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THE USE AND NON-USE OF INSECTS

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THE STATUS OF INSECT SCIENCE IN THE TROPICAL WORLD:

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THE STATUS OF INSECT SCIENCE IN THE TROPICAL WORLD

THE Series of ICIPE Annual Public Lectures are devoted to the general theme of "The Status of Insect Science in the Tropical World". In it, the ICIPE Director examines, each year, the problems and progress of insect scientific research in all its many manifestations, but especially in the way it contributes to national development in Tropical Africa. ICIPE is interested in investigating new frontiers of insect science, in using this knowledge to design novel methods for pest and vector management on a long-term basis, and in building up the capabilities of the African scientific community in meeting these challenges.

On Wednesday, 4th June 1975, the inaugural lecture in this Series was delivered on, "This is a Dudu World". In the second address, delivered on Wednesday, 9th June 1976, Professor Thomas R. Odhiambo explored the problems associated with "National Scientific Capabilities". In the third address, given on Wednesday, 8th June 1977, Professor Odhiambo was concerned with "Science and Technology for the Rural Farmer". In this fourth lecture, the problem discussed is that of "The Use and Non-Use of Insects", an aspect that so far ICIPE has not dealt with directly, and an area of research enterprise that the tropical world as a whole has not yet engaged in systematically.

THE USE AND NON-USE OF INSECTS

The world of management has recently become a very respectable and, indeed, a fashionable one. Different groups of people are seemingly falling upon each other staking out new areas of management: "pest management", "energy budget and management", "science management", even "resource management". What is implied by such a label is that in managing any activity or resource one has done three things:

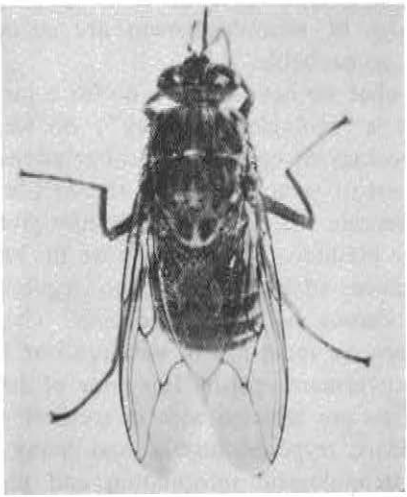
- He has understood the nature of the activity or the resource
- He can predict its behaviour or trend of activity
- He has solved the problem of how to modify the basic elements of it to his own uses.

But these three elements are not always evident in proposals for a new management area. Thus, Professor C. S. Holling of the University of British Columbia, had this to say in relation to resource management:

> "The modern resource manager is still forced to function essentially as those mediaeval alchemists did when they attempted to transmute elements without the knowledge of nuclear physics. Ecological alchemy is scarcely an adequate approach when the consequences of mismanagement are so disastrous and, increasingly, so probable."[1]

Yet, much of what we have tried to do for a long time in pest and vector management is "ecological alchemy": do we have an adequate knowledge of the ecology or epidemiological relationships of any of the important insect pests or vectors vital for the well-being of the tropical world? Can we forecaste their behaviour in any given situation with a reasonably adequate predictive value? Have we the knowledge to modify the basic circumstances of insects so as to regulate their population level and their pestiferous value to any degree? These are some of the critical considerations we must use to measure our readiness to launch a pest or vector management project. For none of the important vectors of human diseases we are afflicted with in tropical regions — malaria, filariasis, leishmaniasis, trypanosomiasis, and many more — have we this corpus of epidemiological information and predictive knowledge with which to mount a sophisticated management operation with a fair potential for biological success. A similar situation is true for crop and livestock pests.

One would have thought that, at least for one of our major insect pests — the tsetse fly — which has been ravaging Africa for the last several thousands of years, man would have devised by now an efficient technique for its control within acceptable ecological limits for our biosphere. In a military theatre, the saying, "Know Thy Enemy", is a battle-cry and makes a great deal of strategic and technological sense. In the closing years of the last century, it seemed that we had sounded the right battle-cry for tsetse, "nagana" of livestock, and "sleeping sickness" of humans. In rapid succession, Bruce demonstrated in 1894 in Zululand in Southern Africa that trypanosomes cause nagana in cattle and horses; that tsetse flies (almost certainly *Glossina pallidipes*) transmitted these protozoan parasites from sick animals to healthy ones; and that game animals can act as reservoirs of this protozoan disease. In 1903 in Uganda, Bruce went on to prove conclusively that human sleeping sickness is also caused by trypanosomes transmitted by another tsetse species, *Glossina fuscipes*. Then in the opening decade of this century, an epidemic of human sleeping sickness broke out in Uganda, and other serious foci of sleeping sickness were identified in eastern, western and central Africa — in addition to the widespread threat of livestock trypanosomiasis then pervading most of Mid-Africa.



The tsetse fly, which causes "sleeping sickness" in man and "nagana" in livestock.

It looked then a classical case for military action. Military people, with biological training, moved in — and predictably, in hind-sight, most of them adopted a military strategy for their research and work on tsetse and African trypanosomiasis. As laconically recorded by one of the famous band of these latter-day pioneers, Dr. T. A. M. Nash concluded that:[2]

> "At the beginning of this century, the great sleeping sickness epidemic along the Ugandan shores of Lake Victoria provided tremendous impetus for entomological research, since the only known safeguard was avoidance of the tsetse."

Seventy years later, the military action is still in full swing. And it is beginning to dawn upon us that what is required is a different strategy: this requires no less than a deep understanding of the place of tsetse in Nature, its interrelationships with other organisms, its behaviour, its organisation at sub-specific and population levels, its eco-physiological circumstances, and the manner in which it develops, reproduces, and operates physiologically.

This radically different approach to our pests and vectors requires that the insect scientist knows his insect almost as well as he knows himself.

A CHANGE IN ATTITUDE TO INSECTS

At least one problem with this thesis is that the "hobby of entomology" is a relatively young activity, although one can easily go back to the time of Aristotle (384 to 322 B.C.) and find that he described fairly accurately the life history of the cabbage butterfly, *Pieris rapae* (L). Up to the end of the eighteenth century, the study of insects in Europe and Asia (and their North American extension) was largely the collection of beautiful and exotic objects for the cabinet and for the taxonomist; and in Africa it continued to be the subject of the ballad-singers and the rustic philosophers, as in the *Song of Lawino*:[3]

> "Ask me what beauty is
> To the Acoli
> And I will tell you . . .
>
> And as you walk along the pathway
> On both sides
> The *obiya* grasses are flowering
> And the *pollok* blossoms
> And the wild white lilies
> Are shouting silently
> To the bees and butterflies!
>
> And as the fragrance
> Of the ripe wild berries

Hooks the insect and the little birds,
As the fishermen hook the fish
And pull them up mercilessly,

The young men
From the surrounding villages,
And from across many streams,
They come from beyond the hills

And the wide plains,
They surround you
And bite off their ears
Like jackals."

The curiosity and benevolence with which insects were treated in the early years of modern science does not seem to have helped us to understand insects in the deep sense I have earlier referred to. Indeed, a movement was started in Europe in the middle years of the last century to encourage a much greater knowledge of insects — and, incidentally, to win greater patronage — by studying the pestiferous species. Thus, the great English entomologist J. O. Westwood wrote in 1845:[4]

> "The reproach which has so often been made against the entomologist, that his attention is not sufficiently devoted to the investigation of obnoxious insects, and to the discovery of beneficial remedies for destroying them or preventing their attacks, has now lost much of its weight. In Germany, works expressly addressed to the horticulturalist, agriculturist, and arboriculturist, have long been numerous and valuable ... In England but few works of merit have appeared illustrating the habits of obnoxious insects. In 1829, 'A Treatise on the Insects most prevalent on Fruit-trees and Garden produce', was published by Joshua Major, a landscape gardener, whose knowledge of insects appears to have been very slight; and, in 1840, a work appeared under the title of 'Blight on Flowers, or figures and descriptions of the insects infesting the flower-garden', by Samuel Hereman (London, Cradock) in 8vo, with numerous gaudily coloured plates, in which are representations of many species of insects which seem to me to have no other existence than in the fancy of the delineator ... The Entomological Society of London also, desirous of acquiring public support by giving proofs of a desire to render its labours useful, instituted prizes for memoirs on destructive insects ..."

The type of entomological knowledge which has sprung around the fly-fishing fraternity — the so-called "fly-fishers' entomology" — is of this kind. It was useful knowledge in a craftmanship way, not necessarily deep, however it gave a lot of pleasure sometimes in an unexpected way. In 1877, Patrick Manson made his historic discovery in China that mosquitoes (eventually identified as *Culex fatigans*) were vectors of bancroftian filariasis. This outstanding discovery can be regarded as the birth of Medical Entomology. But in the following decade, most scientists and medical practitioners still regarded mosquitoes as ephemeral creatures, interesting but only occasionally important as carriers of human disease. They were still enveloped in the naturalist's sense of wonder, and were still able to study them only as objects of fascination. So, we find that Edward Hamilton Aitken, writing from India in 1890, found it quite acceptable to describe a mosquito infestation of his bungalow in these words:[5]

> "Mosquitoes are of many sorts. There are common grey ones; and small, speckled, shrill-voiced ones which sing an overture and then tap the outside of your ear; and large droning ones, which are found, like the best mangoes only in Mazagon and some other parts of Bombay; and queer shy ones, which stand on their heads and bore into you like a bradawl."

Now, the situation looks quite different, coming from our greater statistical knowledge of the size of insect-borne diseases in the tropics. Some 343 million people in endemic areas of the tropics, mostly in Africa, are not protected by any specific anti-malaria measures: 848 million others are living in areas where control measures are in progress. Malaria remains highly endemic in nearly the whole tropical African region and Latin America, where every year it probably kills one million children under the age of 14; resurgence of the disease is occurring in

Asia; and the disease has now been labelled the "greatest killer" of all the parasitic diseases. It is estimated that over 340 million people in the world are currently infected with *Wuchereria bancrofti* or *Brugia malayi;* consequently, filariasis may now be about to share the dubious honour of being the scourge of the tropical world — or, as some more poetically inclined have called them, "the progenitors of human ills." But there are other progenitors of this sort — river blindness, leishmaniasis, trypanosomiasis, and several others. The common feature of all of these insect-borne diseases is the staggering figures of infection we are dealing with, and the toll of mortality and morbidity we have to reckon with. The fact of insect pestilence is not new to human history, especially in cases where the pest ate his crops or pastures for his livestock. In biblical times, harrowing laments were written, as that to be found in the Book of Joel:[6]

> "Tell ye your children of it, and let your children tell their children, and their children another generation.
> That which the palmer-worm hath left hath the locust eaten; and that which the locust hath left hath the canker-worm eaten; and that which the canker-worm hath left hath the caterpillar eaten ...
> For a nation is come up upon my land, strong, and without number . .
> He hath laid my vine waste, and marked my fig tree: he hath made it clean bare, and cast it away; the branches thereof are made white.
> The meat offering and the drink offering is cut off from the house of the Lord ...
> The field is wasted, the land mourneth; for corn is wasted: the new wine is dried up, the oil languisheth.
> Be ye ashamed, O ye husbandmen; howl, O ye vinedressers, for the wheat and for the barley; because the harvest of the field is perished.
> The vine is dried up, and the fig tree languisheth; the pomegranate tree, the palm tree also, and the apple tree, even all the trees of field, are withered ..."

Even in later times, such records of great devastations by insects were given, as that given by Linnaeus in 1750, although not always accurate in particular detail:

> "A single grass caterpillar was able to destroy our meadows, so that a cartload of hay which this year is sold for 12 Talens,

last year was not sold below 50. A few little nocturnal moths can cause the loveliest orchards — where neither labour nor money had been spared and which usually produce hundreds of tons of fruit — to yield now no more than 100 apples or pears."

Consequently, the insect has not always carried a good reputation. Even in Greek times, maggots were thought to be created from garbage and dirt. And their image in recent ages has been one of a plague, a marauder, a scourge, a pestilence. No one is prepared to draw attention to the other side of the story. As Lawino so eloquently sang:[3]

"A man listens
To the roar of his own bull
And shouts praises to it.
But no one praise's another's bull,
Not even the bull of his brother."

But it may be that, even in our great rush to understand pests and vectors, we should devote a little time to the investigation of the myriad species of insects that seem beneficial to us or, the vast majority, which seem to have no use for us — except that they share the same biosphere with us. Like Ocol, we do not want to be laughed at in the far future, when we could have enriched our lives by just spending a little time to pause and look at the obverse side of the insect story:[3]

"Listen
My husband,
In the wisdom of the Acholi
Time is not stupidly split up
Into seconds and minutes,

It does not flow
Like beer in a pot
That is sucked
Until it is finished.
A lazy youth is rebuked,
A lazy girl is slapped,
A lazy wife is beaten
A lazy man is laughed at
Not because they waste time
But because they only destroy
And do not produce."

THE RICHNESS OF THE INSECT WORLD

One of the most vivid recollections of my first visit to Japan six years ago at about this time of the year, was a visit to the Imperial Gardens in Tokyo on a bright Sunday morning. I went with my guide on foot, and perhaps there were 30,000 pilgrims to the Gardens at the time we arrived. There were also probably something like five hundred cameras on tripods, with telescopic lenses or extension tubes, clicking away and recording the virginal beauty of flowers that early morning. Suddenly, a large single butterfly, probably a *Charaxes*, flew into the garden over the shrubs — and all eyes, including the camera lenses, moved almost as one to record the quick passage of this elegant creature. My guide informed me, after the concentrated stillness ebbed away on the disappearance of the butterfly high over the trees, that the sighting of butterflies in Tokyo had become almost an apparition.

A butterfly-less world would be a poor one indeed.

Beauty may be a highly personal matter; but if so, it appears that many people are prepared to pay US $30 million a year for the purchase of butterflies in Taiwan alone.[7] Butterflies have a beauty and grace of their own, in colour and pattern, and in their behaviour (such as hill-topping, migration, and flower-fitting). The ancient Egyptians believed that the soul flew away after death on butterfly wings. And butterflies have become an effective vehicle of conservation education in the USA, Britain, and other countries in recent years. Indeed, there are even a few individuals who have established butterfly parks, butterfly gardens, and butterfly zoos. And there are now calls for the establishment of "management methods to provide productive havens for butterflies in suburbs, other disturbed areas and possibly in some natural areas."[8] Considerations here, for the selection of any particular species or butterfly group for productive management, would be such factors as the likelihood to respond to management, the viewing potential of the species, its aesthetic qualities and its insignificant pest potential. The idea of insect conservation is not an unfamiliar concept in East Africa. It was advocated some years ago in Uganda;[7] and the East African Wild Life Society has established a special working group to consider specific projects for, amongst other things, the conservation of butterflies in the Kakamega forest in Western Kenya — one of the few remaining relicts in East Africa of the primary forest which covered a much larger equatorial area on the African continent a few hundred years ago. Furthermore, it is suspected that the extensive insecticide-spraying programmes to keep adult mosquito populations under control — for the anti-malaria campaigns especially — could have an important depressing impact on the butterfly population in the peri-domestic areas, particularly since the woodlands, hedges, and home gardens surrounding villages and homes are a valuable haven for butterflies.

What I have said about butterflies could be said similarly for the large and diverse fauna of wasps, flies, beetles, grasshoppers, and many other groups of insects. The great majority are non-pestiferous; a large number of them are no use to man otherwise — and indeed may not care at all for the existence of mankind one way or the other.

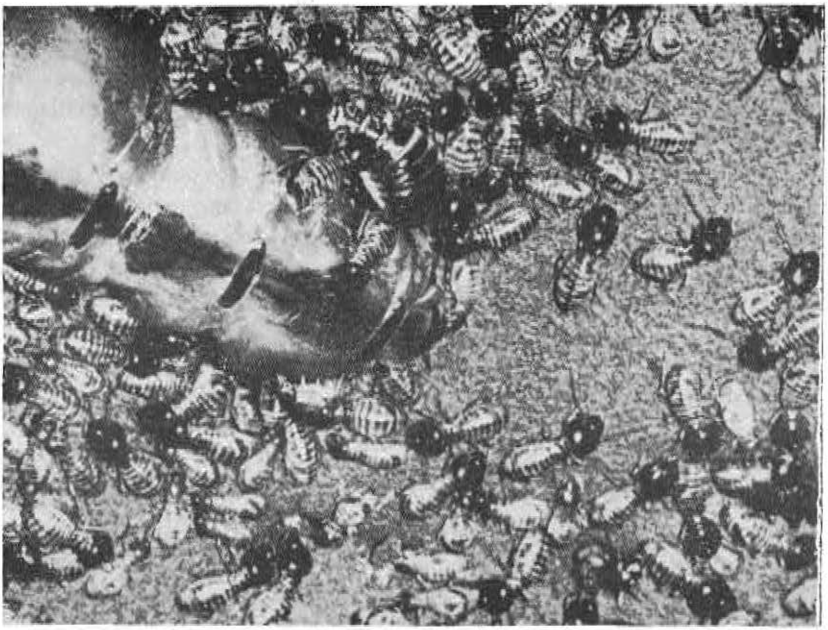
USES OF INSECTS

But there are uses for insects too. In many parts of Africa, certain insects are a delicacy: locusts are a favourite in many regions, being caught and garnered during locust outbreaks, citizens of these areas almost defiantly acting on the basis of "If you cannot beat them, eat them." The long-horned grasshopper, "nsenene", is an important item of diet in certain parts of Uganda and Kenya, as recent swarms in many parts of East Africa have shown this year. Lake flies are collected by many ethnic groups living around Lake Victoria and the great lakes along the Western branch of the Rift Valley; and these are made into large balls marketed in rural market-places, thus providing an important source of animal protein. Termites on the wing are collected throughout most of the Africa as a sort of snack, but in some places, especially in the semi-arid savannah zones, termites do indeed provide an essential element of the diet among the non-livestock keeping groups.

Entomophagy, the eating of insects, is therefore nothing new or strange in Africa — or even in many other parts of the tropical world. A recent book, probably the first book exclusively devoted to insect cookery, had this to say: [9]

> "Most people have never thought of cooking insects. As a matter of fact, most people shudder at the thought, and this is unfortunate. Insects, in general, are wholesome and nutritious, and they can be delicious!"

Taylor and Carter, in their book *Entertaining with Insects*, published in 1976, just a year or so after the World Food Conference in Rome, are enthusiastic about their new-found interest in insect cookery. For instance, they cite the fact that numerous insects are cleaner than many



Termite workers grooming the posterior section of a queen *(Macrotermes* species). Termites, although destructive, also have their uses.

of the animals man regularly slaughters to eat (such as pigs and chickens), and one of the problems of the insect eater is that he usually has to do his own slaughter while the pork or beef eater does not usually have to do so. Secondly, there are no special religious prohibitions against the eating of insects. Thirdly, insects are likely to be the most reliable source of animal food for the individual lost or marooned in the wilderness.

And, lastly, insects are clearly a nutritious source of human food — and could become "an acceptable alternative source of food for man" especially in respect of predictable world food dilemna in the decades to come when it "should be a matter of primary concern to all of us, for if the human race is to survive, we cannot afford to leave unexplored the world's still unknown food potential". In regard to this last statement, perhaps Taylor and Carter were talking with their tongue in their cheek, the latter perhaps savouring the pleasures of a beetle sausage, honeybee soufflé, cricket India, jumping jubilee, popcorn crunch, mealworm chow mein, or the many attractive recipes they experimented with using a rather restricted source material of the mealworm beetle (*Tenebrio molitor*), the house cricket (*Acheta domesticus*), and the honeybee (*Apis mellifera*).

In case one is slow to be convinced about this novel source of insect livestock for human consumption, one should listen to what Taylor and Carter have to say:[9]

> "In many of our recipes the insect is unrecognizable. In fact, in most cases if a person hasn't been told that insects are a part of the dish, he will be completely unaware. This, of course, is not to advocate 'tricking' your guests. Rather it simply emphasizes that objections to eating insects have little or nothing to do with their taste or food value ... If there is a problem, it arises from what we bring to the insect rather than what the insect brings to us."

Even if we agree to follow this novel path, there are still a number of problems to solve: should we still continue to "fish" for insects as the termite and locust gatherers do? Or, should we encourage some of our entrepreneurs to launch themselves on insect livestock production for canning of insects or bulk supply, as some enterprising people have done in the USA states of Louisiana and Tennessee recently by establishing "cricket ranches"?

But man does not live by insects alone. On the contrary, of the estimated annual crop harvest in the whole world in the year 1975 worth US $75 billion, about one-third were lost due to the ravages of insect pests — in spite of the use of all the available means for crop protection. In terms of Africa, losses due to the African armyworm, *Spodoptera exempta*, are estimated to be equivalent to £(K) 2.3 million a year in Kenya and £(T) 0.94 million in Tanzania; again, cereal stem-borers are responsible for 20-35% yield loss in maize in Ghana: and 33% loss in soyabean stand in Tanzania is due to termite infestation.[10] There is no questioning then of our impatience with certain insect species.

But we may wish to caste our mind towards one of the basic human needs which has become of great concern throughout the world in recent years — that of human settlements.

In designing a house, an architect usually bears in mind five considerations:

- *Firstly*, the site, which will always interact with the structure to be built. For instance, the environmental conditions pertaining to the site may demand a strong design, or permit a more open design

- *Secondly*, the building itself, by its very existence, becomes an integral part of the environment, changing it in a way which may influence future buildings in the neighbourhood
- Thirdly, the time horizon, whether the building is meant to stand over a long period of time, or whether it is to serve for only temporary needs
- *Fourthly*, economy of material and labour, which would influence the way in which a building is planned. For instance, available material dictates width, height, and shape of rooms
- *Lastly*, the interconnections between separate units by way of transportation networks.

In a recent study of the architecture of spider webs, Burgess and Witt[11] identify "basic principles in design which serve similar purposes in two groups of otherwise dissimilar living beings [spiders and humans], revealing the systems by which both modify their environment". They concluded that:

> "The interdisciplinary approach of combining architectural and engineering knowledge with biological and ethological thinking can elucidate the reasons for the enormous variety in spider webs; and web analysis can teach us something about optimal forms for the construction of a functional building."

One important aspect of this is the web system design strategy, which is to modify the environment. The availability of diverse sites to many spider species gives opportunity for the occupation of a variety of "niches" by a variety of these species, much in the same manner in which a view of the landscape from a plane in flight shows the zone below apparently divided neatly into farms, towns, forests, and roads uniting the various human settlements. Many animal groups may rely on "morphogical or physiological adaptation for survival, but spiders and man primarily adapt behaviourally by keeping their physical form and changing their surroundings"[11] by establishing web/spider units and human settlements as the case may be.

Spider webs play many roles, and so are formed in many diverse ways. And in large communal complexes inhabited by hundreds of individuals, spider webs subserve many roles: They may provide a silken trap, a protective device, a platform for mating; or they may form a network for movement; or yet again they may form specific thread patterns, able to send information in many directions, so that a multitude of spiders can be recruited simultaneously for a concerted attack on an oversized prey. In such a community, spiders are not autonomous or self-sufficient — just as a man is not always alone, nor is he complete without his society or country. It and he, in their various ways, become part of an integrated system of a settlement.

It was not my intention to compare the physical solution of the problem the spider incorporates in its design system for its web structure or spider settlement, as compared to the engineering solutions man has evolved for his architectural designs and human settlements. Rather, it was my hope that I would have wetted your intellectual appetite for exploring the fascinating world of architecture, be it that of the human society or that of the social insect, with the eventual purpose that we can have a deeper insight into the solutions Nature has already provided for us, which often turn out to be sophisticated yet functional.

THE WORST ENEMIES OF INSECTS

The worst enemies of insects are insects.

Biological control, in the restricted sense, makes use of insect predators and insect parasites to attack other insects which we regard as pests or disease vectors. Control of the latter is therefore achieved by letting or encouraging the predators and parasites to do our dirty job by doing their own eating job.

Biological control in this sense has hitherto been achieved by introducing these predators and parasites into areas new to them where the pest is a major concern, or by conserving and augmenting those that already exist in the area. Using these methods, biological control has been most conspicuously successful in three important situations: in islands where these are physically or ecologically separated from other land-masses or ecological types; under perennial crop conditions (as opposed to annual crops); and against mealybugs and scales.

Perhaps one of the most impressive examples of the success of biological control among the 250 or so successes so far achieved in more than 60 countries, is that of the biological control of the coconut leaf-mining beetle in Fiji in the 1930's.[12] Taylor made a thorough study of the ecology of the pest, and concluded that the characteristics of the parasite that would effectively decimate the leaf-miner population would have to be at least five: the introduced parasite would have to have a rate of natural increase greater than that of the indigenous parasites; it must be able to survive when suitable hosts (the pest species) is not present; it must be able to attack both the larval and pupal stages of the pest species; it must be suited to the climatic conditions prevailing in the area; and it must have a rapid dispersal potential. He found what he wanted in a parasite that was only of minor importance on another pest species of the same genus. The biological control of the coconut leaf-miner was achieved in the 1930's, and is still maintained in Fiji by this insect parasite.

In the short span of time I have given myself here, I have tried to paint a rather complex picture of insect foes, insect friends, and insect indifference to mankind. In the present human world of budgets and deficits, one may be tempted to draw a profit-and-loss account of the insect world as mankind sees it. I believe what I have highlighted here shows that, at least in the rich tropical world, it is impossible to try to do this as yet — even if it was desirable — because we know so little of the biological interrelationships of this vast insect fauna; and mankind may not even be central to this relationship. Goethe once said:

"Do thy little well, and for thy comfort know
Great men can do their greatest work no better than just so."

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