut contents inoculated into mammalian hosts. It was observed that the ingested trypanosomes (previously exposed to Samorin) lost their infectivity to the mammalian hosts shortly after 6 hr of ingestion. Trypanosomes from tsetse flies fed on untreated animals were still infective 24 hr after ingestion. The infectivity of trypanosomes (previously exposed to drug) to tsetse flies was found to be greatly reduced.

Tsetse flies infected with the drug-sensitive strain were allowed to feed on previously treated animals (within 1-2 hr treatment). It was interesting to note that although the same dose of Samorin could cure infections in the mammalian hosts, it did not destroy all the parasites in the tsetse flies. The drug however caused serious morphological damage to a large percentage of the vector forms of trypanosomes. The degree of parasite damage was higher in the flies fed by artificial membrane technique on bloodmeal containing Samorin.

It was thought that Samorin might exert some chemoprophylactic effects in tsetse flies by preventing the establishment of trypanosome infections as it does in livestock. Tsetse flies were allowed to feed on bloodmeal containing Samorin before being infected. No significant difference in the fly infectivity was observed in flies following the prophylactic bloodmeal. In another investigation, flies having immature unestablished infections were maintained on rabbits that were regularly treated with Samorin. The drug did not have any significant effects on the maturation of infection in the treated flies.

SUPERVISORS:

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**CHARACTERIZATION OF DIFFERENT STRAINS OF
TRYPANOSOMA CONGOLENSE COLLECTED FROM THE
LAMBWE VALLEY, WESTERN KENYA AND NGURUMAN AREA,
MAASAILAND, KENYA**

ELNEIMA U. MUSTAFA (SUDAN)
1984 CLASS

Isoenzyme profiles of 20 stocks of *Trypanosoma congolense* taken from *Glossina pallidipes* collected in Lambwe Valley, western Kenya and Nguruman, Rift Valley, Kenya, were compared using starch-gel electrophoresis. The electrophoretic patterns of the following enzymes were studied: glucose phosphate isomerase (GPI), phosphoglucomutase (PGM), malate dehydrogenase (MDH), peptidase 1 with L-leucylglycylglycine as substrate (PEPI), peptidase 2 with L-leucyl-L-alanine as substrate (PEP2), isocitrate dehydrogenase (ICD), L-threonine-3-dehydrogenase (TDH), purine nucleoside hydrolase (NH), malic enzyme (ME), alanine aminotransferase (ALAT) and aspartate aminotransferase (ASAT).

Three of the enzymes, ICD, TDH, and NH, had similar electrophoretic mobilities in all the stocks. Since these enzymes differ in their electrophoretic mobility in the other subgenera of trypanosomes, it is likely that they represent a characteristic pattern for *T. congolense*.

Among the 20 stocks examined, one stock from Lambwe and one from Nguruman shared the same zymodeme, and a further 2 stocks from Nguruman had a common zymodeme. The differences between the remaining 16 stocks were minor in that they differed only in one or two enzyme profiles. This suggests that *T. congolense* undergoes genetic exchange as does *T. brucei*.

SUPERVISORS:

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REGISTERING UNIVERSITY:

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PUPAL ECOLOGY AND THE ROLE OF PREDATORS AND PARASITIDS IN NATURAL POPULATION REGULATIONS OF *GLOSSINA PALLIDIPE* AUSTEN (DIPTERA: GLOSSINIDAE) AT NGURUMAN, KENYA

DELPHINA A. ADABIE (GHANA)

1984 CLASS

A two-year programme was carried out at Nguruman in the Kajiado District of the Rift Valley Province of Kenya, to study the pupal ecology of *Glossina pallidipes* Austen and the predators and parasitoids of both puparia and adults.

Characteristics and spatial distribution of larviposition sites and puparia within the sites are discussed. Coolness and shade are the features of effective sites, and most sites have no vegetation cover except trees with crowns united by creepers and lianes to form a dense canopy. The soils in the breeding sites showed a predominance of sand mixed with loam and clay, with colour ranging from black through very dark brown and greyish-brown to light brown. Though puparia were found in a wide range of soil types, they occurred more frequently in loamy sand soils. The puparia in all sites showed a marked tendency to be aggregated in shade underneath horizontal branches. In general, larvae pupate near the surface of the soil when it is very wet or when it is covered with a thick carpet of leaf debris, but tend to burrow deeper into the soil when it is very dry or has no leaf debris cover.

The trends in the relative abundance and distribution of puparia in different months, sites and vegetation habitats were established using the hand-searching method (based on 2-man-hr per site). The searching efficiency of puparial collectors in finding puparia averaged 60%. There was evidence that seasonal variations in relative abundance and distribution of puparia resulted partly from a seasonal shift in breeding sites from low-lying sites to sites on hilly slopes during the rainy season when most riverine habitats were flooded.

The age structure of the puparia was observed to vary monthly. The survivorship curve from pooled data indicated that mortality rate was very high, up to 4% per day. There was a significant linear relationship between monthly pupal loss rate and log puparia density, suggesting that such losses are density dependent.

Predation estimated from empty puparial cases showed that an average of 24.0% had arthropod-induced damage. The invertebrates found in the larviposition sites and/or captured in baited and unbaited pitfall traps and suspected of preying on the puparia, included Gryllidae, Formicidae, Forficulidae, Coleoptera (carabid and elaterid larvae) and other soil-inhabiting arthropods.

The species composition of puparial parasitoids of *G. pallidipes* comprised mainly of two Dipteran species of the family Bombyliidae, *Exhyalanthrax lugens* Lw. and *E. beckerianus* Bezzi (also known as *T. argentifrons* Austen). Together these species caused 1.8 to 100% mortality in puparia collected from the field with an average of 12% in puparia which emerged and 10.6% in dissected dead puparia. Natural puparial mortalities were caused mainly by developmental failures (mean 18.0%), emergence failures (mean 24%) and fungal infections which caused mortality ranging from 14.3 to 100% with a mean of 33.7%. Flooding and other adverse climatic factors caused 15.9% mortality through degeneration and/or decomposition of puparia.

Serological analysis of predator gut contents was carried out by agar gel double immunodiffusion technique. The gel precipitin test, developed to detect tsetse meals in the guts of

arthropods and to identify the natural predators of *G. pallidipes*, proved specific for *Glossina*. The length of time a tsetse meal remained detectable in the guts of predators varied from a minimum of 9 hr for the gryllid *Liogryllus bimaculatus* to 48 hr for another gryllid *Phaeophyllacris* sp. Positive results were identified in 288 (16.9%) of 1,702 suspected arthropod predators tested. The relative proportions of positive results in predator species varied, but Asilidae (25.0%), Gryllidae (12.9%), Hymenoptera (15.8%) and Odonata (15.2%) were numerous and consistently had high proportions of positive results, indicating that they were the most important natural predators in the natural habitat of *G. pallidipes* at Nguruman, Kenya.

Laboratory studies on the interactions of predators and puparia and adult *G. pallidipes* (prey) showed that increasing prey density reduced searching efficiency due to prey interference, though the number of tsetse killed per predator increased as density and duration of exposure to the predator increased. However, different predators showed different functional responses. Most spiders and *Liogryllus bimaculatus* (Orthoptera: Gryllidae) showed density dependent, sigmoid or Holling's Type III relationships to adult and puparia of tsetse respectively, while responses of *Phaeophyllacris* crickets and two species of solifugids showed curvilinear density dependent relationships similar to Holling's Type II functional response.

Field puparia-burying experiments showed no clear relationship between predation rates and puparia densities. Field adult-tethering experiments showed predation to vary with different predator groups. Predation by ants was strongly density dependent ($r = 0.88$, $P < 0.05$), while that due to birds was inversely density dependent. Predation due to the combined effects of birds and ants was, however, found to be curvilinearly density dependent.

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TRAPPING STUDIES ON *GLOSSINA LONGIPENNIS* CORTI AT NGURUMAN, SOUTH-WESTERN KENYA

CHARLES KYORKU (GHANA)

1985 CLASS

Studies have been carried out at Nguruman, south-western Kenya, on *Glossina longipennis* Corti, a little known member of the *fusca* group of *Glossina*. The first objective was to develop an efficient trap suitable for both sampling and control purposes. Studies were then carried out on the population dynamics of *G. longipennis* using the newly developed sampling methods. Lastly the trap/odour bait system was tested in a control situation.

Replicated Latin square design experiments were used to compare the performance of various trap designs and odour attractants. The Zimbabwe F3 trap proved more effective than the widely used biconical trap, especially for females. A new trap developed at Nguruman, called the NG2B, was also very effective and had the advantage of being cheap and easy to construct. Acetone and cow urine together increased the catches by 4-5x over unbaited traps, but when dispensed alone neither of them was effective. There was no significant difference between the attractancy of cow urine and buffalo urine. Trap catches were further increased when 1-octen-3-ol was dispensed together with acetone and cow urine. A higher proportion of older flies was caught by the NG2B trap compared to the biconical but no significant difference was observed in the age structure of flies attracted by different odour baits. The effect of trap design on sample composition and the potential for using odour baited traps for sampling the *fusca* group of tsetse flies are discussed.

An electric screen adjacent to a baited target was used to determine the precise activity pattern of *G. longipennis* which is known to be crepuscular in behaviour. Morning activity started at about 15 minutes before sunrise at 0630 hr, peaked at about 0615 hr and ceased by 0700 hr. The species was more active in the evenings, when activity began at about 30 minutes before sunset at 1815 hr, peaked at 1845 hr and ended by 1900 hr. Males were regularly active before females. Light intensity was found to be the most important factor of influencing activity. The relationship between activity pattern and cattle-fly contact is discussed.

Changes in the apparent densities of *G. longipennis* were monitored simultaneously using biconical and NG2B traps in two areas located 7 km apart. Both trap types showed similar trends in population changes but higher apparent densities were recorded with the NG2B than with the biconical trap. Apparent densities in both sexes were regularly observed to increase during the rainy seasons and decrease during dry seasons. Peak catches in one area were observed to precede those in the other area by one month. Flies spread out to more open areas during the cool wet seasons and concentrated in the thicker woodland during the dry seasons. The factors influencing changes in population densities, including movement between the two areas and between vegetation types, are discussed.

Mortality rates estimated from ovarian age structure and from Moran curves were observed to be highest during the hot dry seasons and lower during the cool wet seasons. Adult mortality rates showed a significant positive correlation with maximum temperature and a negative correlation with minimum relative humidity. The effect of fly movement on mortality rate estimates and the reliability of the estimates by the two methods are discussed.

Dissections of female flies from NG2B traps showed that all non-teneral but nulliparous females and over 80% of teneral females were inseminated. The average percentage distribution of the various pregnancy stages in trap samples was found to be very close to the values expected from the duration of the different stages, in contrast to the usual under-representation

of flies with third-instar larvae for other tsetse species. The average abortion rate was 6% but ranged from 0% in the rainy seasons to 60% in the hot dry season. A significant negative correlation was observed between abortion rate and minimum relative humidity. A significant positive correlation was also found between fly size and minimum relative humidity of the previous month but one. A discussion is given of the immediate causes of abortions and their effects on population levels and of the factors influencing fly size.

The absolute population size of *G. longipennis* was estimated through mark-release-recapture experiments. The mean population size was estimated at 17,300 males (range 10,471–25,703) and 16,900 females (range 14,125–20,892). The trend of changes in the absolute estimates corresponded with those in apparent estimates from trap catches. From the peaks in the recapture rate of marked flies, the feeding cycle of *G. longipennis* was found to be 2–3 days for males whilst for females the 9–10 day pregnancy cycle was the main factor affecting the recapture rate. There was a considerable amount of movement of marked flies between the two sampling areas but the movement was shown to be greater in one direction than the other.

A trial tsetse population suppression operation with baited NG2B traps was started during the course of the study. After 11 months of operation, the population levels of *G. longipennis* were reduced by about 60% for males and about 90% for females. Much greater reduction levels were obtained for *G. pallidipes*. A discussion is given of the factors influencing the lesser impact on the population of *G. longipennis* with suggestions on improving methods for the control of the species.

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**IN-VITRO STUDIES ON THE VIRUS-LIKE PARTICLES (VLPS)
OF THE TSETSE FLY *GLOSSINA PALLIDIPES* AUSTEN;
(DIPTERA: GLOSSINIDAE)**

ROSEMARY SANG (KENYA)

1985 CLASS

The presence of virus-like particles (VLPs) has been reported in species of *Glossina*. Recently it has been observed that field-collected *G. pallidipes* with enlarged salivary glands carry VLPs in these glands, and that the infected male and female flies are sterile.

This study was proposed to investigate the possibilities of developing cell cultures from carrier species of the VLPS and then growing the particles in the developed cultures and in other available cell lines.

Despite many technical difficulties it has been possible to propagate primary cultures from early third stage larvae of *Glossina morsitans* and *G. pallidipes*, and from embryonic cells taken from the eggs of *Aedes aegypti*.

Cell cultures from *G. morsitans* inoculated with homogenates of whole infected salivary glands displayed cytopathogenic effects visible by phase contrast microscopy. The effect has not yet been confirmed by electron microscopy.

Neither the *Aedes aegypti* embryonic cells nor established cell lines from *Aedes pseudoscutellaris* were receptive to the VLPs. This has been confirmed by electron microscopy. Similarly, two vertebrate cell lines derived from monkey kidney (VERO 76 and VERO BME) were shown by light and electron microscopy not to be receptive to the particles.

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ASPECTS OF THE MATING BEHAVIOUR OF *GLOSSINA MORSITANS MORSITANS* WESTWOOD AND *GLOSSINA PALLIDIPE* AUSTEN

JOHN O.A. DAVIES-COLE (SIERRA LEONE)

1987 CLASS

Sexual receptivity was investigated in *Glossina morsitans morsitans* and *Glossina pallidipes*. In *G. m. morsitans*, the onset of the male jerking phase was the main factor responsible for terminating female receptivity. Females of *G. morsitans* mated only once in their life time, as a single mating provided sufficient sperm for reproduction. Males retained their virility even when they were very old (60 days).

Female sexual receptivity in *G. pallidipes* was highest when 9–13 days old but declined thereafter. The mean spermathecal value (MSV) was high during prime receptivity period and the duration of copulation was comparatively short (mean = 24 minutes). Though ovulation occurred in virgins, mating was generally the determining factor. Group-mating gave better results than single-mating. A higher percentage of females were inseminated when they were left together with males for 72 hr rather than 24 hr. High insemination rates were also obtained with small cages rather than large cages.

There was no significant difference in insemination between females of *G. pallidipes* left together with males in continuous darkness and those exposed to 12 hr light, 12 hr darkness. Males of *G. pallidipes* were more aggressive and made more mating strikes when over 11 days old. The age of male sexual appetitiveness coincided with the maturation of their accessory reproductive glands. Males were however able to inseminate successfully from the age of 7 days onwards. These results are discussed in relation to mass rearing of *G. pallidipes*, and the application of the sterile insect technique (SIT) to tsetse flies.

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ECOLOGY AND VECTORIAL CAPACITY OF *GLOSSINA FUSCIPES FUSCIPES* NEWSTEAD 1910 ON RUSINGA ISLAND AND ALONG THE SHORES OF LAKE VICTORIA

MWANGELWA I. MWANGELWA (ZAMBIA)
1987 CLASS

Studies were carried out on Rusinga island and the mainland in the Mbita Division, South Nyanza District, Kenya, from November 1987 to December 1989 to determine the distribution and diel activity patterns, population dynamics and responses of *Glossina fuscipes fuscipes* Newstead 1910 to various odour attractants and trap types. The vectorial capacity of *G. f. fuscipes*, a vector of both human and animal trypanosomiasis, was also re-examined in the field and the laboratory. The details of the contemporary tsetse/trypanosomiasis situation were assessed in view of the frequent outbreaks of human trypanosomiasis in the neighbouring regions.

Apparent densities of *G. f. fuscipes* were found to be remarkably stable on both Rusinga island and the mainlands varying by factors of five and seven, respectively, during the study period. Low trap catches were recorded during and soon after the rainy season. In one of the study sites on Rusinga island, the absolute population density was estimated at 559 males and 624 females per hectare from mark-release-recapture studies. The mortality rates for the flies derived by two methods (i.e. ovarian age analysis and Moran curves) were not significantly correlated. Mortality rate estimates by ovarian age analysis showed a higher mortality on Rusinga island than on the mainland. This higher mortality was recorded during the rainy season on the island. Reproductive abnormalities in female flies were rare, not exceeding 2%, indicating that the populations were not under stress. Using a random diffusion equation, fly movement was estimated at 112 m per day. This short distance travelled implied that if control programmes involving traps and directed at this subspecies were to be initiated they would have considerable effect on the fly populations in areas within the vicinity of traps (e.g. villages) but eradication of the flies from large areas would be difficult.

Studies of odour attractants indicated that the addition of cow and human urine, acetone, 1-octen-3-ol, phenolic fractions and washings from a monitor lizard and a goat did not enhance trap catches. Trap catches of females were inconsistent when acetone and cow urine were added to traps i.e. at times the catches increased and at other times decreased. Females were strongly repelled by combinations of acetone, cow urine and phenolic fractions. The causal factors for this response are discussed. Of the six trap designs compared, the biconical trap was the most effective followed by, in decreasing order, the pyramidal trap, NG2B and NG2G, Vavoua and F3 traps.

Trypanosome infection rates in wild-collected flies were very low (0% on Rusinga island and 0.1% on the mainland). Laboratory studies indicated that although *G. f. fuscipes* was significantly less susceptible to mature infection with *T. congolense* and *T. brucei* than *G. pallidipes*, there were no significant differences in immature infections between the two fly species. It was unlikely that an epidemic of human trypanosomiasis would occur on Rusinga island and the immediate area on the mainland because of the confinement of the fly distribution to strips of vegetation along the lake shores, the nature of fly feeding patterns and the absence of trypanosome reservoir hosts in the area.

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Prevalence of *Haemaphysalis hyalognathus* and *H. punctulatus* on cattle and sheep in the north-east of Scotland

BY J. M. HARRISON AND J. H. WATSON

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Abstract. The prevalence of *Haemaphysalis hyalognathus* and *H. punctulatus* on cattle and sheep in the north-east of Scotland was determined by examining 1000 cattle and 1000 sheep from 100 farms. The prevalence of *H. hyalognathus* was 10.0% on cattle and 1.0% on sheep. The prevalence of *H. punctulatus* was 1.0% on cattle and 1.0% on sheep. The prevalence of *H. hyalognathus* was 10.0% on cattle and 1.0% on sheep. The prevalence of *H. punctulatus* was 1.0% on cattle and 1.0% on sheep.

Livestock Ticks

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HOST RELATIONSHIPS OF THE TICK *AMBLYOMMA* *VARIEGATUM* ON CATTLE AND RABBITS

ABDULLAH A. IBRAHIM (SUDAN)
1983 CLASS

An abnormal strain of *A. variegatum* has been identified and its life-cycle followed. In normal ticks some of the external features consist of the mouth parts, four pairs of legs and one pair of laterally positioned spiracular plates, and these were all present in the abnormal strain. However, a common feature of ticks of the abnormal strain was a bilobed posterior region in all the developmental stages with an anal groove on each lobe, in addition to two genital grooves. Depending on the number of legs and spiracular plates present on the abnormal ticks, they were grouped into three types. In the first type, adults had four pairs of legs and one large spiracular plate (possibly due to fusion of 2 plates) in the posterior region. The second type had five pairs of legs and one pair of spiracular plates, each positioned on a lobe. The third type had six pairs of legs and a pair of spiracular plates as in the second type. When the abnormal ticks were dissected to look at the internal anatomy, they were found to have two rectums leading to separate rectal sacs and grooves. Adults of either sex also had two pairs of accessory reproductive glands instead of one pair present in normal ticks.

The feeding performance and development of the immatures was normal. Abnormal males were unable to fertilize abnormal females, although they remained in a copulating position for over three weeks on the host, and as a result the females failed to engorge. Under normal circumstances successful mating is necessary for females to feed to repletion. When abnormal females were allowed to feed with normal males they attached and females fed to repletion, indicative of successful mating. However, eggs from the only ovipositing female did not hatch.

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**STUDIES ON THE RESISTANCE ACQUIRED BY RABBITS
EXPERIMENTALLY INFESTED WITH *RHIPICEPHALUS EVERTSI*
EVERTSI (NEUMAN, 1987) (ACARINA: IXODIDAE)**

BARNABAS C. NJAU (TANZANIA)

1983 CLASS

A study was conducted in order to provide information on the immunological responses of hosts to ticks utilizing the rabbit — *Rhipicephalus evertsi evertsi* model. Three groups of three rabbits each were allotted randomly to three adult tick doses comprising 20, 50 and 100 ticks and infested for four successive times in an attempt to make them acquire resistance. A similar study lasting for 5 infestations was conducted using 100, 500 and 1500 larvae of the same tick species. Resistance was assessed using various parameters including mean percentage of ticks engorged, mean engorgement weight, mean feeding period, mean egg mass laid, mean percentage hatch rate, mean percentage moult and mean premoult period. Host sera were examined for specific antibodies to tick salivary gland antigens (SGA) and immunopathological studies on the lesions caused by the ticks were done.

Rabbits acquired resistance to different life stages of the tick after one infestation and this was maintained during subsequent challenges. This resistance resulted in decreased tick feeding success, reduced reproductive potential and reduced numbers feeding normally. There was a significant mortality rate which affected immature stages more than adults. Tick instars that survived on resistant hosts manifested a combination of one and three host cycles in addition to the normal two host cycle shown by rabbits feeding on naive hosts. Small and large nymphs frequently matured on the hosts and moulted in favour of males and females respectively. Moulting periods were shorter for small nymphs. After successful establishment on the host, nymphs were not significantly influenced by the hosts' immune response. Generally, egg hatch rate and nymphal moults were the parameters least influenced by host resistance.

Infestation to *R. e. evertsi* generated significant cross-resistance against a challenge with the 3 life stages of *R. appendiculatus* and larvae and adults of *Amblyomma variegatum*. Cross-resistance was measured in terms of reduction in numbers successfully engorging, and reduced weight of those ticks that engorged. The most significant inter-species cross-resistance was in *R. e. evertsi* infested rabbits challenged with *R. appendiculatus*. It was weak for *A. variegatum*. Immunoprecipitation using rabbit anti-*R. e. evertsi* sera and antigens isolated from the three tick species suggested that they share common antigens.

During primary infestation with adult *R. e. evertsi*, most rabbits developed paralysis. Rabbits which did not develop paralysis during the primary infestation could not be paralysed by subsequent tick challenges, an indication that they had acquired immunity to the toxin. Adult ticks which emerged from nymphs of weights between 5 mg and 24.9 mg were able to paralyse tick-naive rabbits. Paralysis was not induced by the tick instars.

Cutaneous cellular responses, primarily involving lymphocytes developed at the tick feeding sites of resistant rabbits. Similar delayed reactions were elicited by intradermal inoculation of *R. e. evertsi* extracts from SGA in the hosts. The magnitude of these reactions varied according to the dose of adult ticks used to sensitize hosts. It was poor for rabbits challenged with high numbers of ticks, and in particular for those that were paralysed. A common feature in these studies was that significant rejection and death occurred during secondary tick exposure, which continued to the 3rd and 5th infestations in hosts challenged with 20 adults and larvae respectively. During the primary tick challenges, antibodies to tick

SGA were demonstrated in the first week using the Enzyme-Linked Immunosorbent Assay (ELISA) technique. With the agar gel double diffusion technique, antibodies could not be demonstrated until the fourth week. Peak antibody titres attained after secondary challenge could not be raised by increasing the frequency of tick infestations. However, hosts challenged with low numbers of adult ticks and those which suffered paralysis lost precipitating antibodies. This resulted in enhanced tick feeding.

Delayed type hypersensitivity (DTH), a T cell-mediated immune response, occurred at tick feeding sites on a resistant host. Suppression of T cells by administration of goat anti-rabbit thymocyte serum (ATS) to rabbits before tick challenge partially blocked acquisition of resistance. Consequently, tick engorged weights, feeding duration and fecundity were enhanced compared to ATS-untreated controls. In addition, tick mortality was reduced and rejection abolished. Both antibodies to tick SGA and inflammatory reactions at tick bite sites on ATS-treated hosts were suppressed. Ticks fed on naive hosts significantly suppressed DTH response to sheep red blood cells (SRBC). A similar but poor suppression was observed on tick resistant hosts. The intensity of DTH was inversely related to tick engorgement weights.

The capacity of tick-infested resistant and naive rabbits to mount an immune response to a concurrent or subsequent challenge was investigated using SRBC and bovine serum albumin (BSA). Rabbits which completed four successive infestations with the different numbers of adult ticks described, like others prechallenged once for five days with 200 adults responded poorly to subsequent inoculation with SRBC. Both the magnitude and persistence of the antibody response to SRBC were reduced in hosts that were repeatedly challenged with 20 ticks. However, it was reduced and persistent in hosts exposed to the other challenge regimens. Rabbits that suffered tick paralysis had the lowest antibody response. The primary antibody response of naive rabbits to SRBC and BSA inoculated to coincide with tick infestation was severely suppressed, particularly response to BSA. Most rabbits thus treated died from paralysis. Of nine rabbits inoculated with SRBC at the time when ticks were observed to have started feeding (usually on day 3 of tick application), five were paralysed and died while in a group of six rabbits inoculated with BSA and similarly infested, one rabbit was paralysed and recovered. When SRBC and BSA were inoculated together in three naive rabbits while ticks had commenced feeding, two were paralysed and died. Conversely, when three naive rabbits previously inoculated with SRBC and BSA were boosted 14 days later with the two antigens as a single inoculum to coincide with tick feeding, their secondary antibody response was only transiently suppressed. These hosts acquired rapid resistance to ticks and one rabbit was paralysed and died. The characteristics of these responses would suggest that the inability of *R. e. evertsi*-infested rabbits to respond well to a simultaneous challenge with other antigens may be due to antigenic competition. Such competition is immunosuppressive and may also occur among different tick antigens inoculated in the host.

Elution of tick SGA in column chromatography showed that the antigen comprised two immunogenic fractions. By using sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE), one of the fractions resolved into eight protein bands while the other fraction showed only one band. The latter band and two others in the previous fraction had comparable molecular weights M.W. of 67,000 daltons. The remaining protein bands of the second fraction had M.W. below this value.

This study has demonstrated that acquired resistance in rabbits affected the feeding and egg laying of *R. e. evertsi*. Humoral and cellular factors participated in the expression of resistance. However, ticks were able to suppress these two components of the host immune system, a feature suggested to facilitate ixodid feeding on resistant hosts. Since in this study

antigens derived from *R. e. evertsi* salivary gland extract reacted with sera from rabbits infested with this tick, it suggests that they may be used to investigate host-tick relationships.

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STUDIES OF THE IMMUNITY INDUCED IN GOATS TO *RHIPICEPHALUS APPENDICULATUS*

CHARLES B. MARANGA (KENYA)

1984 CLASS

The ixodid tick, *Rhipicephalus appendiculatus*, the vector of the cattle disease East Coast Fever, remains attached to its hosts for several days thus providing a sustained antigenic stimulus. In the present investigation, it has been demonstrated that goats become resistant to ticks after natural infestations and after immunization with crude midgut antigens.

Resistance to the three stages of *R. appendiculatus* was investigated in goats following immunization by natural infestations and by crude midgut antigens. The immunity was assessed by artificial challenge on the ears using larvae, nymphs and adult ticks, and by placing the immunized goats in discrete paddocks seeded with ticks and observing the effect of feeding on the population development. In addition studies to determine the effects arising from the transfer of maternal immunity from naturally immune dams to their offspring was investigated. The passive transfer of resistance to *R. appendiculatus* by serum from dams immunized with crude midgut antigens was also studied. Goat dermal responses to infestation of feeding ticks were examined histologically.

The results presented in this study indicated that the goat responds well to tick antigens and produces a high level of immunity to natural infestation, inoculation of isolated tick midgut protein mixtures and a combination of both types of immunization methods.

The effects of immunization on the tick life cycle were found to be significant. There were reductions in larval, nymphal and adult engorged weights by up to 75%. Egg-mass weights were reduced by up to 76% by both types of immunity.

There were deaths of ticks fed on immunized goats in all groups. The number of tick deaths caused by tick midgut antigen immunisation approached 37%.

A varying percentage of adults and nymphs fed on immunized goats turned black and usually died. Some white, reddish-pink and bright red larvae and nymphs were seen. These colours were probably caused by host erythrocytes or haemoglobin leaking into the haemoglobin following midgut damage in ticks engorging on immunized animals. Many of the adults that survived were infertile and others laid eggs of which only a low percentage hatched. The percentage of eggs hatching was less than 50% in all the immunized groups.

Similar results were found following the transfer of maternal immunity. Mothers that had been naturally immunized with ticks transferred considerable immunity in the colostrum against ticks to their progeny. In the passive transfer studies, similar results were obtained.

The dermal responses to infestation indicate that the nature of the cellular infiltrates changed in character and magnitude during the feeding process and again these differed during successive infestations. The principal cells involved in these infiltrates were eosinophils, mast cells, basophils and neutrophils.

Other studies have shown that eosinophil major basic proteins have a protective function in a number of host-parasite systems. In addition to modulating the effect of mast cell/basophil-derived mediators, eosinophils can damage the cheliceral receptors or the gut epithelia of the tick, thus leading to poor feeding. Similar results were found during this study.

The immunity to ticks produced in goats by natural tick infestation or by the injection of midgut tick antigens or a combination of both methods effectively controlled the development of tick populations on experimental paddocks. If immunity to ticks persists long enough in practice, it is possible that immunization of goats would greatly reduce the economic losses due to ticks.

In summary, tick-resistant goats reduced tick populations by death and impaired feeding, leading to a reduced production of larvae. This tick resistance is an acquired immune response associated with both humoral and cellular reactions. The results show that it should be possible to protect goats from *R. appendiculatus*, thus reducing losses due to tick damage.

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INDUCTION OF IMMUNITY IN SHEEP TO *RHIPICEPHALUS APPENDICULATUS* (NEUMAN, 1901) ANTIGENS

B.E. LISAMULA WISHITEMI (KENYA)
1985 CLASS

Immune resistance to infestation by an ixodid tick, *Rhipicephalus appendiculatus*, the vector of the African cattle disease East Coast Fever, was induced in sheep by immunization with tick extracts. Six groups of four sheep each were allotted randomly to three inoculations of the tick extracts in an attempt to vaccinate them against this tick.

Resistance was assessed using various parameters including mean percentage of ticks engorged, tick mortality, mean engorgement weight, mean egg mass laid, mean percentage rate, mean number moulting and mean egg conversion ratio. Host sera were examined for specific antibodies to tick midgut and female reproductive organs.

Two of the six groups of experimental sheep were controls, that is phosphate buffered saline (PBS) (negative control) and tick infestation (positive control). Tick extract immunization especially solubilised midgut membrane antigens (SMMA) led to a reduction in the viability of eggs laid by ticks feeding on the immunized hosts. This effect was also noted with the soluble female reproductive organ antigens. The animals immunized with solubilised midgut membrane antigens had the highest tick mortality; between 80–90% of tick-instars applied were killed compared to the controls which allowed more than 95% of the applied ticks to complete engorgement successfully in the laboratory ear challenge. Some ticks which fed on animals immunized with midgut-derived antigens appeared engorged with host tissue fluids rather than erythrocytes and others were observed dead while still attached to the host.

Resistance to infestation by ixodid ticks has previously been reported by others to have a humoral immune component. Therefore, antibodies from resistant host animals were used to detect the tick antigens they recognized as an approach to identification of the target antigen(s) for the above observed immune responses on feeding ticks. Sheep which were immunized with soluble female reproductive organ-derived antigens in Freund's complete and incomplete adjuvants (FCA and FIA) showed high antibody titres. The antibody titres which were detected by Enzyme Linked Immunosorbent Assay (ELISA) reached the highest peak on about day 63 before the laboratory challenge.

However the antigen was only protective at the egg conversion factor and the hatchability level of the female ticks. Immunodiffusion tests showed a minimum of 2 to 3 precipitin lines with the antiserum from rabbits which had been immunized with these female reproductive extracts. When the instars were fed on the animals immunized with this antigen, there were no immediate adverse effects observed on the ticks.

Sheep immunized with antigen extract derived from the midgut of partially fed female ticks showed dramatic adverse effects on all three instars feeding on them. There were reductions in engorgement weights, egg production, egg weights and egg viability. Mortalities were also very high, especially among those ticks which fed on animals immunized with solubilised midgut membrane antigens (SMMA).

Antibodies from animals made resistant by immunization with partially-fed tick antigen extract were used to isolate, enumerate and characterise the tick antigens recognised as an approach to identification of the target antigen(s) in feeding ticks. Ouchterlony Immunodiffusion tests showed 4 precipitin lines. Sera from animals immunized with SMMA detected at least

twenty seven antigens. The molecular weights of these antigens as assessed by sodium dodecyl sulfate (SDS) polyacrylamide gel electrophoresis (PAGE) using Immunoblot technique were: 21,000; 22,000; 24,000; 25,000; 28,000; 45,000; 46,000; 48,000; 50,000; 51,000; 52,000; 53,000; 54,000; 55,000; 57,000; 59,000; 76,000; 78,000; 79,000; 80,000; 82,000; 84,000; 86,000; 88,000; 92,000; 94,000; and 105,000 KD.

The proteins, as other workers have reported, increased with each day of feeding, reaching a maximum by day 6 to 8 and then decreased gradually throughout the post-engorgement to preoviposition period. Therefore the rate of synthesis of these antigens appeared to vary in relation to the tick feeding cycle.

Animals immunized with midgut-derived antigens were further exposed to tick populations in the field situation. The paddocks were seeded with 23 nymphal ticks per square metre. Animals immunized with SMMA managed to reduce tick populations significantly, by five times compared to the changeable controls. Following vaccination, serum antibodies to soluble and solubilised extracts of adult ticks were detected by gel diffusion. These antibodies were still evident after the experimental period of 33 weeks. Therefore immunity produced by vaccination was very effective in controlling populations under experimental conditions. The results reported here show that immunization against *R. appendiculatus*, an important economic ecto-parasite of cattle, is feasible.

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THE ECOLOGY OF NON-PARASITIC STAGES OF *RHIPICEPHALUS APPENDICULATUS* AND OTHER LIVESTOCK TICKS, AND THE ROLE OF PREDATORS, PARASITES AND PATHOGENS IN THE REGULATION OF NATURAL POPULATIONS

ESTER N. MWANGI (KENYA)

1987 CLASS

Natural enemies of the important ticks in Kenya were studied with a view to assessing their role in regulating natural populations, and their possible use in biological control of ticks.

Predators of engorged females of *Rhipicephalus appendiculatus* and *Amblyomma variegatum* in the field were found to be rodents, ants, spiders, birds, lizards and shrews. In the field there was about 43% predation of *R. appendiculatus* females, 46% of *A. variegatum* females and 36% of engorged *R. appendiculatus* nymphs. Death due to environmental factors did not exceed 7% for any group while predation contributed by small animals was 7%. Domestic chickens were found to be effective tick control agents in a cattle boma where they ate 86% of engorged ticks put out there. These results have shown that the effect of predators should not be ignored in making a computer model for *R. appendiculatus*.

A hymenopteran parasitoid, resembling *Hunterellus hookeri* and *Ixodiphagus texanus* in some aspects but differing in others was found in *A. variegatum* nymphs from the Trans-Mara area, infesting 49% of 463 nymphs collected over a period of one year. This is the first record of a parasitoid of *A. variegatum*. The parasitoid was however not found in nymphs of *A. variegatum* from Rusinga Island. A 40% infestation of unfed nymphs of *A. variegatum* was achieved in the laboratory when the ratio of parasitoids to nymphs was 1:3.

The bacteria *Proteus mirabilis*, *Pseudomonas* sp. and *Serratia marcescens* were isolated from engorged ticks which had been in the grass for 8 days, and caused about 10% mortality. Laboratory colonies were infected with *Enterobacter cloacae*, *Escherichia coli* and *Staphylococcus aureus*. Only 1% of 484 ticks were found to be infected with fungi: *Mucor* sp., *Fusarium* sp. and *Aspergillus* sp.

Experimental infections of adult *R. appendiculatus* with *Beauveria bassiana* and *Metarhizium anisopliae* resulted in 73% and 30% mortalities respectively.

Engorged females of *R. appendiculatus* were found to have a dropping-off rhythm, with about 71% of them dropping between 0600 and 1000 hr, while 66% of the engorged nymphs dropped off between 1400 and 1800 hr. There was no definite rhythm of drop-off for larvae, however. The drop-off rhythm in females and nymphs was not affected by feeding on tick-sensitised animals or by their time of application on animals. Onset of drop-off was delayed by 24 hr in both cases. These results indicate that delaying animals in the cattle boma until 1000 hr and bringing them in at around 1600 hr would allow most engorged ticks to drop in unfavourable places, and this procedure would therefore be useful in an integrated tick management package.

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Crop Pests

ECOLOGICAL FACTORS GOVERNING BEAN FLOWER THRIPS, *MEGALUROTHRIPS SJOSTEDTI* (TRYBOM) (THRIPIDAE) POPULATIONS IN COWPEA/MAIZE MIXED CROPPED SYSTEMS

SAMUEL KYAMANYWA (UGANDA)
1983 CLASS

Experiments were conducted at the International Centre of Insect Physiology and Ecology (ICIPE) Nairobi to study the effect of mixed-cropping cowpeas (*Vigna unguiculata* L. Walp) with maize (*Zea mays* L.) on the population density of *Megalurothrips sjostedti* (Trybom) (Thysanoptera: Thripidae) and the ecological factors regulating its population densities in this mixture.

Spatial distribution, colonization and population build-up of *M. sjostedti*, relative humidity, temperature, light intensity and abundance of general predators of insects in the mixed- and sole-cropped systems at different densities of nonhost (maize) and host (cowpea) plants were compared under field conditions. Laboratory experiments tested the responses of *M. sjostedti* to the presence of maize plant odour, increased relative humidity and shading.

There was a random distribution of *M. sjostedti* both in the mixed and sole cowpea crops. During the colonization phase (0 to 35 days after plant emergence — DAE), there was no significant difference in the colonization of cowpea plants by *M. sjostedti* in the two cropping systems ($P > 0.05$). However from 35 DAE onwards significantly lower population densities of eggs, nymphs and adults of *M. sjostedti* were observed in the mixed cropped system than in the cowpea sole crop. The reduction in population densities of eggs, nymphs and adults was of the order 51.8, 40.1 and 45.0% respectively. This suggested that the mixture did not affect the initial number of *M. sjostedti* colonizing the cowpea crop, but affected the development of populations of this insect. There was an inverse relationship between the density of non-host maize plants and the population densities of nymphs ($r = -0.985$) and adults ($r = -0.978$) of *M. sjostedti*. Therefore the proportion of the nonhost plant was one of the factors influencing the population of *M. sjostedti* in the cowpea/maize mixture.

The microclimate in the cowpea/maize mixture was different from that in the sole crop. From 35 DAE onwards, the relative humidity and temperature were higher in the mixed crop system than in the sole crop one. In the same period less light intensity (30–40% of the total incoming light) reached the cowpea plants in the mixture compared to the sole. These differences were significant ($P < 0.05$). The relative humidity was on average, 10% higher, and the temperature 2°C higher in the cowpea/maize mixture than in the sole crop. The differences in relative humidity and light intensity between the mixed- and sole-cropped systems were positively correlated with the differences in the population density of *M. sjostedti* between the two cropping systems. Multiple regression analysis indicated that difference in light intensity contributed most significantly to the reduction of population density of *M. sjostedti* in the mixture.

There were no significant differences in the population densities of the general predators between the two cropping systems ($P > 0.05$). Predator exclusion cage experiments indicated that the general predators were not responsible for the reduction in the population density of *M. sjostedti* in the cowpea/maize mixed-cropped system.

Under choice situations, significantly ($P < 0.05$) more *M. sjostedti* settled on cowpea plants under unshaded conditions (12.2 ± 1.9 adults/plant) than under shaded conditions (3.1 ± 1.9 adults/plant). Similarly, more adult thrips settled on cowpea plants in less humid areas (37.1 adults/plant) than on plants in a high humidity area (20.6 adults/plant). When

equal numbers of adult thrips were introduced in the cowpea/maize mixture and the sole crop, fewer numbers of the insect were recovered from the mixture than from the sole crop. This suggested that the mixture encouraged emigration of the thrips. Given a choice, more adult thrips oriented towards and settled on cowpea plants in the pure stand (14.1 adults/plant) than on cowpea plants mixed with maize (5.1 adults/plant). Similar responses were observed in an olfactometer where the presence of maize plant odour reduced the number of thrips orienting towards the cowpea odour source.

It is concluded that differences in microclimatic factors (shading in particular) and plant odour dilution were the most significant factors in reducing the population densities of *M. sjostedti* in the mixture. These aspects are discussed in relation to current concepts of ecological diversity.

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COLONIZING RESPONSES OF *MARUCA TESTULALIS* (GEYER) (LEPIDOPTERA: PYRALIDAE) TO DIFFERENT COWPEA CULTIVARS IN RELATION TO THEIR RESISTANCE/ SUSCEPTIBILITY

SULEMAN H.O. OKECH (KENYA)

1983 CLASS

A comparison of the resistance/susceptibility levels of ten cowpea cultivars to the pod borer *Maruca testulalis* revealed that VITA 1 was the most susceptible, TVu 946 most resistant and VITA 5, Chola local and Kamboinse local moderately resistant. In all the cultivars which were compared, flowers and pods suffered the heaviest damage compared to the stems.

Colonizing responses of *M. testulalis*, namely oviposition, larval orientation, feeding, utilization of ingested food, larval development and adult fecundity, were studied on three cultivars: VITA 1 (susceptible), VITA 5 (moderately resistant) and TVu 946 (resistant). The adults showed ovipositional non-preference for TVu 946 and VITA 5 when these cultivars were available to the moths as a choice against VITA 1. All the cultivars were equally accepted for oviposition in a no choice situation. Most of the eggs were laid on the leaves.

Settling sites for first instar larvae on the cowpea plant were in a decreasing order of preference: flowers > terminal shoots = flower buds. The first-instar larvae were capable of reaching any part of the cowpea plant either by walking or by means of silken thread which they produced and used for swinging from one plant part to the other. However, the fourth instar larvae were not very efficient in climbing vertical objects since a majority of them lost grip and dropped down when climbing up the peduncles of the cowpea plant, especially those of TVu 946, which were very long and erect. As a result, pods cultivar, which were raised above the canopy were less infested by *M. testulalis* larvae.

Attraction of first-instar larvae and their arrest/stay was lower for the resistant TVu 946 and VITA 5 than for VITA 1. The volatiles serving as olfactory stimuli from the leaves and flowers and the chloroform and n-hexane extracts of these parts were attractive to *M. testulalis* larvae. However, the attractancy of the volatiles and extracts of VITA 1 to the larvae was higher than that from TVu 946 and VITA 5. The larvae were also attracted by high humidity and their speed and rate of arrival on the cowpea plant were enhanced on moist ground, compared to a dry surface.

Non-preference for larval feeding coupled with a shorter feeding duration was also observed on TVu 946 plant parts as compared to VITA 1. Growth and development of the larvae on stems of TVu 946 and VITA 5 were slower than on VITA 1 because TVu 946 was consumed in very small quantities while food from VITA 5 was poorly converted into body tissues. Although the quantity of food ingested from pods was similar for VITA 1 and TVu 946 and even higher on VITA 5, digestibility of the food from TVu 946 was very low compared to VITA 1. This led to a higher larval mortality on TVu 946 than on VITA 1. Conversion of the food from VITA 5 into body tissue was very low and this led to a lower pupal weight on VITA 5 pods. Antibiosis was therefore considered to be partly involved in the resistance of TVu 946 and VITA 5 pods and stems.

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POPULATION ECOLOGY OF THE LEGUME POD BORER, *MARUCA TESTULALIS* GEYER (LEPIDOPTERA: PYRALIDAE) IN RELATION TO ITS NATURAL ENEMIES ON COWPEA IN WESTERN KENYA

J.B. OKEYO-OWUOR (KENYA)
1983 CLASS

Studies were conducted at the International Centre of Insect Physiology and Ecology, Mbita Point Field Station (MPFS) farm and on Lambwe Valley farmers' fields during 1983–1985, to determine the natural population changes of *Maruca testulalis* Geyer (Lepidoptera: Pyralidae). The role of natural enemies, host plants and climatic factors on natural population development and survival of *M. testulalis* was investigated. Further investigations on the biology of *Tetrastichus sesamiae* (Chalcididae: Eulophidae) a gregarious pupal endo-parasitoid as well as bioassays on *Nosema* sp., a protozoan pathogen of the pest were conducted in the MPFS laboratory. It was found that *M. testulalis* colonised the crop at least 15 days after plant emergence when the first adult moths were recorded in the pheromone traps. The egg and larval populations started increasing steadily at the flower initiation stage reaching a peak between 42 and 54 DAPE at both sites. Only one generation of *M. testulalis* occurred on each crop of cowpea.

From the partial ecological life tables it was found that total real mortality for the generations at MPFS and Lambwe ranged between 51.7–98.9% and 96.4–97.7% respectively indicating very low survival in this species. Several natural enemies were found associated with *M. testulalis*, including seven parasitoids, five of which attacked pupae and two larvae. No egg parasitoid was found. The major pathogenic microorganisms found on dead *M. testulalis* larvae and pupae were *Nosema* sp. and *Bacillus* sp. Observable parasitism played a negligible role in causing mortality on *M. testulalis* being only 0.02–0.09% and 0.04–0.06% at MPFS and Lambwe respectively. Pathogens especially *Nosema* sp. and *Bacillus* sp. contributed significantly to *M. testulalis* mortality at both sites. Disappearance designated as other losses not due to either parasitoids or pathogens also accounted for a large proportion of mortality. Analysis using key factor and correlation methods revealed that disappearance at the egg stage (k_1) was the key factor causing population change at MPFS. In Lambwe, although more observations are necessary for this analysis, the factor k_3 , representing disease at the third instar larval stage, was identified as the key factor. Temperature and rainfall also affected seasonal abundance of *M. testulalis* under field conditions. Under laboratory conditions, temperature was found to be an important factor affecting development and survival of the pest.

Biological studies on *T. sesamiae* showed that the development period ranged from 14–18 days. Major factors found to influence the biology and efficiency of the parasitoid included quality of food, age of host pupae and the host species. Results from bioassay for pathogens showed that *Nosema* sp. was the most virulent naturally occurring pathogen on *M. testulalis*.

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RESPONSES OF COMMON BEAN (*PHASEOLUS VULGARIS*) CULTIVARS TO BEANFLIES: (DIPTERA: AGROMYZIDAE)

JOHN HURIA NDERITU (KENYA)
1984 CLASS

The population patterns and behaviour of the immature stages and the adults of two species of *Ophiomyia*, namely *Ophiomyia spencerella* Greathead and *Ophiomyia phaseoli* Tryon on seven selected cultivars of common beans (*Phaseolus vulgaris* L.) were studied under field conditions with a view to determining the resistance/susceptibility of the cultivars to infestation of beanfly. The method adopted for evaluating resistance/susceptibility of the cultivars involved exposing growing bean plants to natural beanfly populations in the field and recording the number of leaf punctures, eggs, larvae, pupae/puparia and percent infested plants, percent plant mortality and damage scores of representative sample for each cultivar. On the basis of level of infestation and damage, Glp 1004 and Glp x-92 appeared to have some resistance while Glp 2, Glp 24, Glp 585, Glp x-1127(a) and Mexican 142 appeared to be susceptible. However, seasonal differences in the response of the cultivars to beanfly infestation tended to obscure this finding. The anomaly in the results was attributed to differences in the size of the initial population of beanfly in the vicinity of the bean crop, being highest in the noncropping season of 1985 and lowest in the long rains of 1985. In cases of high beanfly infestation all the bean cultivars, including those that had shown signs of resistance under moderate infestation, were severely damaged. Thus there were difficulties in having a uniform beanfly infestation of sufficient level to which the cultivars were subjected during the growing period. However, natural populations of beanfly on beans planted in a single planting in the late part of the cropping season or the beginning of the noncropping season was sufficient to cause observable damage symptoms, which could be reliably used as parameters for resistance. Successive plantings of bean cultivars in the middle part of the cropping season could also produce a beanfly population sufficiently high for screening purposes.

Under moderate field infestation, determination of percent plant mortality due to *O. spencerella*, stem damage scores due to *O. phaseoli* and the number of pupae/puparia were more reliable indices of resistance/susceptibility than the number of beanfly leaf punctures, eggs or larvae as parameters for resistance measurement.

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THE INFLUENCE OF SOME CULTURAL PRACTICES AND APHID NATURAL ENEMIES ON THE INFESTATION OF COMMON BEANS (*PHASEOLUS VULGARIS* L.) BY THE BEANS APHID, (*APHIS FABAE* SCOP.); (HOMOPTERA: APHIDIDAE)

MORRIS W. OGENGA-LATIGO (UGANDA)
1984 CLASS

The infestation of common beans by the bean aphid *Aphis fabae* was monitored when beans were grown either as a sole crop or with maize as an intercrop. Two growth stages and four inter-row spacings of maize plants were used.

For both old and young maize intercrops, aphid infestation on beans was lower when the maize inter-row spacings were smaller. However, beans intercropped with old maize suffered less overall aphid infestation. Thus, at peak aphid infestations, 5 weeks after bean emergence, bean intercropped with old maize at inter-row spacings of 0.5, 1.0, 1.5 and 2.0 m had 1.5, 6.5, 10.9 and 22.7% infestations respectively. The corresponding values for beans intercropped with young maize were 14.4, 44.5, 47.4 and 55.9%, while the infestation of beans grown alone was 70.3%.

Regression analyses showed that there were linear relationships between the percentage of beans infested by aphids and the spacing of intercrop maize, for both old maize ($r = 0.97$) and young maize ($r = 0.91$) intercrops. However the relationship of percent beans infested by aphids to the number of maize rows per plot was linear for the young maize intercrops ($r = 1.0$), but non-linear ($r = -0.94$) for the old maize intercrops.

Further analyses showed that in both old and young maize intercrops with inter-row spacing of 1.5 m and 2.0 m, beans growing adjacent to the maize plants had lower levels of aphid infestation.

The results showed that reducing the spacing of intercrop maize increased the protection of beans against aphid infestation, and that there were strong interaction effects of age and spacing of intercrop maize on levels of *A. fabae* attack on beans.

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**STUDIES ON SOME ASPECTS OF THE BIOLOGY AND FEEDING
BEHAVIOUR OF *ELDANA SACCHARINA* WALKER
(LEPIDOPTERA: PYRALIDAE) ON ONE MAIZE AND ONE
SORGHUM CULTIVAR**

LEONARD M. KANTIKI (MALAWI)
1984 CLASS

The growth and development of *Eldana saccharina* larvae reared on the maize cultivar Katumani Composite B and on the sorghum cultivar Serena was investigated. Larval weights increased significantly with time after infestation ($P < 0.05$). During the third week after infestation the larvae were 2–5 times heavier than during the first and second week. When larvae were reared on nodes and internodes of maize and sorghum, larvae offered sorghum internodes had the longest larval period (51.1 ± 8.2 days) whereas larvae reared on maize nodes had the shortest (22.0 ± 1.7 days).

With both maize and sorghum a linear relationship was obtained between the larval age and head capsule widths. The number of larval instars for moths reared on sorghum and maize were 5 and 6 respectively. Females generally developed through more instars than males. Larval development regarding head capsule widths conformed with Dyar's rule of 1890.

The present study has indicated that *E. saccharina* larvae can survive and attain maturity on both maize and sorghum cultivars.

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**BIOECOLOGICAL STUDIES ON *DENTICHASMIAS BUSSEOLAE*
HEINRICH (HYMENOPTERA: ICHNEUMONIDAE), THE
PARASITOID OF *CHILO PARTELLUS* (SWINHAE)
(LEPIDOPTERA: PYRALIDAE) AND ITS POTENTIAL FOR
BIOLOGICAL CONTROL**

JOHN W. BAHANA (UGANDA)
1984 CLASS

The stalk borer *Chilo partellus* (Swinhoe) is an important member of a group of lepidopteran pests responsible for heavy yield losses in maize and sorghum in East Africa. Attempts to control this pest have in the past not been successful and alternative means are now being actively sought.

An ichneumonid parasitoid *Dentichasmias busseolae* Heinrich endemic in the Ethiopian region parasitizes *C. partellus* in nature and is widespread in the region. This study examines the role of *D. busseolae* in the population fluctuations of *C. partellus* in the Lake Victoria basin of Kenya. Using laboratory experiments and field observations, biological data on the parasitoid was obtained in order to determine its potential as a biological control agent against the stem borer.

D. busseolae is a solitary endoparasitoid which parasitizes and completes its development in the pupa of *C. partellus*. Five larval instars and a pupa were recognised as the immature stages. The developmental period ranged from 64.5 ± 9.5 days at 15°C to 12.0 ± 1.5 days at 30°C for males, and from 66.7 ± 9.8 days to 13.1 ± 2.1 days for females respectively. Beyond this range, the parasitoid did not complete development.

The fecundity and survival of the parasitoid were highest on honey-water mixture and lowest on maize stalks. A similar pattern on longevity was evident.

Mating behaviour of *D. busseolae* is controlled by sex pheromones which the female starts to emit slightly before emergence.

A pre-oviposition period of 2-3 days exists during which the parasitoids do not respond to the presence of hosts and other host-seeking stimuli. The oviposition period lasts until a few days before the female dies. The sex ratio of the progeny is female - biased at the beginning of the oviposition period in mated females, but tilts in favour of males as the parent female approaches the end of its life span. Unmated females give rise to males only.

Oviposition females respond at a distance to the presence of odour originating from frass. Attractiveness of the host is limited to the prepupa and pupa. This is mediated by host chemicals that appear to originate from mandibular secretions in the larval frass surrounding the host. Tests for superparasitism indicated that a single parasitoid was able to discriminate against hosts previously parasitised. There was no evidence of host-marking pheromones or Search Deterrent Substances (SDS).

The intrinsic rate of natural increase of *D. busseolae* was calculated at 0.102, and the population multiplied 28.24 times in the mean generation time of 35.7 days. The functional response of the parasitoid was curvilinear.

Field parasitism in sorghum and maize was evident 7 weeks after plant emergence (APE). Thereafter parasitism was persistent until crop harvest. The range of parasitism was 9.7% to 90% ($\bar{x} = 36.0\%$) and 0-45.5% ($\bar{x} = 23.3\%$) on sorghum and maize respectively.

Using the laboratory and field observations a model for the host-searching process in the *D. busseolae* has been constructed. The components of a population model that can predict the role of *D. busseolae* in a particular host population have also been developed.

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THE BIOLOGY AND HOST-PARASITE RELATIONSHIPS OF AN ENTOMOGENOUS NEMATODE, *PANAGROLAIMUS* SP.

JOHN F. OMOLLO (KENYA)
1984 CLASS

Laboratory studies have revealed that the entomogenous nematode, *Panagrolaimus* sp. will parasitize a wide range of insect species and some acarids, especially the *Pseudoscorpionidae*. Experiments have been carried out to determine the LD50 of the nematode against insect crop pest species, including *Busseola*, *Eldana*, *Sesamia* and *Maruca*.

Behavioural studies have shown that the nematode is capable of moving downwards in moist soil to a depth of 4 cm and parasitizing soil dwelling insect larvae of crop pests. Upward movement appears to be more difficult.

Survival studies in various levels of salinity have shown that the nematode can only tolerate a low level of salinity, and has an optimal salinity range of 0.011 to 0.014 g/ml of sodium chloride in water.

The nematode is strongly attracted to its host, and to washings of the host, particularly *Chilo* and *Galleria* larvae. This suggests the existence of water-soluble chemical attractants from host species.

The attraction between male and female nematodes has been found to be very weak, and only evident over distances of less than 1.0 cm. Copulations in most cases depend upon chance encounters.

A field trial using an aqueous suspension of *Panagrolaimus* sprayed on to the soil and in the leaf funnels of sorghum plants has shown that the nematode produces a significant level of protection for sorghum against attack by stem boring moths.

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EFFECT OF INTERCROPPING SORGHUM AND COWPEA ON THEIR LEPIDOPTERAN STEM AND POD BORER POPULATION BUILD-UPS WITH PARTICULAR EMPHASIS ON *CHILO PARTELLUS* (SWINHOE) (LEPIDOPTERA: PYRALIDAE) IN SOUTH WESTERN KENYA

ELIAINENY M. MINJA (TANZANIA)

1986 CLASS

Polyculture or intercropping is widely practised in eastern Africa. Normally, crops with widely differing growth habits such as legumes and cereals are interplanted. Such crop mixtures may, however, lead to increased or decreased pest incidences depending on crop combination, location, season and cropping pattern. The results described in this thesis involved field studies on sorghum stem and cowpea pod borers in relation to cropping patterns and microclimatic factors in 1986-88.

Five cropping patterns were investigated: cowpea and sorghum monocrops; cowpea and sorghum sown simultaneously in the same plot; and cowpea sown before and after sorghum in the same plots. Crops were planted in randomised blocks replicated thrice at ICIPE Mbita Point Field Station (MPFS) and on a farmer's field on Rusinga Island.

Chilo partellus (Swinhoe) egg counts were made on twenty sorghum plants. *Chilo* moths were released on caged field plants to study oviposition. Sorghum plants were artificially infested with eggs to study larval establishment. Stem borer larval and pupal populations were monitored on destructively-sampled sorghum plants. Pod borer egg and larval counts were made weekly. Pupae were sampled every five days. Dead borers and other arthropods in plant samples were noted.

Soil arthropods were sampled weekly using pitfall traps to monitor potential predators. Light intensity was recorded at ground level using a quantum radio meter (L1-1905). Canopy temperature and humidity were recorded.

C. partellus, *Busseola fusca* (Fuller), *Eldana saccharina* Walker and *Sesamia calamistis* Hmps. were recorded on sorghum throughout the study. Stem borer larval and pupal populations appeared to increase with the age of sorghum. Monocrop sorghum had a significantly higher number of borers and leaf damage than intercrops. There was a significant delay in borer colonization and establishment on sorghum sown after cowpea compared to the other cropping patterns.

Monocrop cowpea had a significantly higher number of *Maruca testulalis* (Geyer) eggs, larvae and pupae and of damaged pods than intercrops. Borer colonization and establishment was delayed in cowpea sown after sorghum.

Diseases and parasites were the predominant mortality factors in larvae and pupae respectively. Soil arthropods were fewer in sorghum monocrop than intercrops. Furthermore, light intensity, temperature and humidity variations within crop canopies were higher in monocrop than intercrops.

Cowpea and sorghum grain yields seemed to have been adversely affected by late planting. However, it appeared that if both crops are to be produced efficiently on a piece of land, then cowpea could be sown before sorghum.

In conclusion therefore, intercropping appeared to have substantial influence in disrupting borer colonization and establishment as well as favouring predators and parasites.

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POPULATION DYNAMICS OF THE CASSAVA GREEN SPIDER MITE *MONONYCHELLUS TANAJOA* IN RELATION TO ITS NATURAL ENEMIES

MILLICENT F.M. NDONGA (KENYA)
1986 CLASS

Study of the biology and population growth rates of *Mononychellus tanajoa* (Bondar) and its two local predators *Neoseiulus teke* Pritchard and Baker and 'Ex-seme' were conducted in the laboratory at Mbita Point Field Station.

The life history of *M. tanajoa* was compared with those of its two predators. The parameters for population growth rates were calculated using life history data. Population growth rate parameters of *M. tanajoa* are discussed in relation to its host plant, other tetranychids and the two local phytoseiid predators.

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STUDIES ON SOME ASPECTS OF BEHAVIOUR OF THE CASSAVA GREEN MITE, *MONONYCHELLUS TANAJOA* BONDAR (ACARI: TETRANYCHIDAE)

ELDAD B. KARAMURA (UGANDA)

1986 CLASS

Some aspects of behaviour of the CGSM (*Monononychellus tanajoa* Bondar) were studied to identify areas that could be manipulated for its control. These aspects included the CGSM's orientation to feeding, mating and oviposition. Orientation to feeding was found to be affected by the mite's hunger state and the substrates on which the mites walked. Lower walking speeds were recorded on host than on non-hosts substrates. However, irrespective of the substrate type, unfed mites had lower walking speeds than fed ones. It was therefore inferred that for the CGSM to accomplish successful migration to new hosts, it should be able to 'measure' both the quality and quantity of food available in the old host plant. This will enable the mite to 'decide' to leave a host plant while it is still able to obtain sufficient food energy to enable it accomplish the host-searching process for a fresh plant. By implication, feeding mites on a given host plant whose nutritional quality is falling will have to search for new hosts if critical food situation levels as reckoned by a feeding mite are not reached.

The study also revealed that the CGSM lacks the ability to perceive its hosts at a distance and instead employs contact signals. This host location by the CGSM is a random process. This mode of host-searching is associated with excessive energy expenditure, many of the mites perishing from starvation, predation and other natural causes. In terms of pest management, it is suggested that this excessive energy loss can be enhanced and exploited by increasing the duration of random searching, for instance, by making the only host (*Manihota* spp.) more patchily distributed.

On reproductive behaviour the study further revealed that the CGSM has a very heavy energy investment in the high rate of reproduction. It was therefore inferred that this level of investment represented a biological compensation for losses incurred during random searching for new host plants. Whereas in host-location the lack of distant host perception was considered a key factor, in the case of reproduction, it was the phenomenon of arrhenotoky, whereby unmated females oviposit male eggs only. This not only appears to nullify the heavy energy investment in reproduction but also, theoretically at least, can bring about sudden extinction of mite populations. Investigations on behaviour of the species also revealed an elaborate behavioural sequence of courtship that ensures the success of the process and helps the species to avoid arrhenotoky. The sequence observed consists of seven acts that operate in a chain fashion, leading the mates to consummation of copulation. It was also discovered that the acts are propelled along the chain by tactile and olfactory signals. It was suggested that the presence of these signals offers great potential for a mating disruption programme.

In reference to the overall objective of the study, it was concluded that the development of a behaviour control programme for the pest should be aimed at achieving three broad objectives. Firstly, management measures should enhance excessive energy losses by making the distribution of the host both spatially and temporally patchy. Secondly through plant breeding, the feeding and breeding sites of the mites can be made unsuitable, which will lead to non-settlement for the two vital processes, and subsequently to population depressions. Thirdly, behavioural manipulation measures can be directed at maximizing conditions that enhance arrhenotoky through disrupting mating, and by stimulating vitellogenic activity and oviposition in virgin females.

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THE EFFECT OF INTERCROPPING RESISTANT AND SUSCEPTIBLE COWPEA CULTIVARS WITH MAIZE ON INFESTATION AND DAMAGE BY THE LEGUME POD BORER, *MARUCA TESTULALIS*

MACHARIA GETHI (KENYA)
1986 CLASS

Intercropping or mixed cropping is the most common agricultural system in developing countries. One of the most predominant combinations involves grain legumes grown in association with cereals. This practice is characterized by a reduced pest population compared to monocrop. This reduced pest population in mixed cropping is due to a number of factors, some of which are physical, which include natural enemies, microclimatic gradient and chemical interactions. Some crops may act as dispersal barriers to migrating pests. The consequences the prevailing factors in a mixed cropping agro-ecosystem have on host plant resistance or susceptibility are not clear since most of the crops are selected and bred for use in monocultures.

In these present investigations, field and screen cage experiments were conducted to determine and quantify the effect of mixed cropping resistant and susceptible cowpea cultivars with maize on the incidence of legume pod borer *Maruca testulalis* (Geyer), and also to monitor the effect of intercropping on the relative resistance and susceptibility of cowpea cultivars to *Maruca*. Colonization processes of *Maruca* on these varieties, environmental variables between cropping systems and the stem borer complex on maize were also observed. The studies were conducted at Mbita Point Field Station in South Nyanza district of Kenya for three consecutive cropping seasons of 1987 and 1988.

Experimental design used in both field and screen cage experiments was randomised complete block. However the data was analysed in the manner of a split plot design. This type of analysis was necessary so as to show the differences between the cropping systems and varieties.

Results obtained revealed that larval populations of *M. testulalis* were significantly different according to the varieties, cropping systems and seasons. These differences were much more related to the intercropping than resistance or susceptibility. The subsequent larval populations was actually the one that was affected by mixed cropping. However the number of larvae did not differ significantly ($P > 0.05$) between pure stands of resistant cultivar TVu 946 and susceptible cultivar ICSV2.

Reduced sunlight reaching the cowpea canopy in the intercropped stands greatly reduced the number of pods/plant. This resulted in a reduction in the number of pods with larval damage. The incidence of *Maruca* larvae during the long rains was higher than during the short rainy season. However as the number of larvae increased so did the number of pods and seeds with damage symptoms.

The population density and build up of *M. sjostedti* were significantly ($P < 0.05$) lower in the mixed crop during the short rainy seasons than during the long rains. However resistance traits of cultivar TVu 946 did not have a significant effect on the population build up in the mixtures. The results revealed that reduced light intensity in the cowpea/maize mixtures contributed to the low number of the thrips.

Results indicated that intercropping affected the relative resistance and susceptibility of cowpea cultivars. The resistance of TVu 946 was reduced when the cultivar was planted together with maize. This could have been due to the phenological changes that were observed.

When the variety was planted together with maize, pods and peduncles were significantly longer while the branches were significantly fewer. The changes were attributed to the micro-environmental conditions that were created by maize, suggesting that cultivar TVu 946 is not well adapted to intercropping.

In the screen cages, stems of cultivars TVu 946 were equally damaged when interplanted with maize and cultivar ICV2. Similarly for cultivar ICV2, intercropping reduced the amount of damage caused by *Maruca*. It was, therefore assumed that microclimatic differences created by intercropping had an adverse effect on resistance of TVu 946, since its resistance is rather phenologically oriented, thus modifying it genetically.

There was a plant age preference for oviposition on the cowpea cultivars with the underlying role of intercropping being demonstrated by the fact that there were significantly ($P < 0.05$) more *Maruca* eggs in pure stands than in the intercrop. Similarly the role of resistance and susceptibility during the initial colonization in the field was realized, with the resistant cultivar TVu 946 having fewer eggs than cultivar ICV2. The subsequent larval population was not affected by mixed cropping. In the screen cage more eggs were recorded on the edges of all the intercropped plots and on pure stands of all the two varieties.

Weekly mean temperatures and relative humidities indicated that there were significant ($P < 0.05$) differences between cropping patterns. Temperatures were lower and relative humidities higher in the intercrop. Similarly there was significant reduction in the photosynthetic active radiation incident on cowpea canopy in all the intercropped plots.

C. partellus was found to be the dominant stem borer within the study area and its populations were only slightly regulated by mixed cropping. However other borers namely *H. armigera* and *E. saccharina* were recorded later in the season on silk and top cob respectively.

Land equivalent ratios (LER) for the cropping seasons were significantly ($P < 0.050$) higher, indicating that intercropping had a yield advantage with both cultivars. It is therefore concluded that intercropping maize and cowpea reduces pest damage on cowpea; however it is capable of modifying the level of resistance.

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ENDOCRINOLOGY OF DEVELOPMENT AND REPRODUCTION IN THE MAIZE STEM BORER, *BUSSEOLA FUSCA* (FULLER) (LEPIDOPTERA: NOCTUIDAE)

MARCELIAN A. NJAU (TANZANIA)

1986 CLASS

Busseola fusca (Lepidoptera: Noctuidae) is one of the most important insect pests of maize and sorghum in Africa, south of the Sahara. Last instar larvae of this species survive the dry season in the stalks and stubbles of their host plants by undergoing diapause.

The present study was done with the main objective of investigating the involvement of the neuroendocrine system during the development of the last instar larvae with respect to non-diapause and diapause development. The main aspects studied were the biology of last larval instar, history, ultrastructure and physiology of the components of the larval neuroendocrine system, particularly the type-A neurosecretory cells, corpus cardiacum, corpus allatum and prothoracic glands. Endocrine involvement in the regulation of development during the last instar larvae and in induction, maintenance and termination of diapause development were also investigated.

Studies on the biology of the last instar showed that two types of development, namely, non-diapause and diapause occur in *Busseola fusca*. The non-diapause form of development is characterized by the feeding phase and post-feeding phase and the diapause form of development is characterized by only a long, non-feeding phase.

The structure of the component of the endocrine system revealed that in both non-diapause and diapause larvae the type-A neurosecretory cells in the brain and the prothoracic glands were structurally comparable, with insignificant differences. However, the corpora allata were structurally different in non-diapause and diapause larvae. The corpora allata in non-diapause development had cells which completely lacked glycogen-like deposits, which were found abundantly in the corpora allata of diapause larvae. The mitochondria of the cells of the corpora allata in non-diapause development were not conspicuous and did not contain dense bodies. On the other hand, the mitochondria of the cells of the corpora allata in diapause larvae were large and pleomorphic and contained bodies within the matrix. The corpora allata in non-diapause larvae were slightly smaller in size than those of diapause larvae. However, the prothoracic glands in non-diapause larvae were larger than those in diapause larvae.

The titers of juvenile hormone in non-diapause larvae were very low (as determined by *Dysdercus* bioassay, out of an average score of 0.8 out of 3.0), while those in the diapause larvae were high (average score of 2.8). The titers of the moulting hormone in non-diapause last instar larvae were 10,170, and 500 ng/ml on days 1, 4 and 7 respectively; in diapause larvae the titer was generally low with a monthly mean titer of less than 200 ng/ml.

Injection of the juvenile hormone analogue resulted in induction of diapause in non-diapause larvae. Elevation of the moulting hormone titers by experimental injection of ecdysone into the diapause larvae triggered moulting, but it was usually a larval-larval (stationary) moult. Injection of the moulting hormone in isolated abdomens of diapause larvae induced progressive moult. These observations indicated that diapause development was not due to deficiency of moulting hormone. Diapause can be initiated and maintained by high titers of juvenile hormone. Thus the corpora allata of the diapause larvae were active. Precocene showed no allatocidal effect on the corpus allatum of the diapause larvae. Fluoromevalonate treatment of the late diapause larvae at a dosage of 10 µg per individual prevented larval moult and delayed pupation relative to the non-treated larvae. At a dose of

5 µg per individual, larval moults occurred and pupation was not delayed but the resultant adults were deformed.

In conclusion, this study has shown that non-diapause development is characterized by a last-instar period of two distinctive behavioural phases whereas diapause development has only one behavioural phase. Also, diapause development in *Busseola fusca* lasts up to the pre-pupal stage of the last instar. In addition, type-A neurosecretory cells stain less with advance of time in non-diapause and diapause development during the last instar, while the presence of glycogen in the corpora allata of the diapause larvae signified storage of metabolites to be used during the long period of diapause. Ecdysone titers in the haemolymph during non-diapause and diapause development were quite normal and so were the JH titers in non-diapause development. However, the persistent high titers of JH in the haemolymph during diapause development indicates that diapause development in *Busseola fusca* is primarily controlled by the juvenile hormone. Thus, both ecdysone and juvenile hormone are involved in the regulation of the type of development which occur during the last larval instar of *Busseola fusca*.

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STUDIES ON THE MAIZE STALK BORERS, *BUSSEOLA FUSCA* (FULLER) (LEPIDOPTERA: NOCTUIDAE) WITH SPECIAL REFERENCE TO ITS BIOLOGY, ECOLOGY AND YIELD LOSS IN MAIZE

MUNENE WA MACHARIA (KENYA)
1986 CLASS

The maize stalk borer, *Busseola fusca* (Fuller) is a serious pest of maize in the Highland areas of Kenya. In an effort to generate information that could be useful for integrated management of the pest, the main factors studied in the current investigations were its biology and ecology. Other studies involved its population patterns in relation to planting dates, crop losses caused by the pest and evaluation of crop loss assessment techniques used in estimation of losses due to *Buseola fusca*.

It was revealed by these studies that development was completed with intervening larval diapause. About 30.4% of the larvae from the same egg batch underwent diapause, while the rest (69.6%) underwent normal development without experiencing an intervening diapause. Duration of non-diapause larval period was 40.9 ± 0.5 days, while in diapause larvae the duration was 238.5 ± 13.1 days. There were no significant differences ($P > 0.05$) in the durations of pre-oviposition, oviposition, post-oviposition, longevity and fecundity rate between moths originating from diapause and non-diapause generations.

Maize stalk residues with an infestation of 1.5 insects/m² were identified as being a major avenue of the carry-over population of *B. fusca* as compared to other hosts. Columbus grass, *Sorghum alnum* had 1.4, Sudan grass, *S. sudanensis* 0.9, grain sorghum, *S. bicolor* 0.9, and napier grass, *Pennisetum purpureum* 0.1 insects per m².

When the effects of mortality factors and influence of weather on diapausing *B. fusca* larvae during the dry season were determined, larval mortality due to *Apanteles sesamiae* Cameron was 12.3%, indicating that the parasite could be manipulated for the control of the pest. Mortality due to other causes was 87.7%. Rainfall was negatively correlated (for 1987: $r = -0.45$; $P < 0.05$; for 1988: $r = -0.25$; $P > 0.05$) with the number of larvae. On the other hand, mean temperature was positively correlated (for 1987: $r = 0.47$; $P < 0.05$ for 1988: $r = 0.41$; $P < 0.05$) with larvae population. This indicated that increased rainfall and reduced mean temperatures probably influenced the larva to pupate and emerge.

It was also revealed by studies on seasonal abundance of *B. fusca* moths that the pest was present throughout the year. Three peak periods were identified, the first peak occurring in April, the second peak in August and the third peak in November. Rainfall and minimum temperature were positively correlated ($r = 0.40$, $r = 0.24$ respectively) with moth catches. On the other hand, maximum temperature was negatively correlated ($r = -0.24$) with moth catches. This indicated that increased rainfall and reduced temperatures probably influenced the emergence of adult moths to lead to higher trap catches. Lunar phases of the moon significantly ($P < 0.05$) influenced the number of the moths caught. However, these lunar phases did not significantly ($P > 0.05$) influence the sex ratios of the moths caught.

Field experiments were also conducted to compare the effect of different maize stubble disposal practices on the survival of the pest during the dry season. Harrowing and deep ploughing as treatments caused 86.7% and 75.9% mortalities, respectively, which were significantly ($P < 0.05$) higher than other treatments. Burning, cut stumps and standing stalks as treatments achieved 61.2%, 30.4% and 23% mortalities, respectively. Compared to the standard practice of leaving harvested standing stalks in the field, harrowing and deep

ploughing as treatments achieved 94.5 and 90.7% reduction of *B. fusca* population relative to standing stalks treatment, respectively. It was therefore concluded that harrowing and deep ploughing held some potential as cultural control techniques for *B. fusca*.

The effect of early and late plantings on *B. fusca* infestation patterns was also investigated. No significant differences ($P > 0.05$) existed in larval populations, and stem and internode damage between the treatments. A significant difference ($P < 0.05$) in percentage plant damage was recorded, with the late-planted crop being more severely damaged than the early crop.

Experiments were also conducted to evaluate the effect of *B fusca* infestation on yield and yield components of maize. The results demonstrated that the stage at which the crop was attacked is critical with young plants incurring heavier damage. It was further shown that damage increased with increased pest density. The 8-leaf was the most critical growth stage even when the infestation was low. Significant ($P < 0.05$) variations in damage existed among vegetative parameters tested. Apparently, damage on vegetative parts adversely influenced grain yield. Infestations of 2, 4, 8 and 16 larvae per plant resulted in yield reductions of 26.4, 37.0, 48.2 and 74.4%, respectively. When economic injury levels (EILs) were calculated, it was revealed that even slight infestation (0.01 larvae/plant) at the 8-leaf stage caused economic losses. Damage at other plant growth stages was also heavy with slight infestations (6 leaf stage = 0.03 larvae/plant; 10 leaf stage = 0.04 larvae per plant). These observations pointed to the fact that the pest was a voracious feeder, able to cause economic losses even at very low population levels.

Results of the evaluation of techniques for assessing crop losses in maize due to *B. fusca* showed that both methods, (damaged/undamaged plants method and chemically protected/unprotected plants method) were identical in accuracy and any one of them could be used instead of both. The technique based on damaged/undamaged plants was appealing for use by farmers since it has practically no side effects.

An on-farm crop estimation of losses caused by *B. fusca* using the technique based on damaged/undamaged plants was conducted in five agro-ecological zones in Nakuru area of Rift Valley Province. The results obtained indicated that there were differences in potential losses among the zones that were studied. This was due to differences in levels of infestation which was attributed to varying environmental conditions.

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GENETIC INCOMPATIBILITIES AMONG POPULATIONS OF THE
CASSAVA GREEN MITE COMPLEX, *MONONYCHELLUS* SSP.
(ACARINA: TETRANYCHIDAE) AND THEIR IMPLICATIONS IN
THE TAXONOMY OF THE MITE

THOMAS N. MUREGA (KENYA)

1987 CLASS

Hybridization tests revealed various levels of reproductive isolation among 19 populations tested. Mean egg lethality was higher in the F_2 than in the F_1 and F_3 ($P < 0.0003$). Populations from Nyanza, Western and Coast Provinces had higher lethality than those from Central Kenya (mean lethality = 11.69, 9.26 and 6.35%, respectively). Sub-specific population differences were recorded on populations from Central Kenya ($P < 0.05$) compared to other sites ($P > 0.05$). However intra-populational check crosses revealed that these differences were not due to gene interaction but resulted from heterogeneity as a result of extra-chromosomal factors ($P > 0.05$) in the different setal morphs. This is evidenced by successful zygote formation, showing that a common gene pool is shared.

Hybrid success of the subsequent progenies indicated absence of hybrid sterility, inviability or breakdown and distorted sex-ratios (range = 1:1–8:1). Preponderance of diploid offspring indicated that fertilization was successful among all the populations hybridized. The arrhenotokous mode of reproductive parthenogenesis was demonstrated, which gave an exclusive haploid male progeny from uninseminated virgin females.

Based on the shape of their aedeagii, all the males from the six sites were identified as *Mononychellus progresivus* while the 6 females were classified as short, long or intermediate setae parents (range = 20.02–45.76 mm). The 6 F_1 generation lines crossed segregated into distinguishable short, long and intermediate setal forms (range = 17.56–33.24 mm). The D_1 , D_2 and D_3 setae increased with body size ($r = 0.877, 0.97$ and 0.93 , respectively; $P < 0.0001$), but were different in each of the 6 sites ($P < 0.0001$). The existence of the three setal morphs suggested that seta inheritance is polygenic and is controlled by three non-allelic genes. Because of their great variability, the dorsal setae cannot, therefore, be reliably used for species diagnosis. The shape of the aedeagus was found to be the only reliable morphological species-diagnostic tool due to its genetic stability.

It is questioned whether *M. tanajoa* and *M. progresivus* are discrete species. The weight of the evidence justifies the conclusion that *M. tanajoa* and *M. progresivus* are one and the same species.

SUPERVISORS:

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STUDIES ON THE TRANSMISSION AND SURVIVAL OF *NOSEMA* SP. (MICROSPORA: NOSEMATIDAE)

JAMES OGWANG (UGANDA)
1987 CLASS

Studies were conducted to elucidate the modes of transmission and survival of *Nosema* sp. Results showed that factors, both parental and physical, determine the environmental persistence of the pathogen.

The principle mode of persistence of *Nosema* sp. in the main host (*Chilo partellus*) population was through vertical transmission of the pathogen by infected mothers to offspring. Infected males however, were not found to play any role in the parental transmission of the pathogen.

Microscopic studies on the vertical transmission of the pathogen revealed that *Nosema* sp. contaminates the egg chorion. The hatching larvae then get infected when they eat their way through the egg shell during eclosion. No spores were seen in the egg yolk.

Several physical factors including sunlight, temperature, ultraviolet radiation and pH were found to reduce the viability of *Nosema* sp. spores. The viability of *Nosema* sp. spores suspended and exposed to direct sunlight was reduced after seven hours of exposure. Five hr exposure of a suspension of the pathogen to artificial UV radiation resulted in a complete loss of viability of the spores.

Incubation of *C. partellus* larvae inoculated with the pathogen at between 25°C and 30°C promoted the development of symptoms of an infection with the pathogen after one week.

On the other hand, inoculated larvae incubated at temperatures below 15°C developed no symptoms and by the time of examination all the larvae were dead. At 35°C the inoculated insects developed normally but with no symptoms of an infection.

The effects of pH on *Nosema* sp. showed that viability was not affected at values of pH 5 and below but at pH values of between 7 and 9, the pathogen lost its viability.

Studies on the persistence of *Nosema* sp. in soils showed that *Nosema* sp. spores would persist at very low concentrations for up to four weeks in soils collected from five localities in Western Kenya. While on sorghum leaves, the pathogen persisted for five weeks.

Studies on the host range of *Nosema* sp. carried out on three common lepidopteran sorghum stem borers indicated that this pathogen infects *C. partellus* and *Eldana saccharina* larvae. *Busseola fusca* was found to be resistant to the pathogen.

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Chemistry and Biochemistry

**ALLELOCHEMICALS FROM *SORGHUM BICOLOR* THAT
STIMULATE FEEDING BY THE LARVAE OF THE STEM BORER
*CHILO PARTELLUS***

BALDWIN TORTO (GHANA)
1985 CLASS

Feeding bioassays with cellulose acetate discs impregnated with the hexane, ethyl acetate and methanol extracts of the leaf-whorls of field grown plants of sorghum cultivars IS 18363 (susceptible) and IS 2205 (resistant) showed that the methanol extracts were most stimulatory to the feeding of the third-instar larvae of *Chilo partellus*. Ethyl acetate extracts were intermediate in stimulatory activity whilst hexane extracts were the least stimulatory. Extracts of the more susceptible cultivar were more stimulatory than those of the more resistant cultivar and those of the whorls of the 3-week old plants were more stimulatory to larvae than those of the 6 week-old plants.

The phagostimulatory compounds in the ethyl acetate extracts were phenolic, p-hydroxybenzaldehyde and p-hydroxybenzoic acid being the major components and ferulic and caffeic acids being in minor amounts. p-Coumaric acid was also present in minor amounts but was non-stimulatory at all the doses tested. p-Hydroxybenzaldehyde was a more potent feeding stimulant for the larvae relative to some of its possible theoretical biogenetic analogues. Limited structure-activity studies with some hydroxybenzoic acids and their corresponding cinnamic acids showed that the former were more stimulatory to the feeding of the larvae than the latter and that oxygen substitution in the benzene ring was crucial for activity.

The phagostimulatory compounds in the methanol extracts were phenolic, identical to those in the ethyl acetate extracts, and sugars. The sugars which were identified in the extracts comprised: sucrose, fructose, glucose and xylose. The feeding response of larvae to these sugars followed the order: sucrose >> glucose = fructose; xylose was non-stimulatory. Comparison of the activities of sucrose with mixtures of glucose and fructose showed that the high activity of the disaccharide is due to its total structure and not to a summation of its monosaccharide moieties.

Sugars synergised with phenolics to give an enhanced feeding response in the third-instar larvae.

Chromatographic analyses of the extracts showed that stimulatory and non-stimulatory components in the extracts differed quantitatively rather than qualitatively in the whorls of the two cultivars at the two growth stages. This may have implication in resistance screening and breeding programmes.

SUPERVISORS:

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Termite Research

BIOSYSTEMATIC STUDIES OF THE TERMITE GENUS *ODONTOTERMES* (HOLMGREN) WITH SPECIAL REFERENCE TO KENYA

RICHARD K.N. BAGINE (KENYA)
1983 CLASS

Odontotermes is a large and diverse genus containing some species that are pests in agriculture and forestry. Work on this genus has been hampered by taxonomic difficulties. The genus has never been revised since it was erected by Holmgren in 1912. In East Africa there are thirty recorded species, more than in any other genus of termites, but most of these cannot be identified with confidence. Some of the type specimens are of alates while others are of soldiers.

All available primary types have been examined and compared with East African *Odontotermes* material. In the study area, *Odontotermes* species were divided into two groups defined by their size and shape. Species were defined by numerical taxonomy and cluster analysis on a suite of morphological measurements. In addition ecological characteristics were examined, especially the external and internal structure of the nest and the detailed sculpture of the fungus combs. By these means, ten species were distinguished, which are described and illustrated. Four species are described as "sp. near". These species are believed to be new. An attempt has been made to key the East African *Odontotermes* species on the basis of the soldier caste.

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***ARPPIS M. Phil. Programme in
Biological Control***

***Theses submitted in partial
fulfilment of the requirements
for the award of Master of
Philosophy (M. Phil.) Degree in
Applied Entomology at the
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**A MORPHOMETRIC STUDY OF THE CASSAVA GREEN MITE,
MONONYCHELLUS SPP. (ACARI: TETRANYCHIDAE) IN AFRICA**

ROSETTA BOB-MANUEL (NIGERIA)

1985 CLASS

The study deals with investigations undertaken to assess and identify characters other than the dorso-central body setal lengths ($D_1 - D_3$) in the adult females for better morphological understanding of the *Mononychellus* spp. in Africa. Twenty-seven characters were measured on 200 adult female specimens from 10 African countries. Fifteen characters each, on 150 immature stages (larva, protonymph and deutonymph) from Kenya were also examined. The ontogeny of body setae in all the instars was also studied.

Measured characters were subjected to principal components analysis (PCA), cluster analysis and other basic statistical analysis. Characters assessed using the PCA were mostly intercorrelated. The few uncorrelated characters, such as all the ratios, particularly RL_2 in the adult, P_1 , P_2 , D_3 and D_5 in the larva and P_1 , I_2 and D_4 in the protonymph could not effectively indicate indices of variation of classification. The pattern of the scatter plots of the "Operational Taxonomic Units" (OTUs) for all the instars and the results obtained from the cluster analysis of adult females inferred a single species. Location effect was significant for all the variables with analysis of variance (ANOVA) tests but the percentage variances due to location were very low (except for variable RL_2 with 50%), suggesting in the non-statistical sense, an insignificant role of geographical influence in the species distribution using the intercorrelated characters. Mean setal lengths for the instars were not all directly proportional to the increases in body sizes.

Setal counts on the life stages from both the laboratory cultures of immatures and preserved adult specimens showed a constant number of 13 pairs of setae on the dorsal idiosoma from larval to adult instars, while there was a progressive addition of setae on both the ventral idiosoma and leg segments.

Complete setal formulae for the leg segments for all the instars, including mean setal lengths and body sizes of the larva, protonymph and deutonymph are presented.

Finally, the results of the study, based on the variables used, indicated no real evidence for describing the complex as more than a single species.

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THE BIOLOGY AND BEHAVIOUR OF *NEOSEIULUS IDAEUS*
(DENMARK AND MUMA) (ACARINA: PHYTOSEIIDAE) REARED
ON NATURAL AND ARTIFICIAL MEDIA

EDNA CH. NWOFOR (NIGERIA)

1985 CLASS

The biology and behaviour of *Neoseiulus idaeus* (Denmark and Muma) was compared on natural and artificial diets under controlled laboratory conditions (27°C and 80% r.h.). The predator culture was maintained on a diet of red spider mites (*Tetranychus* spp.) while the prey was maintained on bean leaves (*Phaseolus vulgaris* L.).

Five developmental stages namely, egg, larva, protonymph, deutonymph, and adult, common to phytoseiid were observed on the natural diet. The mites did not develop beyond the protonymph stage when maintained on the artificial diets.

Eggs are laid singly on leaf hairs or in the web strands of the prey. The males are bronze coloured and smaller than the females and some female deutonymphs. The females are light orange coloured and bigger than the other stages.

Observed fecundity was low owing to high mortality in the ovipositing females. Mating was necessary for oviposition. Repeated mating was required for continued oviposition and for the females to lay their full complement of eggs.

Longevity was compared on natural diet, artificial liquid diet, artificial solid diet, a no-food situation and a modified artificial liquid diet. The mites lived significantly longer on the natural diet than on the other food situations. There was no significant difference in the longevity of the mites on the rest of the diets.

N. idaeus preferred the eggs of its prey to the other stages. The larva did not feed. Cannibalism was observed in the absence of its prey.

The highest mortality was recorded at the adult stage. The intrinsic rate of increase was quite high (0.845 per head per day) with a short generation time (2.969 days).

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A BIOCHEMICAL INVESTIGATION OF THE TAXONOMY OF THE CASSAVA GREEN MITE *MONONYCHELLUS* SPP. (ACARI: TETRANYCHIDAE) IN KENYA

KENNETH O. KAMBONA (KENYA)

1986 CLASS

Biochemical methods have been applied to elucidate the species systematics of cassava green mite (CGM). Traditionally CGM have been classified using the length of the dorso-central setae ($D_1 - D_3$), which groups CGM into two species, the short setae form, *Mononychellus tanajoa* (Bondar) and the long setae form *Mononychellus progresivus* Doreste. However the validity of this method of classification is being questioned because the setae were found to vary from short to long in a continuous gradient. This characteristic, therefore becomes unreliable for species separation.

Isoenzyme analysis and cuticular hydrocarbon studies were carried out using isoelectric focusing and gas chromatography respectively. Thirteen enzyme/substrate systems were used in distinguishing closely related species. These were: Aconitate hydratase, alcohol dehydrogenase, glucose-6-phosphate dehydrogenase, isocitrate dehydrogenase, malate dehydrogenase, mannose phosphate isomerase, malic enzyme, phosphoglucomutase, superoxide dimutase, nucleoside hydratase, hexokinase, glucose phosphate isomerase and pyruvate kinase. Out of the thirteen, three enzymes proved most powerful as taxonomic indicators, namely malic enzyme, glucose phosphate isomerase and malate dehydrogenase. CGM populations showed identically migrating bands for these enzymes. Multivariate analysis was applied to demonstrate the statistical significance of the electrophoretic data. No major significant differences were observed within the band parameters.

Hexane soluble cuticular hydrocarbons of the short and long setae forms were separated by gas chromatography. The chromatographic profiles were identical for the two setal forms.

It is clear from these results that there are no biochemical variants in CGM populations in Kenya. Consequently, there is no evidence to warrant species differentiation. Only a single species of CGM, *Mononychellus tanajoa* can be considered to occur in Kenya.

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**BIOLOGY OF *TRICHOGRAMMA* SPECIES NEAR *EXIGUUM*
PINTO & PLANTNER (HYMENOPTERA:
TRICHOGRAMMATIDAE) ON SOME LEPIDOPTEROUS
HOSTS IN SOUTH NYANZA, KENYA**

GERALD R.S. OCHIEL (KENYA)

1986 CLASS

The effects of various physical and biotic factors on important biological parameters of the hymenopterous parasitoid *T. sp. nr. exiguum* were investigated, as well as fundamental aspects of its population ecology.

The parasitoid was reared on *Chilo partellus* (Swinhoe) for 28 generations under ambient laboratory cage conditions of $26.2 \pm 1.0^{\circ}\text{C}$ and $49.2 \pm 5.6\%$ r.h. *C. partellus* was the reference host in a study of the parasitoid's preference for four lepidopterous hosts.

No consistent relationship was evident between temperature and four biological parameters. However, female longevity and developmental period were both inversely related to temperature.

Optimum and threshold temperatures for growth and development were determined on the basis of life-tables studied at 18, 20, 25, 27 and 30°C . Survivorship and daily progeny production, growth and mortality rates, reproductive potential and female longevity were determined for each temperature.

The first two days of parasitization were significantly different from the last three, for all biological parameters considered, except for female progeny production, at each tested temperature.

Two sucrose and three honey solutions tested, as well as three controls, were equally effective for three biological parameters of the parasitoid. Only 5% and 20% sucrose solutions were significantly different from the controls, for female longevity.

C. partellus eggs were equally preferred by female parasitoids in choice and no-choice situations. Preference for *Heliothis armigera* Hubner eggs was greater than that for *Busseola fusca* (Fuller) and *C. partellus* eggs, which were equally preferred. The least preference was shown for *Galleria mellonella* L. eggs.

SUPERVISORS: ICIPE: Dr. G.W. Oloo
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**AN ENTOMOPATHOGENIC FUNGUS, *HIRSUTELLA THOMPSONII*
FISHER (FUNGI IMPERFECTI) AS A POTENTIAL BIOLOGICAL
CONTROL AGENT OF *MONONYCHELLUS TANAJOA* (BONDAR)
(ACARI: TETRANYCHIDAE)**

BENSON ODONGO (UGANDA)
1986 CLASS

The infectivity of *H. thompsonii* on cassava green mite, (CGM), *M. tanajoa* was determined in laboratory, cage and field experiments.

In the laboratory, eggs, larvae and adult females were sprayed with suspensions of the fungus at concentrations ranging between 9.8×10^5 to 1.0×10^8 conidia per ml (CPM). Between 3% and 21% egg hatch reduction was recorded from *H. thompsonii* treatment compared with the control. Phase contrast micrographs did not show that the fungus grew onto the surface of, or penetrated into the eggs. Significantly mortality (up to 34%) was recorded from *H. thompsonii* treated CGM females. The number of eggs laid per CGM female with the fungus was significantly lower than the number laid by the control batch. Death of infected female mites mainly occurred between 3 to 6 days after infection in the laboratory. Within this time, mite cadavers were observed to undergo some morphological changes, e.g. body coloration changed from creamy through brown, dark-brown and development of fungal growth; the body became turgid, and then broke open and rapidly shrank to disappearance; they were invariably attached to the substratum; fungal mycelial penetration into the mite tissue and their conidiation could be demonstrated from 72 hr after treatment. CGM larvae were not appreciably killed by *H. thompsonii*.

In potted experiments, the number of eggs and live mites on the leaves were reduced following application of the fungus. The protection given was slightly better than that from introducing *Amblyseius teke* (a phytoseiid mite predating on CGM).

In the field, aqueous suspensions of *H. thompsonii* conidia at a concentration of 8.0×10^5 and 3.7×10^5 CPM were applied to *M. tanajoa* pest on field cassava at the peak of pest infestation, which occurred at the driest and hottest period of the season. The treatment reduced the number of eggs and live CGM by 63 and 77% respectively. The damage symptoms caused by the pest were also reduced. This was particularly evident from the second week after treatment application.

Rainfall was a density-independent mortality factor. Heavy precipitation led to a sharp reduction in mite numbers and in subsequent levels of pest damage.

It is therefore shown here that timely application of *H. thompsonii* in coordination with other control or mortality factors, e.g. under integrated pest management practices, could greatly help reduce the level of pest damage. Pest distribution was most concentrated on the upper, younger leaves between leaves 1 to 5. The numbers fell with increasing age of the leaves. The effects of temperature, rainfall totals and number of rainy days per month on pest population and damage symptom indices are discussed.

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THE PATHOGENICITY OF *BEAUVERIA BASSIANA* (BALS)
VUILLEMIN (DEUTEROMYCOTINA: HYPHOMYCETES) TO
CEREAL STEMBORERS WITH EMPHASIS ON *CHILO*
PARTELLUS (SWINHOE) (LEPIDOPTERA:
PYRALIDAE)

1987 CLASS

Two strains of *Beauveria bassiana* (Bals.) Vuill. (Deuteromycotina: Hyphomycetes) were tested under laboratory and field conditions for the control of the sorghum stem borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae).

Laboratory tests indicated that the pathogenicity of *B. bassiana* was dependent upon the spore-dose used, and the time following treatment. The highest concentration of 2×10^9 spores/ml of the local and exotic *B. bassiana* strains caused 100% larval mortality in 12 and 24 days after treatment, respectively. The LD_{50} for the local strain was 3.17×10^6 and that of the exotic strain was 3.53×10^7 spores/ml, 3 days after treatment. The LT_{50} for the local strain was 3 days at the concentrations of 2×10^7 , 2×10^8 and 2×10^9 spores/ml. The LT_{50} for the exotic strain was also 3 days at the concentration of 2×10^8 and 2×10^9 spores/ml.

Dry-spore preparations were more effective than aqueous spore suspensions in infecting *C. partellus* larvae. Mortality levels were higher in larvae than in eggs and pupae (95% in second instar, twelve days after treatment as compared to 63.27% in eggs and 35% in pupae). First instar larvae were the most susceptible development stages of the pest.

Both the spore viability and virulence of *B. bassiana* to *C. partellus* larvae decreased following culture incubation at 25°C for 35 days. Spore germination in seven-day-old cultures of the local and exotic *B. bassiana* strains was 91.0% and 89.75% respectively. In 35-day-old cultures, germination was 63.75% for the local and 72.0% for the exotic strain. Repeated subculturing on Sabouraud Dextrose Agar (SDA) also reduced spore viability and virulence of *B. bassiana*.

The fungus was infective at relative humidities ranging from 40–80% and over a temperature range of between 15 to 35°C. Maximum larval mortality occurred at 80% relative humidity and 15 to 25°C.

Application of *B. bassiana* spore suspensions to plants artificially infested with *C. partellus* larvae in the field reduced plant damage levels and suppressed the *Chilo* population. There was however, no significant difference between the yields obtained from infested and non-infested plants.

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**A MODEL OF PARASITISM BY *TRICHOGRAMMA* SPECIES NEAR
MWANZAI SCHULTEN & FEIJEN (HYMENOPTERA:
TRICHOGRAMMATIDAE) ON THE STALK BORER, *CHILO
PARTELLUS* (SWINHOE) (LEPIDOPTERA:
PYRALIDAE) ON SORGHUM**

ADELE J. NGI-SONG (CAMEROUN)

1987 CLASS

Effects of the sequence of parasitoid release and three ecological factors, i.e. parasitoid densities, pest densities, and climatic conditions, on the rate of *Chilo partellus* (Swinhoe) egg parasitism by *Trichogramma* sp. nr. *mwanzai* Schulten and Feijen, were studied in caged experiments and in the field. Predictive models were developed using data generated from the above studies.

The five different parasitoid population densities used were positively correlated with the number of eggs and egg batches parasitised in the caged experiments. Mutual interference between the parasitoids was observed at the highest population density of the parasitoid (48).

The five different pest population levels were positively correlated with the number of eggs and egg batches parasitised. As pest density increased, significant variations were observed in the rate of parasitism. An inverse relationship was found between the formation of black heads and the parasitoid population size. The sequences of parasitoid release used in the study did not significantly affect the level of parasitism obtained.

For the caged experiments the maximum and minimum temperatures on the day of parasitoid release showed an inverse relationship with the number of eggs and egg batches parasitised, while the relative humidity of that same day was positively correlated.

T. sp. nr. mwanzai showed a Type II functional response in the caged experiments. Field data confirmed the cage observations in several cases.

Data generated in the study were fitted into modified general host-parasitoid models for the prediction of parasitism rates if the pest and parasite population densities are known. A regression model was developed to express the proportion of egg batches parasitised as function of climatic factors, the number of parasitoids released and the number of pest egg batches exposed.

Variable types of fit were obtained when either the number of eggs parasitised or the number of egg batches parasitised were used as dependent variables. A model developed from the data generated in the caged experiments was validated using the field data. Results indicated similarity in fits for the two cases.

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