A NATURALIST ON LAKE VICTORIA

G. D. HALE CARPENTER

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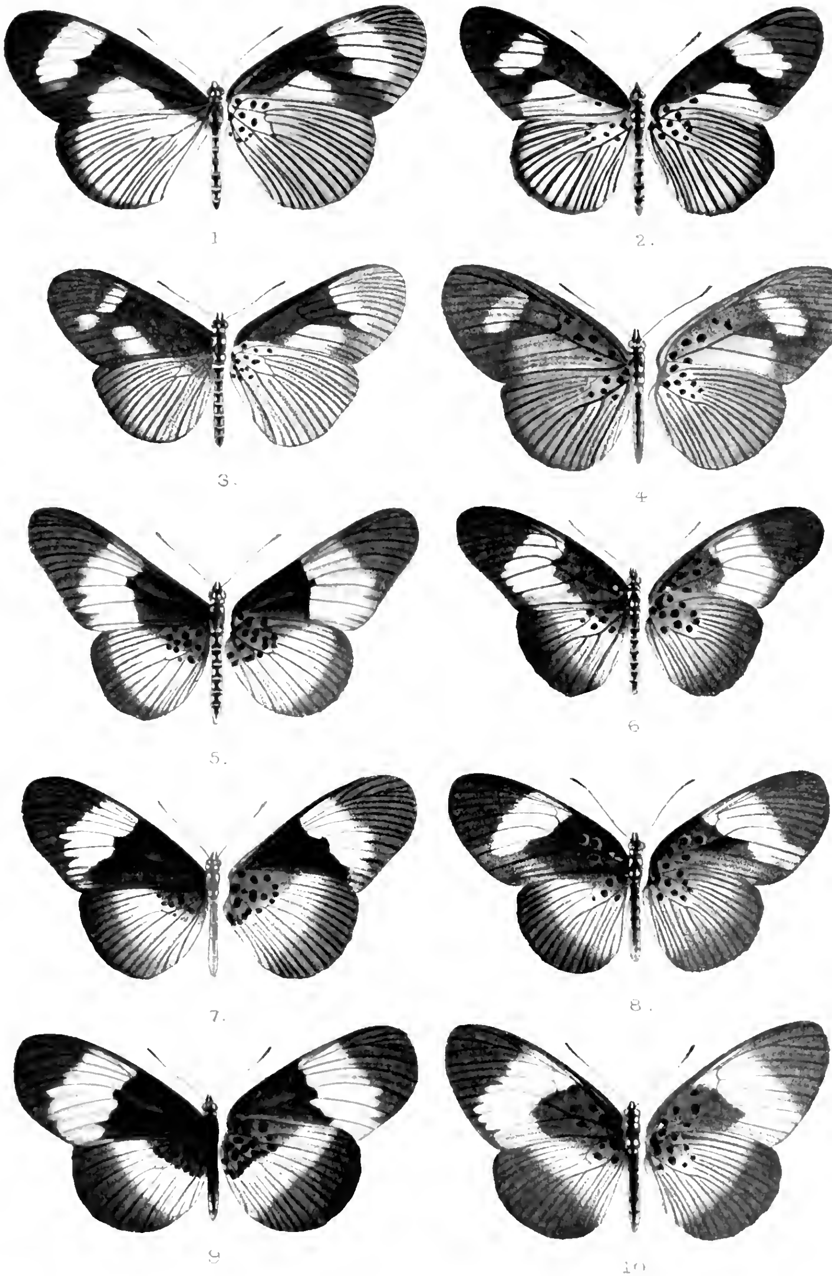
WITH AN ACCOUNT OF SLEEPING SICKNESS AND THE TSE-TSE FLY

PLATE I.

Acraeine models | *Nymphaline mimics*



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[illegible] the Entomological Society of London [illegible]

PLATE I

1. *Planema tellus* ♀, Kome Island, L. Victoria, 12 viii, 1914.
Caught by native.

2. *Pseudacraea eurytus* form *terra* ♀, Damba Island, 1–15 ix, 1911.

3. *Pl. epaea* form *paragea* ♀, Bugalla Island, 24 ii, 1912.

4. *Ps. eurytus* form *obscura* ♀, Bugalla Island, 18 ii, 1912.

5. *Pl. macarista* ♂, Entebbe, 15 viii, 1910.
Caught by one of Dr. Wiggins' natives.

6. *Ps. eurytus* form *hobleyi* ♂, Wema Island, 1 iii, 1918.

7. *Pl. macarista* ♀, Kome Island, 29 vi, 1914.

8. *Ps. eurytus* form *tirikensis* ♀, Bugalla Island, 6 xii, 1912.

9. *Pl. poggei* ♀, Bulago Island, 15 iii, 1914.

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Caught by S. A. Neave near west foot of Mt. Elgon, Eastern Uganda.

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WITH AN ACCOUNT OF SLEEPING SICKNESS AND THE TSE-TSE FLY

BY

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WITH 2 COLOURED PLATES, A MAP,
CHARTS, AND 87 ILLUSTRATIONS

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TO THE

MEMORY OF MY FATHER

P. HERBERT CARPENTER, D.Sc., F.R.S.

AND TO MY DEAR MOTHER

THIS, MY FIRST BOOK,

IS DEDICATED

"It appears to me the doing what *little* we can to increase the general stock of knowledge is as respectable an object of life as one can in any likelihood pursue."

Letter from Charles Darwin to his sister, 1833.

INTRODUCTION

At the commencement of 1910, when studying Tropical Medicine at the London School, I was asked if I would undertake an investigation into the bionomics of the Tse-tse fly, *Glossina palpalis*, in Uganda, as the Tropical Diseases Committee of the Royal Society had come to the conclusion that a greater knowledge of this fly was essential for the successful dealing with the disease.

I left England in June 1910, and during the second half of this year and beginning of 1911 worked at Jinja, on the north shore of the Victoria Nyanja,[1] where the Nile takes origin, and endeavoured to familiarize myself with the novel surroundings and with the fly.

It soon appeared that residence on the completely depopulated islands known as the Sesse Isles, in the north-west part of the lake, would afford ideal conditions for studying *Glossina* unaltered by the presence of mankind and his surroundings; accordingly, in February 1911, I went to Nsadzi Isle, which, lying south of Entebbe and within two or three hours of it by canoe, had been recommended by the P.M.O. as suitable for a beginning. This island, however, did not furnish all the conditions required for the investigations, and camp was moved, after a fortnight, to the large Island of Damba to the east and on the Equator, where the rest of the year was spent.

[1] *Nyanja*, not *Nyanza*. The former is Luganda for lake, the latter means nothing, and is erroneously copied from one book to another.

In January 1912, a new site was chosen on Bugalla, the largest island of the Sesse group, lying in the north-west corner of the lake, and fourteen months of uninterrupted residence were spent there, after which I went home on leave, returning in December 1913. On arrival at Entebbe I met Mr. W. F. Fiske, from the States, who had been deputed by the Tropical Diseases Bureau of London to investigate *Glossina morsitans*, and had decided to first make the acquaintance of *palpalis*, the problems connected with which seemed more readily soluble, and by their solution might throw light on *morsitans*. He had decided, as a result of several months' previous work, to undertake a tour of the chain of islands lying parallel with the north shore of the lake, in order to compare one with the other, hoping that the presence or absence of *Glossina* might be found to be correlated with definite factors. He proposed that I should join him, and we made the tour together, very greatly to my benefit not only regarding *Glossina* in particular, but in field work in general, his wide experience of field entomology and acute powers of observation showing me how much I had missed when working by myself. At the close of a tour of about two and a half months Fiske left for another part of Uganda, and I settled down on the western spur of Kome Isle to carry out a year's continuous cycle of experiment and observation on the smaller islets within working distance (Ngamba, Nsadzi, Kizima, Tavu, Bulago, Kimmi). Unfortunately this was brought to an end by the outbreak of war; for in August 1914 I was called off for duty with the troops on the Uganda-German frontier, and subsequently with the Belgian Northern column under Colonel Molitor, which invaded German East Africa via Kigezi and Ruanda, to Tabora, after which my duties took me to various parts of German East Africa and Portuguese East Africa. When released from active service in November 1918, I returned to Uganda, and had a further most interesting tour among the same islands that were visited with Mr. Fiske in 1914.

This book is an attempt to give an account of the life on the islands of the Victoria Nyanja: and very nearly all the examples mentioned were met with there, between February 1911 and August 1914. During active service, however, other examples were met with, an account of which seemed not to be out of place in this book because of their bearing on certain of the points discussed. The fascinating question of the Colouration of Insects has been treated at some length, but mainly from the point of view of the bearing on it of examples met with on the islands. Consequently this chapter must not be taken as a discussion of the relative merits of rival theories from an abstract, or "arm-chair," point of view. Similarly the chapter on *Glossina* must not be taken as a complete summary of all that is known, since this book deals almost entirely with some of my own observations and work.

The chapters on Mammals, Birds and Reptiles, I am aware, are dreadfully scanty. In defence, I can only urge that I am primarily an entomologist; and my knowledge of field botany is a minus quantity!

* * * *

I am indebted to the Royal Society and the Controller of His Majesty's Stationery Office for permission to reproduce illustrations and other matter that have appeared in my reports to the Sleeping Sickness Commission.

The beautiful photograph of *Glossina* is the work of Mr. A. Robinson, of the Oxford University Museum.

Grateful acknowledgment is also due to the Council of the Entomological Society of London, for permission

to reproduce the two plates of butterflies which have appeared in the *Transactions* for 1920. Many of the observations on Insects have already appeared in the publications of the Society, others in *Bedrock*, and some of those on the Fossorial Hymenoptera in the *Journal of the East Africa and Uganda Natural History Society*.

Mr. A. L. Shephard, of the Tropical Diseases Bureau, very kindly gave me references which were of great help in the preparation of the chapters on Sleeping Sickness, and thanks are also due to the Director, Dr. A. G. Bagshawe, C.M.G., in this matter. Dr. H. Eltringham most kindly complied with a request for the use of his talent as a draughtsman, and provided an original and humorous drawing of an imaginary example of mammalian mimicry.

To my friend and mentor, E. B. Poulton, F.R.S., Hope Professor of Zoology at Oxford, I owe more than I can say for his ever ready advice and encouragement, for his kindness in writing the Preface, and in particular for reading the MS. of Chapter XI, and suggesting improvements therein. To him and Dr. S. A. Neave are due the selection and arrangement of specimens illustrating by two plates forms of *Pseudacraea eurytus* and their models. Dr. Karl Jordan, of the Tring Museum, was most kind in showing me Lord Rothschild's collection of this wonderful species, including a unique specimen of a new form which shows the geographical range to extend further southwards than has been known hitherto.

G. D. H. C.

PREFACE

BY

PROFESSOR POULTON

EVERY reader of this book will, I feel sure, recognize that it contains a really wonderful body of observations; especially so if the brief time in which they were made be borne in mind—from February 1911 until the day in August 1914 when, without a word of preparation or a hint of warning, the author arrived in Entebbe to find in full progress, and to bear his part in, the fiercest struggle of human history. And even this short period of "island life" was broken into by nearly a year's leave.

The observations recorded, whether dealing, now and then, with men, or, throughout the book, with other animals, are both loving and accurate. The two qualities are closely associated, for the love of living beings renders the patient study of them an unceasing fascination and delight.

Apart from the chapters on Sleeping Sickness and its carrier, the Tse-tse fly, the most important discoveries are those which add to our knowledge of *Papilio dardanus*, and, above all, the breeding experiments which brought final confirmation to the conclusions of Dr. Karl Jordan upon that wonderful series of mimetic butterflies here proved beyond doubt to be forms of a single species—*Pseudacraea eurytus* of Linnaeus.

It is a curious fact that the African butterflies—far less numerous in species than those of the tropical East, and outnumbered even more by the American—should include what are probably the two most remarkable examples of mimicry in the world—*Papilio dardanus* and *Ps. eurytus*; furthermore, that they should illustrate such different aspects of the subject.

The Swallowtail, *dardanus*, whose non-mimetic male is accompanied by a very similar non-mimetic female in Madagascar, the Comoro Islands, Somaliland, and Abyssinia (although two single but different mimetic females were once taken in this last locality), is represented, wherever it occurs on other parts of the African continent, by females entirely different from males, and either mimetic of other butterflies, or, far more rarely, intermediates between these mimetic forms, or persistent stages enabling us to retrace the history of their origin. Until 1903 the mimetic females were all believed to resemble the commonest Danaine butterflies of each locality—often mimicking in a single area three different species with widely different patterns.

This interesting and complicated story became still further involved, when, on October 7, 1903, the late Mr. Roland Trimen brought before the Entomological Society an account of a new and entirely different female, mimicking not a Danaine, but an Acraeine model, belonging to the genus *Planema*. For some years the new mimic, appropriately named *planemoides*, was only by strong inference assumed to be a form of *dardanus*, but definite proof was soon afforded by the study of a specimen captured by Mr. T. T. Behrens, R.E., near the old southern boundary of Uganda on the west shore of the Victoria Nyanja. This single example was, on the left side, a gynandromorph, viz. one of those rare individuals in which the patterns of the two sexes occur combined. In this case parts of the yellow and black non-mimetic pattern of the male are, as it were, let into the mimetic female pattern, clearly proving that the two belonged to the same species. The specimen, now in the Hope Collection of the Oxford University Museum, is figured in the *Transactions of the Entomological Society* for 1906 (Pl. XVIII, Fig. 4).

The evidence of this specimen was very satisfactory, but how much better was the proof by breeding from a known parent, obtained by the author in Bugalla island, Sesse Archipelago, when he captured on December 1, 1912, a *planemoides* female, and reared from its eggs three females like the parent, seven of the black-and-white *hippocoon* females, and twelve non-mimetic males. And later on, in 1915, when Medical Officer to the forces acting on the southern frontier of Uganda, he reared one *planemoides* female, one *trophonissa* female (similar to *hippocoon*, but with the main white areas replaced by orange), and five males from the eggs of a captured female combining the patterns of her two daughters. These are the only occasions on which the *planemoides* female has been bred, although rare forms which evidently represent an imperfect *planemoides*, many hundreds of miles away from its model, have been bred by Mr. C. F. M. Swynnerton in S.E. Rhodesia, and by Mr. G. F. Leigh, in the neighbourhood of Durban.

The *Pseudacraea* mimics, belonging to the Nymphaline sub-family, and allied to our own White Admiral (*Limenitis sybilla*), illustrate the second great group of mimetic butterflies in which the males resemble models as well as the females. The models of the *Ps. eurytus* series, with which this book deals, all belong to the Acraeine genus, *Planema*, but in some of them the sexes differ, while in others they are alike. In Uganda there is one common example of the first, mimicked by a *Pseudacraea* whose male resembles the male and female the female, and also two examples of the second, each mimicked by a *Pseudacraea* with sexes alike; and when, in 1910, Dr. Jordan announced that these three Pseudacraeas could not be separated structurally from each other, from the Linnean West African *eurytus*, or from other mimics west, east, and south, which had been described as distinct species, I felt that the obvious conclusion that they were in fact all of them forms of one and the same species ought to be confirmed by breeding experiments before it gained acceptance. And it was the occurrence, in the same area, e.g. Uganda, and *ex hypothesi* interbreeding, of forms with sexes different and with sexes alike, which raised the greatest difficulty, and at the same time would prove of the deepest interest if the conclusion were confirmed. In order to test it I wrote to every naturalist known to me who was in a position to undertake the work, pointing out its exceptional interest and importance. I even tried to persuade the late Mr. A. D. Millar who had just been very successful in breeding the Natal form of the *Pseudacraea*, to undertake the journey to Uganda and apply his experience there.

The complete success finally attained by the author on Bugalla may be gathered from the results fully set forth in Chapter XI. Dr. Jordan's conclusions were thoroughly confirmed, and the large group of conspecific forms, now proved to interbreed in the same areas, and interbreeding, it may be legitimately inferred, with those of other areas when they meet on the boundaries, the group of *Pseudacraea eurytus*, took its place beside that of *Papilio dardanus* as one of the greatest examples of mimicry in the world.

This discovery was completed by another of equal importance described in the same chapter, the evidence that the mimetic patterns were only kept up to the mark in islands where and when their models were relatively abundant. As these became scarce, so did the mimetic Pseudacraeas run into each other more and more completely through the intermediation of an increasing number of transitional forms.

In concluding I should wish to take this opportunity of thanking all those naturalists who, during the past quarter of a century, in distant lands, have helped me in my work and have given me the great pleasure of helping them; and, among all, especially to thank the author, Dr. G. D. Hale Carpenter, D.M., not only for the mutual help which may be gathered from this book, but for much further help in S.W. Uganda, and ex-German East Africa; the late C. O. Farquharson, in S. Nigeria, whose death in the sinking of the *Burutu* almost at the end of the war, was so great a loss to Natural History; W. A. Lamborn, in S. Nigeria, ex-G.E.A., and now in the Federated Malay States; Dr. G. A. K. Marshall, D.Sc., C.M.G., in Natal and S. Rhodesia; the Rev. Canon K. St. Aubyn Rogers, M.A., in British and ex-G.E.A., the late R. W. C. Shelford, M.A., in Borneo, another grievous loss to science; C. F. M. Swynnerton, in S.E. Rhodesia; and C. A. Wiggins, P.M.O., Uganda, in this country and B.E.A. To all these and many others I offer most grateful thanks for some of the greatest happiness I have known.

EDWARD B. POULTON.

August 3, 1920.

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CHAPTER I

SLEEPING SICKNESS

In this chapter a general account will be given of the history and symptoms of Sleeping Sickness as it was known during the epidemic in Uganda. It may be said at once that the disease is entirely confined to tropical Africa, nor does there seem any reason, as will be explained later, to fear its spread beyond Africa.

In a few words it may be said that the cause of the disease is a minute unicellular creature, called a Trypanosome, belonging to the lowest order of animal life, which is as it were inoculated by the bite of a blood-sucking fly, the "Tse-tse," or *Glossina*.

A common history given by patients who suffer from Sleeping Sickness is that they have been in a country where they were much bitten by Tse-tse flies, and that after a few days a painful swelling has appeared on the neck, accompanied by high fever. The swelling may appear to be on the point of becoming an abscess, but does not do so, and gradually subsides. It is probable that this represents the site where the fly which was the cause of the infection actually bit. The fever may subside in a few days, and recurs at irregular intervals lasting weeks or months: it often reaches a high point attended with delirium.

There is a good deal of headache, debility and languor, and vague pains in legs. An interesting feature is the appearance of an erythematous rash, mainly on the chest and back. There is great wasting and enlargement of the glands of the neck. Another interesting feature is puffy swelling of parts of the face and body: this œdematous swelling is a particular feature of the diseases of animals, which are, as will be seen, so very closely connected with Sleeping Sickness.

This condition may go on for years, and has been known to disappear altogether with an apparent cure; it is known as "*Trypanosomiasis.*" Next comes the stage to which the term "Sleeping Sickness" more properly applies. The drowsiness becomes accentuated, so that the subject takes no interest in his surroundings and does not trouble to eat, though he will eat food if it is brought him, and he is fed. The fever continues irregularly, the eyes become more puffy, the lips and tongue tremulous, the wasting more and more pronounced, until death finally supervenes with the patient in a state of coma. At the last there may be mania and convulsions.

It has been noticed that natives suffering from Sleeping Sickness appear to feel the cold very acutely, and will often sleep so near to a fire that they inflict severe burns on themselves. This also shows how the senses are dulled, so that one can conclude that they cannot suffer much.

Death may occur in a few months after the initial fever, but more usually after one to three years.

The earliest account of Sleeping Sickness which is known in print dates from 1742, and is of considerable interest because it reflects the current medical opinion of the day.

Dr. E. D. Whittle, in the *Malay Medical Journal* for April 1911, drew attention to a book by a naval surgeon named John Atkins, called *Physical Observations on the Coast of Guiney.*

The following extract is given in *The Sleeping Sickness Bulletin :*

"The Sleepy Distemper (common among negroes) gives no other previous Notice, than a Want of Appetite two or three Days before: Their Sleeps are sound, and Sense of Feeling very little; for pulling, drubbing, or whipping, will scarce stir up Sense and Power enough to move; and the moment you cease beating, the Smart is forgot, and down they fall again into a state of Insensibility, driveling constantly from the Mouth, as if in a deep Salivation; breath slowly, but not unequally, nor snort.

"Young People are more subject to it than the Old; and the Judgement generally pronounced is Death, the prognostick seldom failing. If now and then one of them recovers, he certainly loses the little Reason he had and turns Ideot.

* * * * *

"The immediate Cause of this deadly Sleepiness in the Slaves, is evidently a Super-abundance of Phlegm or Serum extravated in the Brain, which obstructs the Irradiation of the Nerves; but what the procatartick Causes are, that exert to this Production, eclipsing the Light of the Senses, is not so easily assigned.

"We find sometimes in *Europe* that Enormities in the Non-Naturals, Surfeiting and Drunkenness do gradually, as Age and Custom advance, weaken the Tone of the Brain, to the Admission of serous and extrementitious Humours, including Sleepiness, etc. But here the Case is different, they being young People that are generally afflicted, and who have been destitute of the Means of Surfeiting.

"I shall ascribe the Cause to *catching Cold, and their Immaturity; to Diet and Way of Living; and to the natural*

Weakness of the Brain ; some or all of these Causes co-operating to it.

" *First.* In *Immaturity,* or Childhood, it is a common and true Observation, that more of Phlegm and recrementitious Humour is bred, than at Manhood ; because the Fibres, and consequently the Faculties resulting from their Constitution, have not attained their due Spring and Perfection ; and it is only supposing the *Africans* continue longer Children than the *Europeans.*

" *Secondly.* Promoted here *by their Diet and Way of Living.* At Home it is mostly on Roots, Fruits, and Herbage, greedily devouring such as are wild and uncultured ; which, together with the intolerable Heats of the Sun, weakening the concoctive Faculty, together with their Inactivity, render a very recrementitious Nutriment : Their Indolence is such (when shipped on Board for Slaves) as to be entirely dispassionate at parting with Wives, Children, Friends, and Country, and are scarcely touched with any other Sense or Appetite, than that of Hunger ; and even in this, for want of Custom or Instinct, they cannot distinguish proper Food, nor know when to leave off, voraciously eating though Victuals be never so dirtily cook'd ; and whether the Flesh be raw or dressed, whether of the Guts or a Sirloin ; a Practice also that may sometime, by over-stretching the Fibres of the Stomach, occasion Crudity and Indigestion. By their Sloth and Idleness the Blood becomes more depauperated ; and those recrementitious Humours bred from it, that Exercise would throw off through the proper secretory Organs, are here disposed towards the weakest Part, which in the Generality of Negroe Slaves I take to be the Brain.

" *Thirdly, The natural Weakness of the Brain,* I am apt to think the principal Cause of the Distemper. Doubtless that Part gains Strength by Exercise, *i.e.* by the Employment of our rational Faculties, as well as the Muscles and external Fibres of the Body by Labour ;

and since the *Africans* are hereditarily ignorant, destitute of all Art and Science, or any mechanical Knowledge to exercise the Brain, it consequently grows weaker in its inward Structure and Recesses; and falls together with the Judgement and Passions.

* * * * *

"The Cure is attempted by whatever rouzes the Spirits; bleeding in the Jugular, quick Purges, Sternutories, Vesicatories, *Acu-Puncture*, *Seton*, Fontanels, and sudden Plunges into the Sea, the latter is most effectual when the Distemper is new, and the Patient not yet driveling at Mouth and nose." [1]

Noteworthy in this account are the number of causes assigned to this mysterious disease, and the naïve way in which the author assigns the conditions to "some or all of these causes"!

The essential characteristics of the disease in an advanced stage are all noted; the "Indolence," "State of Insensibility," "Hunger," "Sense of Feeling very little," but the preliminary stages were not noted, for Atkins says it gives no other notice than a want of appetite two or three days before!

With the aid of a little imagination one can see a terrible picture of these wretched, somnolent natives being subjected to "pulling, drubbing or whipping" in the endeavour to give them sufficient "Exercise" to "throw off the recrementitious Humours" and afterwards "voraciously eating though Victuals be never so dirtily cook'd"!

The "Sudden Plunges into the Sea" are not used for curing Sleeping Sickness at the present day!

[1] *The Navy Surgeon: or Practical System of Surgery with a Dissertation on Cold and Hot Mineral Springs and Physical Observations on the Coast of Guiney*, by John Atkins, Surgeon. London: Printed for J. Hodges, at the Looking Glass, over against St. Magnus Church, London Bridge. MDCCXLII. pp. 364–7.

It was, I believe, well known to the African slave traders that natives with enlarged glands were of no use to them, as they always died and could not be made to work. So they were careful not to take any in this condition, but nevertheless took, without knowing it, many cases who had the earliest stages of the disease, and the American slave-owners used to find their slaves dying of this peculiar drowsiness.

Yet it was not infectious, that is, it was not communicated from one to another: the reason for this will be entered into more fully further on.

In 1890, a French doctor discovered in the blood of a patient from Africa who was suffering from a peculiar fever, a microscropic organism which he recognized as a *Trypanosome*, but he did not establish any relation between this and the fever, and the credit of first discovering this belongs to an Englishman. In 1901 Dr. Forde, in the Gambia colony on the West Coast, had an English patient with a peculiar fever of a chronic and irregular type. He found in the blood a curious organism whose nature he could not recognize, and called in the late Dr. Dutton, who at once recognized the creature as a Trypanosome;[1] the first one to be discovered in man, though one had been described as the cause of a disease in horses in India some ten years before.

At first, and for some time, Sleeping Sickness was only known to occur in West Africa, but when equatorial Africa was gradually opened up the disease found its way into Uganda with disastrous results.

This is believed to be due to Stanley's expedition for the relief of Emin Pasha, which in 1888 travelled from the Congo to the Lake Albert Nyanza. In 1891 the Sudanese soldiers of Emin's force were brought into South Toro

[1] *British Medical Journal*, 1902, January 4th, p. 42, and November 29th, p. 1741.

with their followers, and eventually were brought into Uganda itself to be under control.

In July 1901, Dr. Albert Cook of the Church Missionary Society at Mengo (Kampala) noted eight cases of a mysterious disease, and six months later reported that on Buvuma Island over two hundred natives had died and thousands appeared to be infected. The mortality became appalling, and the Government were at their wits' end, for it seemed as if the whole population was doomed.

In July 1902, the first Royal Society Commission arrived in Uganda, composed of Drs. Low, Christie, and Castellani, and Colonel Sir David Bruce arrived in February 1903. On April 28th, it was announced that the disease was caused by a Trypanosome and conveyed by a Tse-tse fly, *Glossina palpalis*.[1]

It was suggested at once that as the haunts of this fly were strictly limited, it would be easy to check the disease by removing the population;[2] but the natives, with their characteristic fatalism, refused to leave their villages along the shores of the lake. In the meantime the disease raged unchecked, and by the end of 1903 the number of deaths had reached over 90,000; whole villages were being depopulated, and great tracts of highly cultivated country relapsed into scrub and forest.

In March 1905 Lieutenant Tulloch, R.A.M.C., who had been sent out by the Royal Society to help in the investigations, became infected with the disease in its virulent form, and died a few months later.

By November 1904 the epidemic had appeared on the shores of Lake Albert in North-West Uganda, and a survey of Uganda by six specially appointed medical officers in 1905 showed that the banks of the lakes and

[1] Reports of Sleeping Sickness Commission of the Royal Society, 1903, Nos. I, IV.

[2] See Bulletin of Sleeping Sickness Bureau, vol. 4, pp. 241–2.

watercourses throughout Uganda were infested with the Tse-tse fly.

Statistics furnished in a dispatch by the Governor showed that "during the last five years the total mortality from this scourge in this Protectorate has considerably exceeded 200,000."[1]

Sir Hesketh Bell also reported "the natives have been almost completely wiped out everywhere along the lake shore, and in the islands the mortality has been even more appalling. Buvuma, for instance, which a few years ago was one of the most thickly populated and prosperous of all the islands, counted over 30,000 inhabitants. There are now barely 14,000. Some of the Sesse group have lost every soul; while in others a few moribund natives, crawling about in the last stages of the disease, are all that are left to represent a once teeming population."

In November 1906, it was again suggested that the only way to save the people was to remove them into fly-free areas, and segregate the infected natives into camps. The aid of the chiefs was sought and the matter fully explained to them, compensation was made to the heads of evicted families, they were given land away from the infected areas, and by degrees not only the mainland shores of the lake, but the islands also, were cleared of their population, so that by 1909 all these were deserted and going back to the wild state.[2]

Great difficulty was experienced in preventing the natives from returning to their homes, and some managed to obtain canoes and cross back to Buvuma and Damba Islands, but at length the evacuation was finally completed, and at the present day the whole of the fertile and valuable island territory is abandoned to the Tse-tse fly.

But the lake shore can only be kept in this condition by stringent regulations and penalties, and a few natives

[1] Dispatch No. 218 from Sir Hesketh Bell, November 1906.

[2] See Bulletin of the Sleeping Sickness Bureau, vol. 4, pp. 241–2.

are frequently discovered in the forbidden areas by the patrolling canoes.

By these means the inhabitants of Uganda were saved, and at the present day there are very few deaths a year; from 1905–1917 there were just over 30,000 deaths for the whole of the Uganda Protectorate.

At the end of 1909 considerable alarm was caused by the discovery in Nyassaland of Sleeping Sickness (or rather, *Acute Trypanosomiasis*) in a native there, and since then a number of cases have been found, some of them Europeans, in Nyassaland, North-East Rhodesia, and Portuguese East Africa: in the case of some natives, they had certainly never left their homes. This was very interesting from a scientific point of view, because *Glossina palpalis*, the species of Tse-tse which carries Sleeping Sickness in Uganda and the West Coast, does not exist in those countries.

It was soon found that the carrier was another species, namely, the very one which has been so long known to travellers in Africa as the cause of Tse-tse fly disease or "*Nagana*" of horses, cattle and dogs.

This species is known as *Glossina morsitans*.[1]

As this new form of human Trypanosomiasis appeared to be very much more acute than the form known as Sleeping Sickness, the discovery was disconcerting. It is, however, possible that our ideas of the severity of this form of Trypanosomiasis will need to be modified in the light of further knowledge, for during the campaign in East Africa a number of natives were found to have Trypanosomes in their blood while under treatment for other complaints, and appeared to be little the worse for their presence; these natives had not been in the area of *Glossina palpalis*, so that either the Trypanosome was *gambiense* carried by *morsitans*, or else it was *rhodesiense*

[1] Kinghorn and Yorke, *Annals of Tropical Medicine and Parasitology*, 1912, vol. 6, pp. 1–23.

in a non-lethal form. It is of interest to note here that a case of true Rhodesian Trypanosomiasis has recently been recorded as the first to be cured by treatment; hitherto this form had always been regarded as fatal.[1]

[1] A case of *T. rhodesiense* infection which recovered. Daniels and Newham, *British Medical Journal*, 1919, November 8th, p. 829.

CHAPTER II

NATURAL HISTORY OF SLEEPING SICKNESS

I PROPOSE now to deal at greater length first with the Trypanosomes and next with the Tse-tse flies, then the inter-relation of the two will be considered and the relation of both to the wild animals of the countries in which they occur.

Trypanosomes are not "microbes" in the accepted sense of the word as commonly used; that is, they are not micro-fungi, but belong to the *Protozoa*, the lowest members of the animal kingdom. The *Protozoa* can be divided into four main groups, in each of which are found species causing disease in man and other vertebrates. The *Sarcodina* is exemplified by the well-known *Amœba* and the species known as *Entomœba*, which causes dysentery.

The next group, *Mastigophora*, is the one with which we are most concerned at the moment, since to it belong the Trypanosomes and their allies. The name, which means "Whip Bearers," refers to the possession of one or more lashes or *Flagella*, which by their rapid movements draw or push the animal through the fluid in which it lives.

The third great group of *Protozoa* is the *Sporozoa*, which is only too familiar through the various species that cause malaria. To the last group *Infusoria* belong the myriad forms which are the delight of the amateur microscopist and may be seen so easily in stagnant water. One species, *Balantidium*, is a cause of dysentery.

Let us now look a little more closely at the *Mastigophora.* The group is divisible into six sub-groups,[1] but only that which includes the Trypanosomes need be mentioned here. This is named *Protomonadina,* and includes the following genera :

1. *Trypanosoma.*—There is a single flagellum arising near the posterior nucleus and continued forwards as a marginal flagellum of an undulating membrane; usually continued into a free flagellum. The species are found mostly in blood and in the digestive tracts of invertebrates, but are also forms in the life cycle of species wholly parasitic in insects.
2. *Trypanoplasma.*—There are two flagella, the posterior one united to the body by an undulating membrane along most of its length. According to their mode of life they fall into three groups.

   1. Parasites in the blood of fresh-water fish and in the digestive tract of leeches.

   2. Parasitic in the digestive tract of marine fishes.

   3. Parasitic in invertebrates.
3. *Crithidia.*—A single flagellum arises about the middle of the body and runs forwards to form the marginal flagellum of a short or rudimentary undulating membrane, and is continued beyond as a free flagellum.

   Crithidia occur as parasites in the gut of insects or as a stage in the life cycle of a Trypanosome.
4. *Leptomonas* or *Herpetomonas.*—There is a single anterior flagellum but no undulating membrane. These are parasitic on invertebrates, chiefly insects, but also occur as a form of the next genus

[1] This classification is taken from Minchin.

in invertebrate hosts or in artificial cultures. It is also of great interest that they are found in the milky juice of certain plants (*Euphorbiaceae*).

5. *Leishmania.*—There is no flagellum, but there are two nuclei as in the other genera. These animals have become specialized to live in the tissue cells of vertebrates and so have no need of organs of locomotion. It is of much interest that in artificial cultures *Leishmania* develops into forms like the two preceding genera or like Trypanosomes. The type species causes a fatal disease in Asia known as "Kala-azar."

Now let us consider a little more fully the Trypanosomes themselves. They are elongated bodies with a pointed posterior extremity where is a small nucleus, and at the anterior extremity the whip-like flagellum which by vigorous movements drags the Trypanosome along. The undulating membrane pursues a wavy course along the body and is responsible for the name, which is derived from τρυπανον, meaning a carpenter's tool: the allusion is probably to the spiral thread on an auger. In the middle of the body is a large nucleus. *T. gambiense* in the blood is several times as long as the diameter of a red corpuscle, but much narrower. The different species that may be found in the blood vary very greatly in size and activity; *gambiense* is not very active and merely wriggles, but a species such as *vivax* in goats can hardly be kept in the field of a microscope. The first one to be seen was found in the blood of a frog, but the first reliable description was not given until 1841, when a specimen was described from the blood of a trout.[1] Not until 1879 was one found in a mammal, and this was *Trypanosoma lewisi*, seen in the blood of the rat. It is

[1] By Valentin. Recent work by Mlle. M. Gauthier, however, places this species in the genus *Trypanoplasma*.

now known that in nearly every place rats are infected with this species, often to the extent of 50 per cent., but it is not harmful to them unless present in great numbers. The first disease-producing Trypanosome described was *T. evansi*, which kills numbers of horses, camels, elephants and dogs in Asia and North Africa by causing a disease known as "Surra"; it was discovered in 1880. Not until 1895 was the next pathogenic species discovered, and this was an extremely important one, the knowledge of which was of the utmost help to the subsequent investigations into Sleeping Sickness.

This species was named *T. brucei*, after Sir David Bruce, who proved it to be the cause of "Tse-tse fly disease" or "*Nagana*" in South Africa.[1]

In 1901 another species was described as *T. equiperdum*, the cause of "Dourine" in stallions, brood mares, and donkeys in America and North Africa. Also in 1901 was discovered *T. gambiense*, the first Trypanosome to be known for a cause of disease in man.[2]

In 1902 *T. equinum* was shown to be the cause of "*Mal de Caderas*," a fatal disease of horses in Brazil and the Argentine Republic. Another human Trypanosome was discovered in 1909,[3] by Chagas; it causes in children, and adults who have not become immune in childhood, chronic fever, enlargement of the thyroid gland, and puffiness of the face, and may rarely result in death. This species was found to differ sufficiently in its life-history to be put in a new genus, and has been named *Schizotrypanum cruzi*. In 1910 it was shown that the cause of the acute Trypanosomiasis of Rhodesia was differentiated, not by its morphology, but by its effects

[1] Preliminary Report on the Tse-tse fly disease or Nagana in Zululand, 1895.

[2] *British Medical Journal*, 1902, January 4th, p. 42.

[3] Chagas, *Brazil Medico*, 1909, April 22nd. See Bull. Inst. Pasteur, 1909, May 30th, pp. 453–4. Also Bulletin of the Sleeping Sickness Bureau, vol. 1, p. 252; vol. 2, p. 117.

upon animals, from its close allies *T. gambiense* and *T. brucei*, and it is now known as *T. rhodesiense*.[1]

In 1913 another species was found in man, causing in natives of Nigeria a chronic swelling of the glands in the neck very like the earliest stages of Sleeping Sickness, but very rarely going beyond that; it has been named *T. nigeriense*.[2]

It must not be thought that every Trypanosome is a cause of disease. This is very far from being the case; the production of disease is a mere accident from the Trypanosome's point of view, an occurrence of fatal import for itself as well as the host should the latter die!

Although only a few of the pathogenic species have been mentioned, all of them together are a very small fraction of the total number of Trypanosomes and their allies that are known. They occur in the blood of fishes, reptiles, amphibia, birds and mammals; in the vital fluids of molluscs, in the alimentary canal of insects and other invertebrates.

By cultural methods it has been found that normal English cattle have Trypanosomes in their blood, and Bruce first found that even the species that cause disease in domestic animals lives harmlessly in the indigenous wild animals. Dr. Duke has shown that the "Situtunga" antelope (*Tragelaphus spekei*) carries in its blood the deadly *Trypanosome gambiense* without any harm to itself. It must be remembered that Trypanosomes are not like the bacteria such as that of anthrax, which form highly resistent spores, and by the death of their host and its disintegration are disseminated more widely in a condition in which life may be maintained indefinitely.

The position seems to be this. Many insects, for instance

[1] Stephens and Fantham, *Proc. Royal Soc.*, Series B, 1910, No. 561, pp. 28–32.

[2] J. W. Scott Macfie, *Annals of Tropical Medicine and Parasitology*, 1913, August, vol. 7, No. 3A, pp. 339–56.

the house fly, contain in the alimentary canal Flagellates of a type closely allied to Trypanosomes, which live a natural parasitic life in the fly only.

When the ancestors of the present blood-suckers became addicted to this habit, probably a development of the habit of feeding on the fluid exuding from sores, it may well have happened that some of these internal parasites were inoculated into the blood of the animal. Those that survived may well have caused disease as a result of their vital activities; if so, by the process of natural selection, those which soonest became adapted to the new conditions and no longer brought about a condition unfavourable to the host, on whose life they would now depend, would have most chance of surviving.

This theory is supported by some very interesting work done by Fantham and Porter, who showed that *Herpetomonas jaculum*, a normal inhabitant of the gut of the "Water scorpion" (*Nepa cinerea*), when introduced into the peritoneal cavity of mice or even taken by them in food eventually finds its way into the blood and causes symptoms like those of "Kala-azar" in man, from which the mouse dies.[1] But if the mouse had not died so quickly there might have been developed such immunity to the new substances circulating in its blood as the result of the vital activities of the *Herpetomonas* that friendly relations between the two would result and mammal and parasite would become mutually immune to each other, as appears to be the case with wild game and *T. brucei.*

When man with his non-immune *domestic* animals comes into relation with this equilibrised system the equilibrium is disturbed; the Trypanosome finds itself introduced into the circulation of hosts to which it is a novelty and "disease" results.

[1] Fantham and Porter, *Proc. Camb. Phil. Soc.*, 1915, vol. 18, pp. 39–50, 137–48.

But even man himself shows a gradual acquirement of immunity. In West Africa Sleeping Sickness is not generally so virulent as in the Uganda epidemic, and the disease has been known in that area for a very much longer time. The species of Trypanosome known as *T. nigeriense* causes only a mild form of disease which is very rarely fatal, so it would appear to be the species which has been longest in contact with man. On the other hand, *T. rhodesiense* is very much more virulent than any other human Trypanosome known to us, and it appears to have arisen as a sudden "mutation" from the animal-inhabiting species *T. brucei.* It is only ten years since this undesirable addition to the list of "human" Trypanosomes made its presence known to us by causing a disease previously unknown in that part, or at least unrecognized as distinct from malaria.

Trypanosomes are transferred from one host to another by the agency of various invertebrates, which are as necessary for its existence as are the animals in whose blood they also live.

In the blood they only multiply by fission, asexually or vegetatively; but in the invertebrate host they go through a sexual form of reproduction. Development generally commences in the alimentary canal, whence the Trypanosomes find their way into the "salivary glands," so that they are inoculated into the new vertebrate host when the blood-sucker injects the irritating fluid secreted by those glands in order to produce a free flow of blood. The effect of this fluid is familiar to all who have been "bitten" by mosquitoes. Such an alternation of sexual with asexual methods of reproduction is called a "cycle"; the complicated life history of the malaria parasite is a more familiar example.

I think the fact that the sexual process takes place in the *invertebrate* host points to that being the original host for the Trypanosomes; the life in the blood is as it were an accident, and many close allies of Trypanosomes can do perfectly well without it.

Trypanosomes of fishes are carried by leeches[1]; of birds, by mosquitoes; those of mammals by various blood-sucking insects. Thus, the rat Trypanosome is transmitted by the rat flea, the species causing "Surra" in animals by the large flies often called "Cleggs" (*Tabanidæ*), and those causing "Nagana" in animals and Sleeping Sickness in man are carried by Tse-tse flies (*Glossina*).

The Trypanosome of "Dourine" is particularly interesting, because it seems to have found that it can do without an intermediate insect host, and is transmitted directly from male to female animal, thus having severed all relations with the ancestral home!

It may be pointed out that there is a close analogy shown by Spirochætal diseases of man, some of which are carried by an intermediate host while others are not; the pathology of the two classes also shows much in common, which is not surprising, considering how closely allied are Trypanosomes and Spirochætes.

Lastly, the very interesting species which causes inflammation of the thyroid gland with fever in Brazil, is carried by an insect (*Conorhinus*) of the order *Hemiptera* or "bugs," an order which numbers extremely few blood-suckers among its ranks, although all are adapted for obtaining food by suction. Darwin made special mention of this bug in his journal, and remarks that "one feast kept it fat during four whole months."[2]

The Tse-tse flies will now be dealt with more fully, but in this chapter I will only give a general account, reserving a full account of the natural history of *Glossina palpalis* for another chapter.

[1] See Miss M. Robertson's paper in *Phil. Trans. Royal Soc.*, 1911, Series B, vol. 202, pp. 29–50.

[2] *Voyage round the World*, edition 1890, p. 316.

Some sixteen species exist, which are entilrey Ethiopian in their distribution; for though one species (*tachinoides*) is found in the south-west corner of Arabia, that area is faunistically part of the Ethiopian region. Tse-tse do not occur in Africa north of the Sahara nor south of St. Lucia Bay in Zululand. It is remarkably interesting, therefore, that fossil flies have been found in Colorado referable to this group,[1] and it has been suggested by Osborn that they were responsible at least in part for the extinction of many of the large mammals which abounded in Cainozoic times and by their migrations came into contact with blood-sucking flies to which, and their associated flagellates, they had not yet become habituated.[2]

The first Tse-tse which I wish to mention particularly is *Glossina morsitans*, known to travellers in Africa as "The Fly," or, collectively, as "Fly." According to Austen [3] the exact origin of the name is uncertain; it is believed to be a corruption of "Nsi-Nsi," said to be the name given to blood-sucking flies by natives of some parts of Africa. A passage in the Old Testament [4] possibly refers to *Glossina*, although it may also apply to other flies with the same habits: "And it shall come to pass in that day, that the Lord shall hiss for the fly that is in the uttermost part of the rivers of Egypt, and they shall come, and shall rest all of them in the desolate valleys, and in the holes of the rocks, and upon all thorns, and upon all bushes."

The early African travellers of the middle of the nineteenth century were, naturally, much impressed by the fly which was so well known to the natives for inflicting a "poisonous bite" upon their cattle.

[1] Cockerell, *Proc. of the United States National Museum*, vol. liv. 1918, p. 308.

[2] Letter from Professor Cockerell in *Nature*, 1919, June 5, vol. ciii. p. 265.

[3] *Monograph on the Tse-tse Flies*, 1908, p. 32.

[4] Isaiah, chapter vii. verses 18, 19.

Thus Gordon Cumming in 1850 wrote as follows:[1] "When under the mountains on the south bank of the Limpopo river I met with this famous fly whose bite is certain death to oxen and horses. This fly is similar to the fly in Scotland called 'Kleg,' but a little smaller. They are very quick and active, and storm a horse like a swarm of bees, alighting on him in hundreds and drinking his blood. The animal thus bitten pines away and dies at periods varying from a week to three months."

And again: "The next day one of my steeds died of Tse-tse. He had been bitten under the mountain range lying to the south of this fountain. The head and body of the poor animal swelled up in a most distressing manner before he died. His eyes were so swollen that he could not see, and in darkness he neighed for his comrades who stood feeding beside him."

Again, Livingstone in 1857 wrote as follows: [2] "The peculiar buzz when once heard can never be forgotten by the traveller, for it is well known that the bite of this poisonous insect is certain death to ox, horse or dog. In this journey we lost forty-three oxen by its bite. We watched the animals carefully, and believe that not a score of flies were ever upon them.

"A most remarkable feature is the perfect harmlessness of the bite to man and *wild animals*." The italics are mine, to emphasize that the scientific mind of the great explorer had noticed this pregnant fact, although the full significance was not made plain until Bruce's work was published. "We never experienced the slightest injury from them ourselves, although we lived two months in their habitat, which was in this case as sharply defined as in many others; for the south bank of the river was infested by them, and the north bank, where our cattle

[1] *Five Years of a Hunter's Life in the Far Interior of South Africa*, vol. ii. p. 210, etc.

[2] *Missionary Travels and Researches in South Africa*, p. 79, etc.

were placed, only fifty yards distant, contained not a single specimen. This was the more remarkable as we often saw natives carrying over raw meat to the opposite bank, with many Tse-tses settled upon it."

This account makes clear one of the most remarkable points in the natural history of this species of *Glossina*, namely, the very sharply marked areas which it inhabits; this must depend upon the presence or absence of certain factors in its environment, but has not yet been thoroughly explained.

After noting the symptoms of "fly disease" Livingstone continues: "These symptoms seem to indicate a poison in the blood, the *germ of which enters when the proboscis is inserted to draw blood. The poison germ, contained in a bulb at the root of the proboscis, seems capable, although very minute in quantity, of reproducing itself.*" The words which I have put in italics were written by Livingstone about fifty years before the discovery of the Trypanosome by Bruce, *and some years before the first discovery of micro-organisms of disease by Louis Pasteur!* [1]

The genus *Glossina* was founded in 1830, when Wiedemann described a new species of fly from Sierra Leone, and in the same year another species was described from the Congo by Robineau-Desvoidy: this is the one which is now known as *Glossina palpalis*. It is interesting that the first scientific description of a Tse-tse was not that of the one so long known to natives in South Africa; this was not named until 1850, when Gordon Cumming's travels made the fly well known in England.

Glossina palpalis frequents forested and humid country, and is not found so far south as its more widely distributed relative *morsitans*. The great river courses and lake shores in the tropics furnish the shade and humidity

[1] In 1857 Pasteur first showed that fermentation was due to micro-organisms; in 1865 he showed that silkworm disease was due to micro-organisms. In 1876 the first "bacterium" (of anthrax) was isolated by Koch.

that it requires, hence the Congo basin, the upper Nile, and the shores of Lake Victoria abound with it.

Tse-tse flies are on the whole diurnal, though one or two species are known to bite at night; but the traveller is safe from both *morsitans* and *palpalis* after dark.

The life history of the Tse-tse flies is very remarkable, and almost unique among insects. No eggs are laid, but a single egg is hatched within the abdomen of the mother fly and the larva, a white grub, is fed by the secretion of special glands. When the larva is full grown the mother fly seeks a suitable spot and the larva is extruded. It is a very active little creature, and crawls about seeking for a spot where it can burrow into the soil. It is helped to do this by two curious bosses at the posterior end of the body which are of hard chitin and give the larva a firm purchase when it begins to burrow. As soon as it has buried itself its skin hardens and it becomes a dark brown oval pupa with the two bosses at the posterior end which were seen in the larva, and differ in shape according to the species of fly.

After a period of very varied duration the perfect fly emerges by cracking the pupa-case or "puparium" at one end and by means of an extrusible bladder on the front of its head works its way up through the soil covering it and creeps up a stem in a great hurry to let the wings hang down and expand before they have hardened. I have seen many *palpalis* thus emerge from the ground, and they always give the impression that it is a matter of the utmost importance that they should lose no time!

Let us now glance at the development of our knowledge of Tse-tse flies and disease. It was quite clear to the earliest travellers in South Africa that "The Fly," as *Glossina morsitans* was called, was a cause of the fatal disease of cattle and horses to which allusions have been made.

Sir David Bruce in 1894 was able to report that the actual cause of the disease "Nagana" was a Trypanosome which was named *brucei* after its discoverer, and was taken up by a Tse-tse when it fed on the blood of an animal suffering from nagana. It was believed that the fly inoculated the Trypanosome into a fresh animal when it fed again in the same manner that a vaccinator introduces the lymph on the point of his lancet, that is to say, by direct inoculation. Thus in the case of Nagana we have started with the carrier of the disease and found the germ which it carried.

When the problem of Sleeping Sickness became so acute in Uganda, the Royal Society sent out a Commission in investigate the disease, and the members arrived in Uganda in July 1902. But the first step towards the elucidation had already been made in West Africa. In 1901 an Englishman in charge of a steamer on the Gambia river was admitted to hospital at Bathurst for "fever," and Dr. Forde found in his blood peculiar organisms whose nature was unknown to him. The patient was sent to Liverpool, and Dr. Dutton recognized the new organism to be a Trypanosome: the patient eventually died at the commencement of 1903.

In 1902 Drs. Dutton and Todd found Trypanosomes in the blood of several West African negroes suffering from the early stages of what we now know to be Sleeping Sickness, but in those days the condition had not been recognized as connected with that well known disease. This early stage of fever now came to be known as "Trypanosome fever," or "*Trypanosomiasis*," and in March 1903 Dr. Baker found the Trypanosome in a case in Uganda,[1] though he did not recognize the full importance of this fact. The next development was the finding by Dr. Castellani of Trypanosomes in the cerebro-spinal fluid of a case of Sleeping Sickness in April 1903,[2]

[1] *British Medical Journal*, 1903, May 30th, p. 1254.
[2] *Proc. Roy. Soc.*, 1903, vol. lxxi. pp. 501–8.

and afterwards by Bruce and Nabarro in every case of Sleeping Sickness examined. Thus was made clear the fact that "Trypanosome fever" is the early stage of the fatal disease, and the next step was to find out how the disease was transmitted.

At this step a comparison of what was known about Nagana with what has been found out about Trypanosomiasis aids in the understanding of further developments. In the former case investigation commenced with strong presumptive evidence that a Tse-tse fly was the agent through which the disease was acquired; in the latter case the germ was discovered and it became necessary to ascertain how it was transmitted. Since Nagana had been proved to be due to a Trypanosome carried by the blood-sucking fly *Glossina morsitans*, and Sleeping Sickness had now been shown to be due to another species of Trypanosome, evidence pointed to a blood-sucking fly as the carrier of this new species *Trypanosoma gambiense*, and requests were made to officials in the Sleeping Sickness areas to send specimens of all biting flies in the neighbourhood to the laboratory in Entebbe. It very soon became clear that one fly was found throughout the areas being ravaged by the disease, that is the shaded margins of the great lakes and rivers; this fly was *Glossina palpalis*. Accordingly experiments were made to test whether the fly can be the carrier, and specimens captured on the shores of the lake were fed upon monkeys whose blood was examined daily, the procedure being the same as in Bruce's classical work on Nagana. Conclusive proof was obtained when the Trypanosome was found in the blood of the monkeys, and the discovery was announced by the Commission in 1903.[1] Further proof was obtained by feeding bred flies on monkeys which had been already infected by wild flies, and then making them feed upon another monkey; the second

[1] Reports of the Sleeping Sickness Commission, No. IV, pp. 56–65.

FLY BEACH ON DAMBA ISLE.
A favourite breeding ground is under the bushes at the gap on the right.
By permission of the Royal Society and the Controller, H.M. Stationery Office.

FLY BEACH ON BUGALLA ISLE.
By permission of the Royal Society and the Controller, H.M. Stationery Office.

To face p. 24.

monkey in a proportion of cases also showed the Trypanosome in its blood. Control experiments showed that a freshly hatched fly contains no Trypanosomes, so that those in the above experiments must have acquired them from the first monkeys fed upon.

The two diseases Nagana and Sleeping Sickness are thus entirely parallel, as is shown by the following table :

Disease.	Subject.	Cause.	Natural Host.	Carrier.
Nagana	Domestic animals	*Trypanosoma brucei*	Big Game	*Glossina morsitans*
Sleeping Sickness	Man	*Trypanosoma gambiense*	The antelope *Tragelaphus spekei*	*Glossina palpalis*

It has been said that the transmission of the Trypanosome of Nagana was believed to be entirely mechanical, and for some years this was also thought to be the case with *T. gambiense.* With further knowledge, however, it became clear that there was a period after the fly had fed during which the Trypanosome could not be transmitted to a fresh animal. It had previously been supposed that this was because the Trypanosome was no longer alive in the fly, but Kleine, working in German East Africa, showed in 1908 that the non-infectivity of the fly after a few days did not mean the death of the Trypanosome, but that it was going through a cycle of development in the alimentary canal of the fly, and was not in an infective condition. For when the development was complete Kleine found that the fly could convey the disease fifty days after it had acquired the Trypanosome. These most important results were fully confirmed in Uganda in 1909 [1] and it was found that the time required for the cycle of development in the fly

[1] Reports of the Sleeping Sickness Commission, vol. x. p. 46, etc. ; vol. xi. p. 12, etc.

varied from eighteen to forty-five days, after which time a fly will remain infective and able to introduce the Trypanosome into every animal it bites for as long as seventy-five days!

The complete life cycle of the Trypanosome in the fly was worked out fully in Uganda by Miss Robertson in 1913.[1] The Trypanosome multiplies in the gut of the fly, but the forms of multiplication are not those which will live in the blood stream of the vertebrate host, and a somewhat different form is developed which finds its way into the "salivary" glands of the fly and is injected with the irritant secretion of the gland which presumably is intended to produce a free flow of blood in the site of puncture. We have now arrived at the most important fact that when once it has acquired the Trypanosome the Tse-tse fly can infect for the rest of its life.

We must now consider the relations between Tse-tse, Trypanosome, and the "alternative hosts" of the latter from which the fly acquires it.

It was known from Bruce's researches on Nagana[2] that *Trypanosoma brucei* is a natural and harmless inhabitant of the blood of various species of big game in the "fly areas," and as soon as Sleeping Sickness was proved to be due to another Trypanosome, efforts were made to discover its natural host or reservoir. The Commission in Uganda made a series of experiments with the blood of such animals and birds that, inhabiting the lake shore, might be justly suspected of harbouring the trypanosome, but with negative results. One important species of antelope, however, was not at this time (1908–10) examined. The next step was to *infect* captive antelope and native cattle by feeding upon them flies

[1] Reports of the Sleeping Sickness Commission, No. XIII, p. 119, etc.

[2] Appendix to *Further Report on Tse-tse Fly Disease or Nagana in Zululand,* 1903, p. 8. London, Harrison & Sons.

caught in the Sleeping Sickness area, and it was found that this could be readily done; waterbuck, bushbuck and reedbuck in captivity could all be made reservoirs of the Trypanosome without any harm to themselves, and could continue to infect bred flies fed upon them for more than twelve months after they had been artificially infected.[1] Finally, in March 1912, Dr. Duke announced that the antelope known to the natives as "Enjobe" was a natural reservoir of *Trypanosoma gambiense*, and the chain was thus completed.[2]

It had seemed for some time probable that there must be a natural host, although it had not been found. Four years and a half after the natives had been removed from the islands the fly there was still infective, and it was impossible to suppose that the same flies were still alive that had been the cause of the epidemic. With one exception the animals and birds and reptiles within reach of the fly had been sufficiently examined to make it almost certain that they were not incriminated, and the one large antelope living on the islands was yet to be excluded. Accordingly, in the latter part of 1911 Dr. Duke came over to my camp on Damba Island to shoot and investigate the very abundant "Enjobe" there. This antelope, the Situtunga (*Tragelaphus spekei*), lives in most intimate association with the fly among the shaded forests at the water side.

A number were shot and their blood was injected into monkeys, one of which, injected on November 5th and 6th, showed Trypanosomes in its blood on the 18th. It was taken to the laboratory on the mainland and the nature of the Trypanosome investigated in every possible way, and Dr. Duke considered that there was no doubt that he had at last found the source from which the

[1] Reports of the Sleeping Sickness Commission, No. XI, p. 71, etc.
[2] Ibid. No. XII, p. 117 et seq. See also article by Duke in *British Medical Journal*, 1914, February 7th.

flies on the island acquired the cause of Sleeping Sickness.

This discovery made the question of the return of the natives to the lake shore a far more difficult one than was anticipated when they were removed during the height of the epidemic. It was then thought that as the fly was merely a mechanical carrier of the Trypanosome, an interval during which all known sources of infection (the natives) were kept away from the fly would allow the disease to die out, and when the life of the infected flies had come to an end, the natives who were free from Trypanosomes could return without danger. But now that it is known that there is a "vicious circle," the fly acquiring the Trypanosome from the antelope and in turn inoculating it into fresh animals, the islands and mainland shore of the lake are still dangerous. It is true that some consider that it is possible that the Trypanosome has been for so long away from man's blood that it may no longer be pathogenic to him, but against this is the fact that as a result of living on the islands with me in 1911–12 three of my native employees were found to be infected when I examined them before returning to the islands in 1914, and one at least is reported to have died.

So far as we know at present, the fly would be harmless without the antelope and the antelope without the fly, and to eliminate the disease from the most fertile and beautiful part of Uganda these two must be kept apart; that is to say, one of them must be exterminated.

In 1914 I obtained most interesting confirmation of Dr. Duke's results. The Island of Nsadzi, lying opposite to Entebbe and south of it, was well populated in the old days, and there was very little refuge for Enjobe there; I was told by my canoe-men that the antelope was not to be found on the island in those days. In 1911 the flies on Nsadzi were tested and were found to be free from infection, for as many as 5,765 failed to cause infection in a monkey. In 1914, however, I frequently saw footprints of Enjobe on the island, which had presumably swum across the narrow channel between Nsadzi and the large isle Kome to the east where Enjobe abound. The flies were again tested and found to be infected, for after 2,076 had fed upon a monkey it showed the Trypanosome in its blood.[1] Less than half the number of flies that did not produce an infection in 1911 produced an infection in 1914, and this is associated with the arrival of the buck in the continued absence of the population.

It seems hardly possible to entertain the idea of destroying the Enjobe, since when hard pressed it takes refuge in dense papyrus swamps, and even if it could once be eliminated from the islands would soon find its way back by swimming from the mainland, and would resume its former relations with the native. Is it, then, possible to eliminate the fly?

On this question I shall have something to say in the chapter devoted to the natural history of *Glossina palpalis*.

[1] Reports of the Sleeping Sickness Commission, No. xvii, 1919, p. 71–74.

CHAPTER III

THE NATURAL HISTORY OF GLOSSINA PALPALIS

THIS species is pre-eminently a frequenter of the shady forests on the shore of the lake, where it may be found in great abundance.

The method of estimating its numbers is to set trained natives to catch the flies with small nets from off the herbage or rocks on which they alight, or from their own clothing when the flies come to feed. At the end of half an hour the boys are whistled in and the catch counted, but, for reasons which will be given later, only the males are used. An average figure is obtained representing the number caught per boy per hour, commonly alluded to as the "male-boy-hour" figure, by means of which one locality can be compared with another. The highest figure I have yet recorded was obtained in 1919 on the north coast of the west of Kome Isle: four boys working for half an hour obtained the average of 125 *male flies per boy per hour.* If it be considered that each fly is caught in a net, from which it has to be taken out by hand and put into a bottle, and that besides the males there were at least a quarter as many females caught at the same time, it must be admitted that the fly can be very plentiful!

One of the first things to be realized is that the number of flies at a locality has little relation to the frequency with which one is bitten, and therefore an impression

ON DAMBA ISLE.

Not a good fly shore, as it was too marshy for a breeding ground.

A FLY BOY (JAKOBO) AT WORK.

The white net in his right hand scarcely shows against his white clothes. He was found to be infected with *T. gambiense* in 1914.

To face p. 30.

derived from a large number of bites gives a very erroneous estimate. This fact has arisen from Fiske's investigations into the reasons for the very varying proportions of the sexes at different localities.

It has been found that the females are much less inquisitive than the males, and do not come to man in any great numbers unless wishing to feed, whereas the male roams about and investigates any new object without necessarily being hungry. The percentage of females is therefore an indication of the hunger of the flies. If, however, a prolonged catch is made in one spot, the percentage of females rises, because the more inquisitive males are first caught; the number of females per boy per hour, however, remains fairly constant, since only the hungry individuals are taken.

An experiment such as the following illustrates this point clearly. Flies were caught continuously at one point on the small island of Tavu on January 13–16, 1914, from early morning until the afternoon, and it is clear that the number of males was soon affected, while the catch of females remained constant. The *percentage* of females, however, rose, owing to the males being caught off; not in this case because there were more females eager to feed.

Date.	Time.	Total Catch.	Males per Boy-Hour.	Females per Boy-Hour.	Percentage of Females.
Jan. 15, 1914	7.45–8.45	473	62.5	7.5	10.7
,, ,,	9–10	303	36.7	4.3	10.5
,, ,,	10.15–11.15	235	23.5	6.5	21.7
,, ,,	11.30–12.30	216	20.3	6.8	25.0
,, ,,	1.30–2.30	222	20.3	7.5	27.0
Jan. 16, 1914	7.45–8.45	275	33.0	5.7	14.7
,, ,,	1.25–2.25	241	21.0	11.4	35.2
,, ,,	2.45–3.45	128	9.8	7.1	42.0

The relation between the percentage of female flies in a catch and the hunger of the flies was borne out by the behaviour of flies on different islands visited by Fiske and myself in 1914. (See Chapter VI.) Certain islands, notably Kimmi and Yempata, were remarkable for the avidity with which the flies bit; on Kimmi they even flew out to the canoe before it reached the shore. On both these isles the percentage of females was higher than usual; on Kimmi it averaged 53 per cent., on Yempata 37 per cent.

The curiosity and spirit of investigation of the male fly was shown by a little experiment on Tavu Island. I noted that during the passage through some thick Kinsambwe bushes many leaves became reversed so as to show the silvery under surface. Male Tse-tse often settled on them as if attracted by the novelty. I therefore spent some time catching every fly that settled on my white net, held out conspicuously, and in one hour thus caught twenty-six males, but only six females. I then caught from off my clothes those flies that had settled and lowered the proboscis intending to feed; there were ten females to eight males. Male flies may very often be seen which seem to have no desire to feed, but merely to rest in a conspicuous position, often on a rock hot with the sun; possibly they are on the watch for females. There can be no doubt that they use their eyes in the search for food: it has long been known in the case of *G. morsitans* that a man on horseback or cycle moving will attract flies where none have been noticed while he was stationary. *Palpalis* would often alight on the canoe drawn up on the beach; presumably the large black object was thought at first to be a hippopotamus!

The fact that the fly will often sit on a rock hot with the sun is of interest, seeing that they are apparently dependent upon shade, and are susceptible to variations in the humidity of the atmosphere. I am convinced, however, that so long as *palpalis* has a shady base it will make long excursions from it, perhaps in search of food or breeding places, and may be found in places where there is practically no shade and where it could not abide permanently. Thus, the western end of Nsadzi Island consists of a high treeless grassy plateau sloping down steeply to a rocky shore along which is a scanty fringe of sparse bushes throwing very little shade over the bare rocks. Yet if one descends to the shore fly is met with, and one is immediately investigated.

An experiment was made to test whether the fly does roam along this kind of coast. At one point there was a small copse about thirty yards square, furnishing ample shade to provide a base for the fly, and ten fly boys were set to catch flies continuously here on June 10, 1914.

Time.	Number of Flies Caught.		Males per Boy-Hour.	Females per Boy-Hour.	Percentage of Females.
	Male.	Female.			
9·45–11·15	51	18	3·4	1·2	26
11·20–11·50	16	24	3·2	4·8	60
12 –12·30	12	15	2·4	3	55·5
12·30–1	16	6	3·2	1·2	27
1·10–1·40[1]	—	—	—	—	—
1·45–2·15	17	24	3·4	4·8	58·5
2·15–2·45	9	17	1·8	3·4	65
	121	104	—	—	—

The fact that the number of males caught per boy per hour was almost unaltered until the end shows that the 121 flies could not have been in the copse at the commencement, but that a continual influx occurred. Had the flies all been there at first ten boys would soon have diminished the number. Also, after an interval spent in looking for pupae there was a decided increase in the total number of flies caught.

[1] One empty puparium found.

It is of some importance, for reasons that will appear later, to know whether *palpalis* does roam out of the shade. There is no proof whatever that it will ever cross the open water from one island to another. The little islet Sanga, off the east end of Kome, has everything that the fly can want, but for some reason it is unable to establish itself there, and none can be found. Yet the adjacent shores of the larger Kome abound with fly, and it could very easily find its way across the few hundred yards of water to Sanga, yet it does not.

Palpalis, like *morsitans*, is at times a great nuisance, for it will quietly sit on men's backs and thus be carried a long way. Indeed, I have sometimes unwittingly taken them back to my tent, where they remained, and rudely bit me while having a bath! On certain days, when it is somewhat overcast but the sun shines through thin clouds, they are perhaps at their worst, and are very eager to bite, and will cling to one for long distances. A very favourite trick is to alight on the under side of the brim of one's hat and to quietly sidle round until the first piece of skin free from hair is met with, when the proboscis is lowered from its sheath and a sharp prick is felt on one's temple. It is a curious fact that sometimes one is quite unaware of being bitten, and may suddenly hear the unmistakable heavy buzz of a bloated fly leaving after a heavy feed; at other times the prick is felt so sharply that it might be produced by a needle. Presumably the difference depends upon whether the fine point of the proboscis finds a nerve end or not!

When a fly alights to feed it sidles about over the skin and appears to be feeling for a soft place: when it is satisfied the legs are slightly straddled out, and the proboscis lowered from its sheath into a vertical position, after which it gradually penetrates up to the bulb at its base. It is then withdrawn slightly and the body of the fly begins to swell with red blood. Almost at once the excess of fluid is exuded as a bead at the posterior end of the body, so that the fly is enabled as it were to have a larger feed of corpuscles than if it were compelled to retain all the fluid part. After a full feed the abdomen becomes as large as a ripe red-currant, and the red blood shows through the distended skin; the gorged insect flies heavily away to a neighbouring leaf and rests awhile to digest the meal!

On clear hot days, when a strong wind may be blowing, *palpalis* is not so eager to bite; nor on any day during the hottest hours. But about 4 p.m. it is always ready again, and I have been bitten quite in the dusk of the late afternoon: at night, however, it is harmless, nor does it come to light as the big East African species *brevipalpis* is known to do. This habit of biting again more freely in the evening is of interest, for it is at this time that the Situtunga antelope, which is a source of food, comes out from the dense forests and wanders along the edge browsing on the bushes, where it meets *palpalis*.

The question of the food of Tse-tse flies is of the highest importance, and was one of those set me by the Tropical Diseases Committee of the Royal Society when I first went out in 1910. In the case of *morsitans* certain observers, notably the late F. C. Selous, held that the blood of buffaloes was essential to it, and that it died out or migrated if none was available. Few observations had been made on *Glossina* in a state of nature, but from an examination of the blood taken from the stomachs of wild flies the Commission in Uganda in 1910 [1] had deduced that "the blood in the majority of the flies had been obtained from birds or reptiles, and of these the reptilian blood was twice as frequent as the blood of birds."

It must however be confessed that the method employed

[1] Report XI of the Sleeping Sickness Commission, 1911, p. 112, etc.

of distinguishing between avian and reptilian blood was crude and open to a wide margin of error.

I repeated this work with a greater number of flies and at greater length, and using as standards such sources of food as the flies might meet with, viz. cormorant, crocodile, *Varanus*, python, frog and lizard.

At Jinja I had found that the proportion of mammalian to non-mammalian blood in over 12,000 wild flies was indicated by

$$M : N :: 31{\cdot}5 : 68{\cdot}5.$$

On Damba Island the proportions in over 6,000 flies were

$$M : N :: 21 : 79.$$

Now in both these places antelope's blood was readily obtainable, for Situtunga abounded on Damba and bush-buck were constantly seen in the fly area at Jinja ; hippopotami were of course available at both localities. In 1914 further work was done and blood was examined from flies taken on islands where there were no Situtunga, and others such as Kome, where Situtunga abounded.

In flies from five small islands not inhabited by Situtunga the proportions of mammalian to non-mammalian blood were :

$$M : N :: 4 : 96.$$

On two isles inhabited by the buck the figures were :

$$M : N :: 25 : 75.$$

Now on all islands hippopotamus blood is obtainable ; indeed, on those of the first group it was the only possible mammalian blood, and accounts for the 4 per cent. of cases.

But even where Situtunga are present only about one quarter of the food is obtained from them, and it appears that *Glossina palpalis* much prefers non-mammalian blood.

The question then arises, does this come from birds or reptiles? In 1911–12 careful measurements were made in forty-six cases, that is, from blood taken from flies that had fed recently enough to allow the corpuscles to be measured unaltered by digestion.

In each case fifty corpuscles were traced with the camera lucida, and the average measurements obtained for comparison with known types. Although in some cases a given specimen was with difficulty allotted to any one type, the following result was arrived at:

Source.	Percentage.	Actual Number.	Source.	Percentage.	Actual Number.
Avian ..	4·3	2	Lizards	56·8	25
Reptilian ..	95·7	44	Crocodile	40·9	18
			Tortoise	2·3	1
—	100	46	—	100	44

In two cases birds appear to have been the source. These would in all probability have been cormorants or darters, which so often sit on a branch at the edge of the water with the wings spread open; but the herons and ibis which frequent the shore may also be bitten.

Nearly 57 per cent. of the blood derived from reptiles seems to have come from lizards, probably entirely from the great monitor or *Varanus*, but measurements of the corpuscles from it and one of the common small brown lizards did not allow any distinction to be drawn.

There is no possible doubt that *Varanus* is a most important source of food. I have several times seen one slowly sculling along the surface of the water near the shore, with the top of its head black with *Glossina* which were evidently so troublesome that at intervals the reptile submerged its head beneath the surface, only to be reattacked the moment its head was raised. On one occasion when sitting on the beach of Damba I saw a *Varanus* come out from the forest and walk slowly past me. Tse-tse were around me in considerable numbers, but the *Varanus* was evidently equally attractive, for several went to it and began to feed, as was evidenced by the repeated movements it made to scratch them off with its hind legs.

Crocodiles are also an extremely important source of food, and their habits favour this, for like *Varanus* they often lie for long periods at the water's edge. Measurements of the blood corpuscles in wild flies seemed to indicate that nearly 41 per cent. of the reptilian blood is from this source. It appears at first sight rather remarkable that the horny plates should prove no impediment to the proboscis of the fly ; yet Fiske and I on Kimmi in 1914 watched closely for half an hour a small crocodile which the natives had caught and was tethered near the water, and between 8·35–9·45 a.m. forty flies had fed fully ! This figure did not include those that were disturbed and did not feed to repletion.

The sites chosen by the fly were carefully noted in each case save two, and are indicated below :

Eyelid	12
Hind leg	9
Neck	6
Flank	2
Fore leg	2
Nose	2
Shoulder	1
Nostril	1
Angle of mouth	1
Hind foot	1
Back	1
	38

It is seen that the fly was even able to penetrate through the back !

On Ngamba Isle I was able to see two flies upon a large crocodile that was resting among the bushes and had not run away at my approach ; one of them had certainly fed.

In a single case out of the forty-four in which the blood in wild flies was recognizable the corpuscles agreed well with those of a tortoise. *Glossina* seems to recognize even this as a source of food, for I saw a tortoise one day with a fly on its back making vigorous attempts to find a way for its proboscis through the shell. But though a crocodile's plates are not insuperable, I fancy that the carapace of a tortoise is proof, and the fly would have to penetrate a leg or the neck.

No example of blood that could be attributed to snakes was found among the forty-four cases, but the python certainly must be counted as a source of food. On Kimmi in 1914 I came upon a small specimen lying among marshy grass close to the water, and two flies were on it, one of which had the swollen red body indicative of a good feed. Other snakes also seem to be attractive, for on Ngamba in 1914 I saw a black species lying on rocks about to shed its skin and in the usual lethargic condition. Two male flies were upon it and were obviously attracted by it, though they did not seem desirous of feeding.

Lastly, the lung fish, *Protopterus* (the "Mamba"), has been suggested as a source of food, though I do not understand how it could serve as such, seeing that it only appears at the surface of the water for a brief interval to obtain a supply of air. Examination of its blood showed that it is a physical impossibility for the fly to feed upon it, for the corpuscles are so enormous that only one at a time could pass up the proboscis, which would require a very great effort of suction on the part of the fly !

The figures that have been given represent the result of examination of many thousands of wild flies. For out of a large number caught on a given day only a few would contain fresh blood, and in these cases a proportion would be mammalian blood. In the other cases many would be merely recognizable as nucleated non-mammalian blood, and in only a very small proportion would the corpuscles be sufficiently unaltered to allow of measurements being taken.

During this work note was taken of the presence or absence of Trypanosomes in the gut of the fly, and in the proboscis. Certain Trypanosomes (e.g. *T. vivax,* which kills goats very quickly) only develop in part of the proboscis and are not found in the gut; but others, such as *gambiense,* may be found in both.

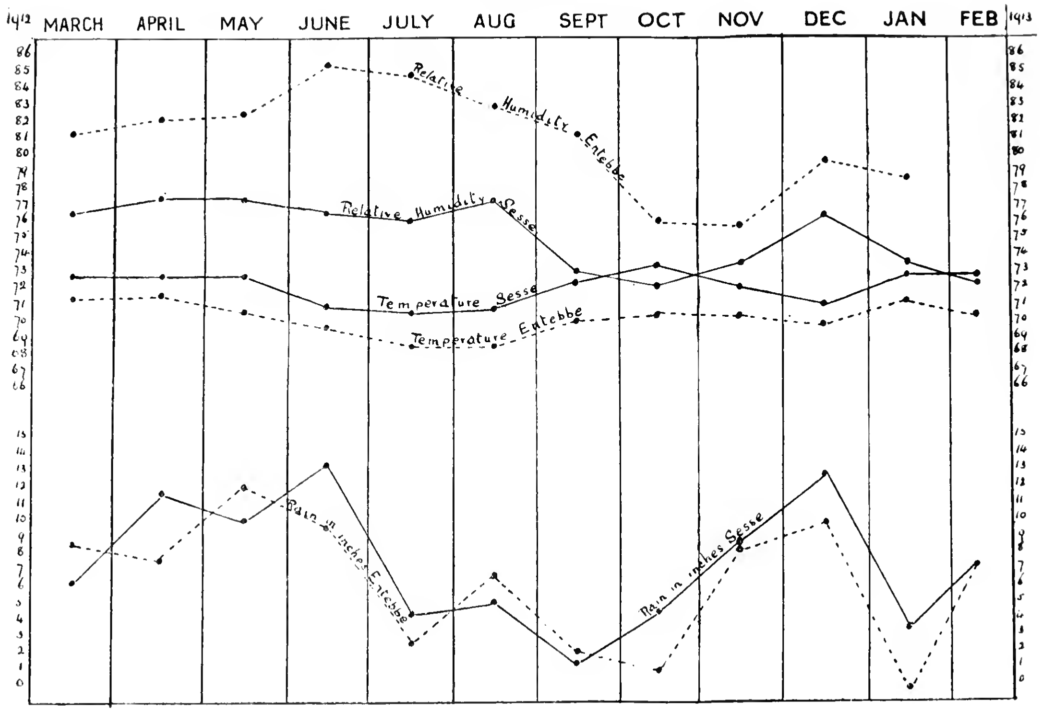
Of 600 flies examined at Jinja, 11 per cent. contained Trypanosomes in the gut; of 695 on Damba, 3·4 per cent. had Trypanosomes; and on Bugalla 1,000 flies showed Trypanosomes in the gut in 1·7 per cent. of the total. Out of 638 cases in which the proboscis was examined on Bugalla, 14 had Trypanosomes in the proboscis alone; i.e. 2·2 per cent. of the wild flies appear to be infected with *Trypanosoma vivax.*[1]

It must not be supposed that all the Trypanosomes found in wild flies are *gambiense:* some are devived from the crocodile (*T. grayi*), and so far as is known are harmless.

Besides Trypanosomes bacilli are often found in countless numbers in the gut of the fly, but in a different part. Nevertheless there appears to be some inverse relation between the two, for out of six hundred flies at Jinja, in only 3·4 per cent. of flies containing bacilli were Trypanosomes also found, and in only 6·1 per cent. of flies containing Trypanosomes were bacilli found. Bacilli were present in 19·3 per cent. and Trypanosomes

[1] Dr. Duke has shown that the Situtunga is a natural host of *T. vivax* as well as of *T. gambiense.* Report No. XII of the Sleeping Sickness Commission, p. 122.

CHART 1



CLIMATES.

Mainland (Entebbe) broken lines; Bugalla Isle (Sesse) continuous lines. Relative humidity in percentage. Temperature in degrees Fahrenheit.

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in 11 per cent. of the wild flies. Thus there is marked incompatibility between the two.

Since I have found bacilli in the gut of freshly hatched flies, and even in pupae, their presence in the fly may have something to do with the fact that only a few out of a batch of flies fed upon an infective animal at the same time will prove suitable hosts and will subsequently be found to contain Trypanosomes. It may be that the presence of bacilli in numbers is inimical to the Trypanosome, or merely that they are present in flies which for some other reason are physiologically unsuited to the development in them of the Trypanosome. It would be interesting to note the presence or absence of bacilli in flies which contain *T. vivax* only in the proboscis.

One of the points set me to be investigated was whether *palpalis* can feed on anything except blood. I have not been able to obtain any evidence that vegetable juices are sucked up save that on Damba Isle I several times found grains of banana starch in preparations made from the gut of flies. I am inclined to think, however, that this was accidental contamination of the preparation, perhaps from a cloth used to wipe the slides, for it is difficult to see how such material as banana could be sucked up the narrow proboscis of *Glossina*. Small fragments of vegetable tissue were sometimes met with in preparations from the gut of a fly, but I am disposed to think that they had been sucked up in water, for pieces of alga were also found.

Flies paid no attention to juicy papai fruit taken down to the shore, although I have seen a mosquito greedily feeding thereon.

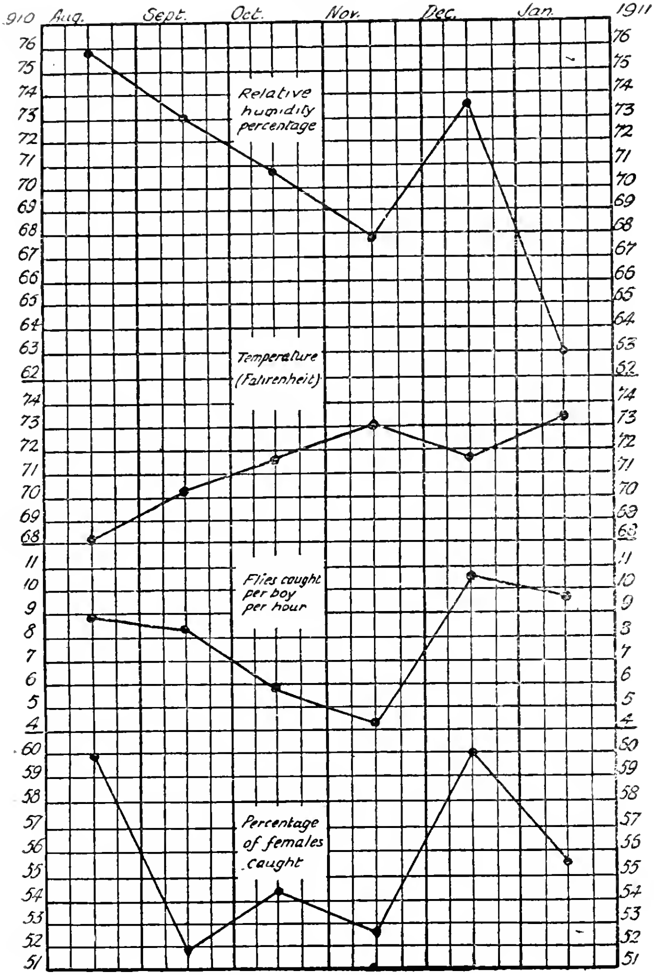
There seems more evidence that *palpalis* imbibes water, but though they have often been seen sitting on wet mud, no fly has ever been seen with its proboscis lowered into the water.

Examination of the contents of the gut of many hundreds of flies on Damba and Bugalla Islands, as well as at Jinja on the mainland, has shown various forms of algae and other low vegetable organisms that must have come from water; and once a very minute ostracod crustacean, only about three times the length of a human red blood corpuscle, was found. Figures of these are given in my first and second reports.

Experiments were made to see if flies lived longer when able to obtain juice from fruit than when starved, but access to fruit made no difference. The longest time for which a wild fly has been kept without food or with only fruit juices available is nine days; a freshly hatched fly will live for eleven days. After a single feed of blood a fly lived for fifteen days (the longest period). This is a remarkably short period, and if it is so in natural conditions is rather surprising. Animals such as ticks appear to be able to live for months after a single feed of blood; the fly, however, is a more active creature, and lives at a higher rate.

What is the natural length of life of *palpalis?* This was one of the first things to be settled when I went out in 1910. For it was then not at all clear why the flies on the lake shore continued to be infective several years after the presumed sources of *Trypanosoma gambiense* (i.e. the natives) had been removed from reach of the fly. There were two possibilities—either the fly was acquiring infection from some wild animal, or the same flies were still alive on the shore that had been the cause of the epidemic some years before. It was not until 1911 that Duke showed what the reservoir of *gambiense* was, and I have showed that the fly probably does not live for more than one year. The drier months of the year cause a large falling off in numbers, so that a fly which has been living for some months probably succumbs when the trying period of diminished humidity comes at the beginning of the year.

CHART II



INFLUENCE OF CLIMATE ON NUMBERS AND PROPORTIONS OF FLIES AT JINJA, ON MAINLAND.

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A chart made at Jinja in 1910 (see Chart II) shows very clearly the direct relation between relative humidity of the atmosphere and the number of flies that could be caught.

In order to estimate the length of life of the wild fly, the method adopted was one that had been used by Dr. Bagshawe to ascertain how far the fly would follow canoes or men.

Large numbers of flies were captured, a portion of one leg was amputated through the middle of either femur or tibia (limbs may be lost at a joint naturally, but never in this way), and then the fly was liberated. By continually catching flies at the same point day after day it could be ascertained for how long a marked fly had lived.

Since a fly has six legs and each can be marked in two ways, twelve markings are possible: one method of marking was kept for the flies of each week. At Jinja, between July 27th and October 15, 1910, some eight thousand flies were so marked, and eight markings were used, an average of a thousand to each marking.

Between August 3rd and February 11th, careful examination was made of each fly caught by the boys, who worked every day for four or five hours. On January 31st, 1911, a female fly was taken that had been marked on one of the days July 27 to August 2, 1910, and on December 29th a male was taken that had been marked on one of the days July 27 to August 2. This gives a period of life of at least 182 days for the female and 149 days for the male, but it is of course impossible to say for how long before the marking the flies had been alive: probably they were hatched fairly recently.

On Bugalla Island in 1912 this experiment was repeated, and between March 18th and April 26th nine thousand flies were marked in six different ways. The last marked flies to be caught were noted on January 17, 1913: two males that had been marked between April 1st and 6th. This gives a minimum duration of life of 247–253 days for the male. A female fly caught again on August 17th had been marked between April 8th to 13th, so it had lived at least 126 to 131 days. This was not quite so long as the longest Jinja period (182 days). Thus it was established that *palpalis* can live for several months, but the probability is that it does not survive a second dry season. In both experiments the last flies were caught at a time when the relative humidity of the air was low.

Both at Jinja in 1910 and on Bugalla in 1911–12 careful meteorological data were kept, and the influence of climatic conditions upon the total number of flies that were caught per boy per hour was found to be very interesting (see Chart III).

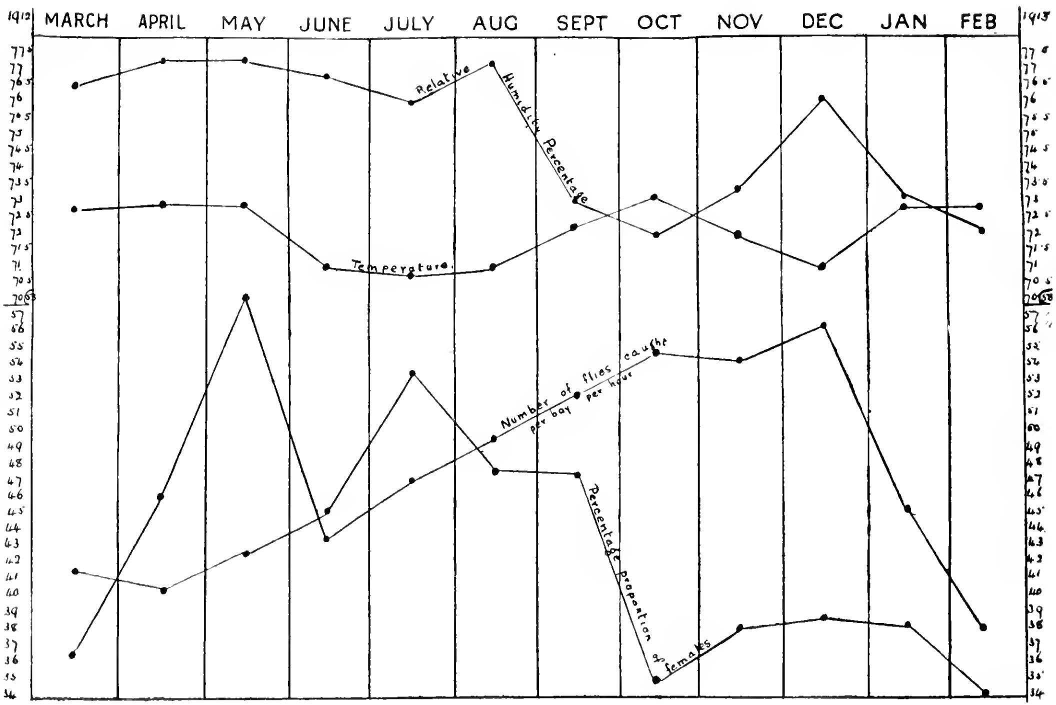
In those days the male catch alone was not used as a means of estimation.

The number of flies caught at Jinja on the mainland varied directly with the relative humidity of the atmosphere, which itself varied during the period from the beginning of August to the end of January from 63 per cent. to 76 per cent. (see Chart II).

On the other hand, on Bugalla Isle no such relationship could be made out, but here the relative humidity only varied from 77 per cent. to 72 per cent. during a continuous period of twelve months. On the mainland there was a very decided inverse relation between the number of flies caught and the temperature. In the hotter (and drier) months there were fewer flies. This did not seem to be so markedly the case on Bugalla, probably because the humidity of the atmosphere was so much more constant on the island that a higher temperature did not necessarily kill off the flies.

In this fact may be the explanation of the occurrence of flies on Nsadzi at the west end, where there was so

CHART III



INFLUENCE OF CLIMATE ON THE FLY.

The figures for percentage of females must be halved to get the correct number.

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little shade: the humidity of the island atmosphere saved them from the heat that might have been fatal on the mainland.

Secondly, the hunger of females, as estimated by the numbers caught, is very dependent upon the temperature. Fiske proved to me in 1914 that the female percentage is not an indication of the actual numbers but of the hunger of the fly. Since the percentage figure varies inversely each month with the temperature, as is shown by the charts for Bugalla and Jinja, it follows that the hotter the month the less the fly is inclined to bite. Indeed, I have noticed on individual days that the fly bites less during the hottest hours, and less on a brilliant sunny day than when the sun's heat is tempered by thin cloud.

A further effect of climate was noted on Bugalla, namely, upon the number of pupae that could be found each month (see Chart IV).

At the end of every month the boys visited certain well known sites much liked by *palpalis* for its pupae, and an average figure was obtained called "pupae per boy" to indicate empirically the number found per month. It is obvious that the total number found at the end of each month must depend in part upon the number of female flies, which is indicated, at least as regards the number of hungry flies, by the "female-boy-hour" figure for the month.

If the "pupae-boy" figure be divided by the latter figure, the quotient may be used as a means of comparing from one month to another the rate of reproduction, bearing in mind that the times when the flies are hungriest will thus appear as months when the reproduction figure "pupae per female" is lowest.

Thus, the average number of pupae found per boy in the given time at the end of February was 187·3; the average number of females caught per boy per hour during that month was 6·3. $\frac{187 \cdot 3}{6 \cdot 3} = 29 \cdot 7$, which is the "pupae per female" figure for the month.

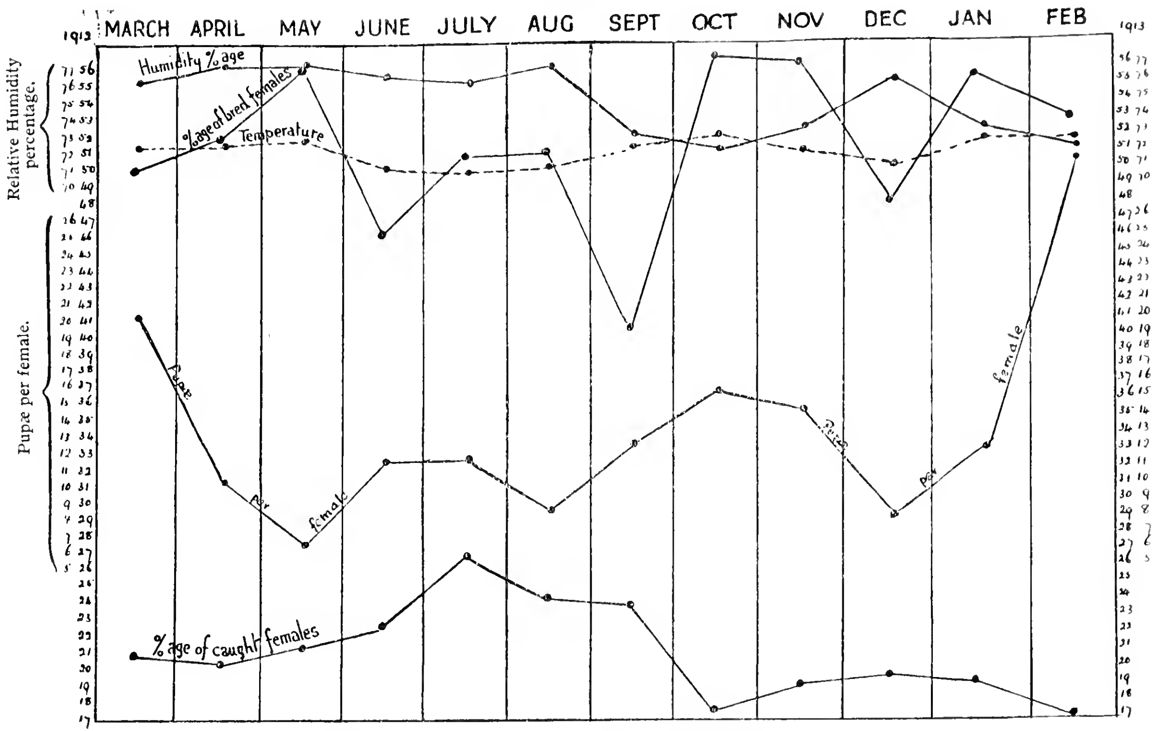
If these figures are plotted out for the twelve months, it is seen that the curve thus formed is inverse to the curve of relative humidity. This may be a definite adaptation to enable *Glossina* to tide over the drier months, which are adverse to the adult fly. That is, during the drier months (of lessened humidity) more pupae are deposited, the pupa being resistant to a greater degree to adverse climatic influences than is the perfect fly.

Experiments were performed to test the vitality of pupae exposed to various conditions of dampness or drought. Batches of pupae were submerged in water daily for different lengths of time, and it was found that daily submersion for twelve hours on twelve successive days only destroyed 36 per cent. of the pupae, and that only 33 per cent. were destroyed by four submersions of twenty-four hours, with an interval between each of twelve hours. The effects of continuous submersion were tried, and it was found that a period of 108-120 hours is necessary to destroy all the pupae in a batch.

Flotation on the surface can be borne for eight days, but ten days are fatal.

Pupae were also put in a small wooden box covered with one inch of earth, and the box was sunk in the ground flush with the surrounding surface and left exposed to the sun during the hottest hours of the day. A single exposure up to six hours does not harm the pupae, but if uncovered by earth a single hour is fatal. The effect of repeated exposures on successive days was then tested : two hours daily for three days made very little difference to the pupae, but three hours daily for three days resulted in only 2 per cent. of flies emerging ; six hours daily for two days killed all. Lastly, alternate submersion and exposure are fatal ; although a single submersion of

CHART IV



INFLUENCE OF CLIMATE ON RATE OF REPRODUCTION, BUGALLA ISLE.

The inner figures refer to the percentages of bred and caught female flies: pupae were collected at the commencement of each month.

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twelve hours, or four hours exposure to sun have, alone, very little effect, if the pupae were submerged one night and exposed to sun next day only one per cent. developed into flies!

Besides variations in numbers of the fly due to climatic conditions, I found in 1914 interesting variations that were very puzzling. The small islands Bulago, Kimmi, Tavu and Ngamba were each visited weekly from the camp on Kome, and catches were made of flies at the same spots around the coast.

It soon became obvious that the numbers of flies (as estimated by the number of males caught per boy per hour) on each of the four islands did not vary concurrently, and that variations did not affect the sexes in the same way on the same island (see Charts V and VI).

On Bulago, for instance, on the south point and west shore the two sexes on the whole varied together, but on the shore of the north bay they varied inversely. In the forest of the north point the variations in number of the males were very great, while the number of females kept very constant. On Kimmi it was noted that the catches from two localities on the north and north-west shores of the island, taken together, varied inversely to the catches from the south and south-east shores, though this was less marked after the beginning of July. This must mean that at certain times the male flies found the north shore more congenial, whereas at others they congregated on the south side of the isle.

By charting together the figures representing the *average* catch per boy per hour of males and females for each of the four islands, a curious and interesting point was brought to light.

On the island where the number of males shows the greatest fluctuations the female figure shows least, and *vice versa*, and the same was found to hold good for individual localities on Bulago Island. On Tavu Island the curve for male flies shows great variation, the female curve little, but on Kimmi the female curve is the greater variant and the male curve more constant. It may be that the supply of food on Tavu is so good that the females are well fed and do not come in any numbers to be caught by the fly boys, whereas on Kimmi the food supply is more erratic : it must be said, however, that there is no direct evidence for this.

A very interesting relation was made out on Tavu between the number of flies caught at the weekly visits and the number of crocodiles seen when the island was circumnavigated in the canoe before a landing was made at each visit. There was a large flat topped rock on the east coast forming a little plateau that was always in use by crocodiles as a basking place ; the number on it varied from one to four, and others were seen in the water. On one visit as many as fifteen large crocodiles were seen on or about this small island, and on that day the number of flies was at the rate of ninety-three per boy per hour ! The lowest figure was fifty-six per boy-hour when only two crocodiles were seen. The accompanying chart shows well the concurrent variation in numbers. It must be confessed that the explanation of this is not at all clear. One would have rather expected that when there was an abundant supply of food on the island the flies would have been less hungry, so that fewer would have been attracted by men, and the catch would have been less instead of greater the more crocodiles there were within reach. On the other hand, had this relation been noticed at one spot on a continuous length of mainland shore it could quite well be explained by the wanderings of flies in search of food which, finding abundance at one spot, remained there.

But, as has been pointed out, there is no ground for believing that flies cross to Tavu over the open water separating it from the larger Kome and Bulago.

AN AMBATCH TREE.

FLY BEACH ON KIMMI.
Behind a row of Ambatch trees on the right.

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It is noteworthy also that this explanation, were it possible, would be opposed by the fact that the number of females caught on Tavu varied very little, unlike the male figure, whereas if the flies had been more attracted to Tavu on days when the crocodiles were numerous, there should have been greater variations in the female catch; perhaps an inverse relation to the number of crocodiles.

The explanation, however, may be connected with the *pairing* of the flies. Male flies flock to the coast from out of the forests when crocodiles are there in numbers in order to meet the females, which go to feed on the crocodiles. When crocodiles are fewer on the coastline the male flies may confine themselves more to the forested centre of the island: the boys caught always on the east and west shore and not in the central forest. It will be remembered that on Bulago and Kimmi the flies seemed to frequent different parts at different times.

Having considered two influences that affect the numbers of the fly, viz. food and climate, it will be interesting now to deal with the natural enemies of *Glossina palpalis* in all its stages.

Considerable attention was paid to this question, and I have spent very many hours observing, in the haunts of the fly, birds and insects that might be expected to destroy the fly.

Very many insects suffer great mortality in their immature stages of egg, larva and pupa, but it will be obvious from what has been said about the reproduction of *Glossina* that it is hardly likely that any great destruction can be wrought upon egg or larva while within the body of the adult fly. It seemed possible, however, that the fat grub in the fly might be "stung" by some parasite such as the Hymenopterous "Ichneumon flies," and that after it had been extruded the adult parasites might emerge from the pupa.

Accordingly I made some efforts to obtain the larvae from pregnant flies captured when the larva was far advanced in growth and kept in a cage, fed at regular intervals, until the larva had been extruded. But premature expulsion of the larva, ending in its death, took place so often that the attempt was given up.

The next opportunity afforded to enemies is the brief moment after the larva has been extruded and is scrambling over the surface of the sand in the endeavour to find a spot where it can penetrate and hide itself. I have watched this happen ; the birth of the larva in the eight cases witnessed took place between 10·45 a.m. and 1 p.m. It is very active, but being white with black bosses at the posterior extremity, is quite conspicuous as it wriggles over the surface. On several occasions I have placed the larva in front of a species of ant, *Paltothyreus tarsatus*, and seen the ant pick up the larva, give it several nips with its large mandibles, and carry it off. Once, on arrival at the breeding ground, among some bushes where I used to lie and watch for events, I saw one of these ants wandering about with a larva in its mandibles.

This ant was very often seen on the beaches where the fly breeds, wandering about and evidently searching for food, and no doubt it does occasionally destroy a larva, as was once seen. But it cannot often enough happen to meet a larva before it disappears into the ground to be of value as a controller of the numbers of the fly. Birds also may occasionally pick up the larva while it is thus exposed, but it can only happen rarely.

The greatest destruction of *Glossina* by enemies probably takes place during the several weeks that it lies just below the surface of the soil as an inert pupa, but I have obtained no evidence of any *vertebrate* enemy. No traces have ever been seen on a breeding ground such as would be left by a bird scratching the surface as do game birds.

It will be said that there were no guinea fowl or francolins (save a single forest francolin) on the islands. Nor have any evidences of the activities of such an animal as a shrew been found on the breeding grounds. The most important enemies, therefore, will be insects, and accordingly efforts were made to breed out from the pupae such enemies as the *Chalcididae*, Hymenopterous parasites or "Ichneumon flies" of minute size which lay their eggs in the immature stages of other insects, particularly the eggs and pupae, as butterfly breeders know to their cost!

On Damba Island five thousand six hundred pupae were kept in boxes with closely fitting glass lids, but not a single one yielded any Chalcids, although from the pupa of another species of fly obtained with Tse-tse pupae a species of Chalcid did emerge.

However, I felt certain that *Glossina* pupæ were attacked, for occasionally an empty pupa case was found with the minute circular hole in the shell through which the Chalcids had emerged. At last, on Wema Isle in 1914, when Fiske and I were opening numbers of pupae to observe the stage of development, he found one filled with rows of little white Chalcid pupae, looking like mummies with black eyes. I obtained more pupae from that locality and succeeded in rearing some of the Chalcids, which proved to be a new species that has been named *Syntomosphyrum glossinae*.

It has been mentioned that some *Glossina* pupae were found with the minute round hole made by the Chalcid, but others are quite commonly found with holes of much larger size and of jagged outline. I have never been able to ascertain what is the insect responsible for this, but in the case of the allied species *Glossina morsitans*, a species of *Mutilla* (ant-like, wingless, fossorial *Hymenoptera*) has been found to be responsible. The female *Mutilla* deposits her egg in the *Glossina* pupa, and its larva destroys the *Glossina*. It has since been found out that the Chalcid *Syntomosphyrum* destroys not the *Glossina* but the *Mutilla*, which has itself destroyed the *Glossina*, so that this Chalcid works on the side of and not against *Glossina*.

When the adult fly has broken through the end of the pupa case and pushed its way up through the loose soil covering it, it seeks for a stem up which to crawl so that it may rest with the wings hanging vertically downwards while they stretch and dry. At this time the fly is a soft white juicy morsel, and any ant that happened upon it would find a pleasant meal. But the fly seems to realize its danger, and is very much on the alert. Moreover, its legs are surprisingly firm, although it appears so weak: I have several times watched newly hatched specimens resting on a pebble until the wings had hardened, and if an ant came near enough to be dangerous they would quickly sidle away.

An interesting insect, the "ant lion," makes its conical pits in the dry loose sand used as breeding grounds by *Glossina*, and lies in wait at the bottom ready to seize such insects as fall into the pit. Since these pits are often very numerous in the soil over which the freshly emerged fly has to scramble, the helpless insect must sometimes fall into one of these pits and be devoured before the wings have expanded, and I have actually seen one as it scrambled along fall down a pit. But the "ant lion" had either pupated or was not hungry, for it paid no attention and the fly scrambled out again.

These pits are often so abundant in the very spots selected by the fly for its larvae to burrow in that I think it cannot be uncommon for the freshly hatched flies to fall in and be devoured.

Much time has been spent in observational work on possible enemies of the adult fly. On Damba Island forty-four insectivorous birds feeding in the fly belt were examined, and the stomachs searched for the wings of *Glossina*, easily recognizable by their peculiar venation, but none were ever found to have swallowed *Glossina*. Twenty more birds were shot on Bugalla with similar results.

A common green tree frog was examined, and in fifty-three cases no *Glossinae* were found in the stomachs. This species spends the day among the vegetation on the shore, but I think only feeds at night, so that it is not likely to meet with *Glossina*.

A large Agamid lizard haunts trees, around which there is a certain space of open ground, and I shot five of them, but their stomachs were found to contain only ants.

It does not seem probable, in view of the above evidence, that vertebrates play a great part in keeping down the numbers of the adult fly.

Of invertebrate enemies of the fly there is no doubt that species of *Bembex*, sand-wasps or Fossors, are of some value, but their distribution is *very* local.

A full account of these most fascinating insects will be found in the chapter on *Hymenoptera*: it suffices to say here that two species[1] have been seen to store up *Glossina* in their underground burrows, and that they seem to know that fat full-fed flies, which they prefer for the food of their larvae, are to be obtained from man and other animals. I have seen the same in the case of a species (unidentified) which preys upon *Glossina morsitans*: as one walked along, pursued and harassed by the Tse-tse, the *Bembex* would accompany one, flying round and round searching for a fat fly.

A species of Dragon fly (*Cacergates leucosticta*) which is very common on the lake shore has discovered the same thing, and individuals have several times been seen to chase *Glossina*, and once or twice I have actually seen them catch and devour the fly. On one occasion I was

[1] *B. forcipata*, *B. capensis*.

able with glasses to see *Cacergates* in attendance on a hippo that was grazing on Bugalla fly ground, evidently on the look out for flies full of hippo blood!

Predaceous two-winged flies of the family *Asilidae* have once or twice been seen to be devouring *Glossinae*, but I do not think that the Asilid is of any importance as a regular enemy.

On the whole, it seems that the chief enemies of *Glossina* are among the Hymenoptera, but I am inclined to think that great loss of life does not result. *Glossina* has such an extraordinarily slow rate of reproduction that it can have few enemies: the greater the number of offspring the more must be destroyed by enemies if the species is to be kept within bounds, and *vice versa*. Climatic conditions, in my opinion, together with facilities for breeding, are the most important influences affecting the numbers of the fly.

We now come to the question of the "breeding grounds" of *palpalis*, on which a great deal of work has been done.

The very peculiar method of reproduction of the genus *Glossina* was reported by Bruce in his papers on Nagana; hitherto *Glossina morsitans* had been supposed to deposit its eggs in buffalo droppings, and this was held to account for the supposed fact that this Tse-tse could not live apart from the buffalo.

When *palpalis* was proved to be the carrier of Sleeping Sickness efforts were made to discover its pupae, with a view to the possibility of destroying it in large numbers when it could be easily reached.

Dr. A. G. Bagshawe [1] in Uganda was the first to find the pupae of *palpalis*: they were deposited around the bases of stems of banana plants. Later he found them sparsely under sundry bushes and masses of creepers, but never in such great numbers as can now be found.

Dr. C. Marshall and Lieutenant A. D. Fraser, R.A.M.C.,

[1] Reports of the Sleeping Sickness Commission, 1908, IX, p. 48.

GLOSSINA PALPALIS AND PUPAE.
Slightly less than natural size.
Photograph by A. Robinson.

UPROOTED TREE ON KIMMI ISLE FORMING IDEAL SHELTER FOR PUPAE.

SEARCHING FOR PUPAE AMONG GRASS TUSSOCKS ON SOUTH POINT, BULAGO ISLE.

To face p. 54.

were the first to find large numbers of pupae,[1] and reported as follows: "They were most readily found on the shore within a yard or two of the edge of the forest. It has since been found that the nearer the forest the more plentiful they are . . . and that the most favourable place is close to the undergrowth that edges the forests —in the loose dry sand near the roots of ferns, etc., and shaded to some extent by the tall forest trees." This excellent account may now be enlarged upon as a result of many months' work and thought devoted to the breeding places of *palpalis.*

It may be pointed out firstly that there are two broad distinctions possible—between large areas of shore suitable, for reasons to be indicated later, along much of its length for the pupae, and isolated spots at the bases of trees, individual rocks, etc., such as the spots first described by Dr. Bagshawe.

The former large areas may be termed "breeding grounds," the latter I have termed "loci," and they will be considered in detail.

The requirements of the pupae of *Glossina palpalis* may be summarized as follows: "Loose dry soil, well shaded, but with the surface thoroughly ventilated; within a few yards from the water but beyond its reach." [2] It is obvious that the soil must be *loose*, else the larva would be unable to burrow down. Hence, however suitable a spot may be in many other ways, if it is hard and bound down by rootlets of grass it will not be a good place for larvae to burrow into the soil.

The character of the soil is important; that it must be *dry* and *well ventilated* has been proved over and over again. A very interesting observation on Tavu Island in 1914 showed this very well. Close to a very favourite

[1] Progress Report on the Uganda Sleeping Sickness Camps, by Dr. A. D. P. Hodges, 1909, Appendix C, "The breeding grounds of *Glossina palpalis.*" The Sleeping Sickness Bureau, 1909.

[2] See my Fifth Report, p. 91.

breeding ground on a ridge was an area of low-lying sand covered by dense vegetation, the leaves of which lying on the sand were mouldy and kept it damp. My fly boys searched for pupae there unsuccessfully, and in so doing of course cleared away the dead leaves and opened up the vegetation, so that a small area of sand about two feet in diameter was much more freely ventilated, though still shaded.

On a subsequent visit a week later I found, in that very spot, about two dozen fresh pupae which had been deposited there since my former visit. Incidentally this observation shows a very important point which will be alluded to later, that the female fly searches carefully for the most suitable spot for the pupae.

The soil itself may be of very diverse kinds: fine pebbles, pebbles mixed with coarse sand, coarse brown sand, coarse white sand, fine white sand, light friable earth, vegetable humus and debris, and the very fine dry dust found in caves and probably mostly derived from disintegrated droppings of bats. Coarse sand with or without pebbles has been found to yield the greatest number of pupae: the very fine white sand such as composes the southern beach of Nsadzi (see Fig.) is not so suitable, because I think it holds moisture too much. The very fine dry dust of caves does not seem very attractive to the flies; possibly it is in its turn too dry.

Vegetable humus and debris are most important, for on long stretches of shore they often form the only material suitable for pupae, elsewhere there being only bare rocks. Little pockets of humus and dried-up debris under angles of rocks or at the bases of trees in such areas form the only spots in which the fly can deposit its larvae, and these are what I have termed "*loci*." Other "loci" are sometimes formed in a forest by loose sand up against the base of a tree trunk not far from the water, often indicated as suitable for *palpalis* pupae by the presence

TREE TRUNK ON BUGALLA ISLE UNDER WHICH MANY *GLOSSINA* PUPAE COULD ALWAYS BE FOUND.

By permission of the Royal Society and the Controller, H.M. Stationery Office.

BREEDING PLACE OF *GLOSSINA* AT HOLLOWED BASE OF TREE ON BUGALLA.

By permission of the Royal Society and the Controller, H.M. Stationery Office.

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of the pits of "ant lions," which have much the same requirements.

On the little Isle of Lula, where fly was found in 1918-19 to be so numerous that the catch was at the rate of 56·5 males per boy-hour, there is nowhere for the fly to deposit larvæ except in "loci"—there is no sand or gravel beach anywhere on this rocky little island.

This figure however is exceptional, but I have no doubt in my own mind that *palpalis* can exist in considerable number on a coast line where there are only scattered "loci" in which to place its larvae.

The next point to be considered is *shade*, which is of great importance. The pupa is dependent upon protection from the sun, although, as I have shown above, it can survive a certain amount of exposure.

Shade for pupae may be either permanent or variable. Permanent shade is afforded by (1) caves or large rocks undercut at the base; (2) prostrate tree trunks arching over the ground; (3) hollows at the base of or among roots of living trees; (4) the pent-house roof formed by the disc of earth torn up by the roots of an overturned tree; (5) thick bushes.

I have not found caves to be nearly as productive as I had expected; on Kimmi Isle, where flies were caught at the rate of 33 males per boy-hour, pupae could only be found at the rate of 6·7 per boy-hour. On the other hand, at a locality on Wema where the fly rate was 59·5 per boy-hour, pupae were found at the base of an undercut rock at the rate of 72·4 per boy-hour. I think the soil in caves is almost too dry.

Prostrate tree trunks arching low over the ground form ideal sites for pupae, and the one illustrated was a favourite collecting ground on Bugalla. On the same beach on Bugalla and close to it was a tree much hollowed at its base, which is figured; it proved to be a very good collecting ground for pupae.

When a tree is torn up by the wind and, unable to fall, is held up by its neighbours, the roots and earth embraced by them form an ideal shelter for pupae if the tree is near enough to water. One such was found on Kimmi in 1918–19 and is here illustrated. In the loose dry earth forming an area of a few feet square under the roots, four boys in half an hour secured 309 pupae, giving a rate of 154·5 per boy-hour, which is extremely high. Search was made for pupae in other localities near this tree, but the result was only 28 per boy-hour!

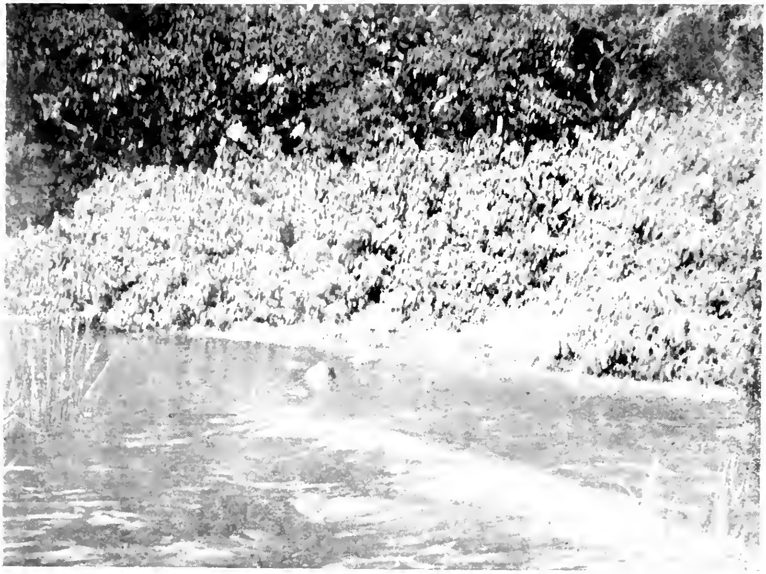
Lastly, thick bushes, especially the "Oluzibaziba" (*Alchornea*), provide shade all the year round, and if the soil and other conditions are suitable, pupae may always be looked for there with success.

The illustration shows a very favourite collecting ground on the fly beach of Damba Island: under the bushes close by but out of reach of the water.

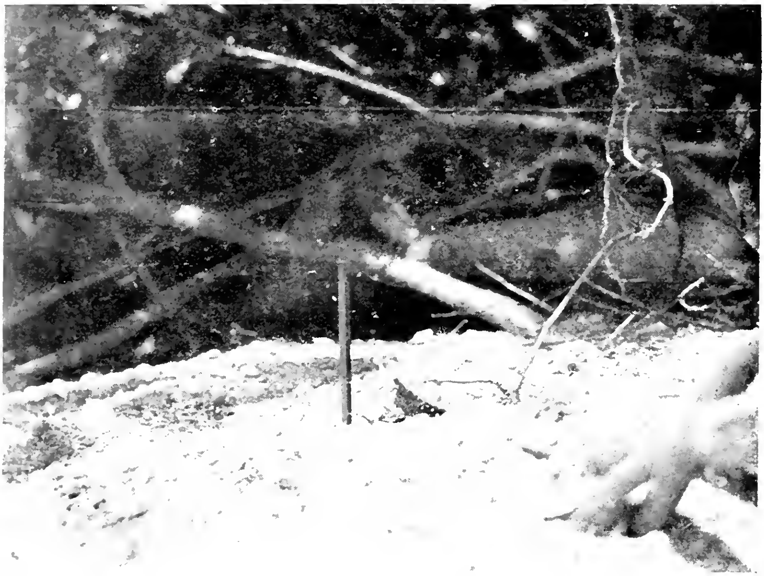
Variable shade is formed by low undergrowth or creepers or dense young growth of bushes near the ground. I have been much struck with repeated evidence of the fly's care in selecting spots where new young growth is rapidly forming dense shade, and the quickness with which such shelter is seized upon by the mother as suitable.

It was a common occurrence to find a cluster of some creeper forming a dense tangle of fresh green that provided admirable shade for the pupae, and investigation of the pupae found there showed that they were in a very early stage of development; that is to say, had been recently placed there. On Wema a very thick tangle of young sprouts of a species of *Polygonaceae* was found on a ridge of sand, projecting so as to arch over the surface below: one boy found here eighty-eight pupae, of which 91 per cent. had only recently been deposited, for they were in a very early stage of development.

Moreover, only six empty cases were found from which the adult fly had emerged. These facts show that the



"ENZIBAZIBA" BUSHES ON DAMBA ISLE FORMING BREEDING GROUND.
By permission of the Royal Society and the Controller, H.M. Stationery Office.



SHINGLE AND SAND UNDER SHELTERING ENZIBAZIBA BUSHES WHERE FLIES HAVE BEEN SEEN TO DEPOSIT LARVAE.
Foot-rule set upright shows scale.

To face p. 58.

green growth had only just reached the condition deemed suitable by the fly as cover for the pupae. An opposite condition was found on Bulago. A tree had large horizontal branches near the surface of the sand arching over which was a canopy of half dead creeper, throwing very poor shade, but with some fresh green shoots springing out so that in a very little while it would form a good shelter. Forty-five pupae were found here, of which twenty-seven were dead ; in three the adult fly was almost ready to hatch, and the other fifteen were in the earliest stage of development.

These facts show that the herbage had been at one time dense enough to throw good shade, but having died, many pupae beneath it had been killed by exposure to the sun's heat. Now that fresh green shoots were growing again, the fly considered the shelter good enough, and had begun to use the spot again as a nursery.

At another time a boy searched for pupae at the base of a papilionaceous tree, which having thin foliage throws poor shade, and in this case had recently died. Here were found 130 shells from which the adult fly had emerged, and five pupae, all dead. Owing to the death of the tree, and the poor condition of rambling plants around its base which had at one time thrown good shade, the fly no longer considered the spot a suitable one, and all the pupae that had been deposited there when the shade was good had either hatched out or died.

Lastly, among the requirements of the pupae is proximity to water. The pupa seems to require this, although its actual surroundings must be dry. Now, inasmuch as the optimum conditions of soil and shade are provided by the raised beaches of sand or gravel that have been left by the subsidence of the lake from a former higher level, these raised beaches being naturally near the water it might be argued that the pupae were found here not because the beaches were near the water, but because on the beaches were found the optimum conditions. But a recent observation, I think, disposes of that argument. On Kimmi Isle in 1914 was a broad flat strip of low lying marshy land, soft and waterlogged, that obviously owed its origin to the level of the lake having fallen and the water having receded from the real shore marked at the edge of the forest by the usual raised beach, which was thus separated from the water by a hundred yards of marshy grass land.

This raised beach satisfied all the requirements of pupae except proximity to the open water, but no pupae were found in 1914. In December 1918, however, there having been an exceptionally wet season in 1916, the water had returned to a former height and had covered the former marsh land, so that it came right up to the old beach, which thus formed a typical "fly beach." It was now used by the fly as a breeding ground, and pupae were found there.

It may be said, then, that the ideal requirements of the fly for its pupae are found on the beaches near the water, well shaded, and composed of dry sand or gravel, and that where these occur *palpalis* is found in maximum numbers. But in their absence the fly makes use of such scattered nooks as can be found, so that it can exist in some number in the absence of "breeding grounds" on rocky coasts. I consider this to be very important, for it has been thought that it would be possible to destroy the fly by merely cutting down and clearing the low shade producing vegetation on the beaches so as to spoil the breeding grounds. This would doubtless lessen the numbers of the fly, perhaps by half, but would not exterminate it.

In order to exterminate Sleeping Sickness two animals must be kept from each other—the Situtunga antelope from which the fly obtains the Trypanosome, and the fly, which inoculates the Situtunga with the Trypanosome.

Each without the other is harmless, for the Trypanosome cannot multiply indefinitely in the fly, and requires to live for a cycle in mammalian blood.

Can the Situtunga be exterminated? This would be an extraordinarily difficult matter. It might be destroyed, temporarily, on the islands, for there are *very* few localities where it would be out of reach. But on the mainland there are vast areas of papyrus swamps in which it finds sure refuge and where it would be quite beyond reach. Now it is well known that the antelope swims readily, and I have given an example of its wanderings on to islands where in the old days it was kept down by natives. Hence it would easily swim out again to the islands from the mainland papyrus swamps, and from one part of the mainland to the other. If, however, a price were put upon its head and natives were allowed to destroy it, it might conceivably be kept to the papyrus swamps, where, beyond the reach of *Glossina*, which is never found in such localities, it would be harmless.

As to the other side of the question, whether *Glossina* can be destroyed, or at least so diminished in numbers as to be harmless, there is a good deal to be said. It must be remembered that when the fly is only present in small numbers the chances of any one being infective are minute. For every fly does not feed from a buck, and every buck that is fed upon does not contain Trypanosomes. Moreover, as Miss Robertson has shown, if the buck does contain Trypanosomes they are not always in a condition ready to multiply in the fly when it bites, and lastly, every fly that takes in Trypanosomes is apparently not a suitable medium for their further development.

When an undesirable insect is to be destroyed, it is often found that the larval stage is easy to deal with, or the next stage, when the insect is a quiet pupa or chrysalis.

But since there is no free larval stage in *Glossina*, the pupa is all that remains to us. Can we then destroy it?

This is theoretically easy since shade is a requisite. If all the low bushes and creeper growing on dry sand near the water were cut down, the "breeding grounds" would be destroyed and the numbers of the fly might be reduced by half.

This would leave, however, all the "loci" that have been discussed, and I see nothing for it but to clear all the shore of low bush for at least fifty yards back from the water, and probably a great deal further. This would be a colossal task with a lake of such a size. But a better way occurred to me in 1914, and an observation in 1918 on Kimmi that has been already quoted made it seem very likely to succeed.

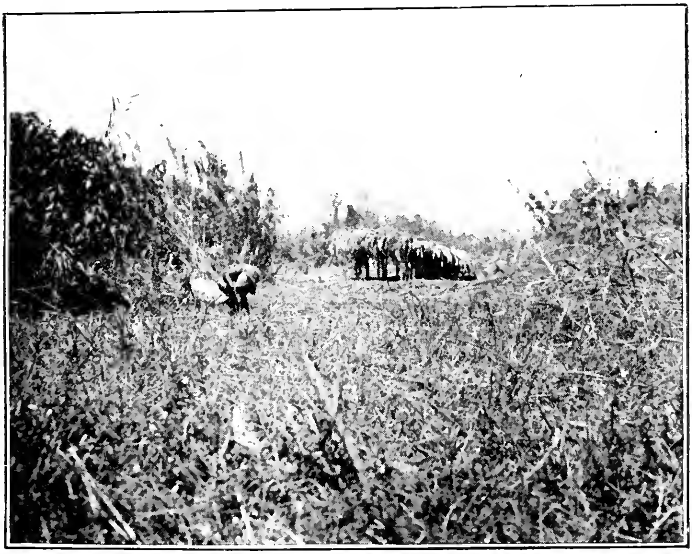
The method is to provide for the fly all the conditions that it requires in a concentrated form, in such a way that it will deposit its pupae in the place chosen for it rather than elsewhere. The pupae can then be easily collected and destroyed. The conditions required by the fly have been dealt with above, and they are provided by building a low roof of thatch covered with green creeper on a bank of sand or gravel near the water. In 1914, I had commenced experimental work on these lines on Tavu and Ngamba, which was cut short by the call of active service, but I had satisfied myself that these shelters *were* attractive to the fly. I also found that although, as has been said before, a thick layer of dead leaves on the surface is inimical to the pupae, yet the fly prefers the surface to be lightly strewn with flakes of bark, sticks or dead leaves. In the preliminary tests one half of the sheltered area was strewn with bark or leaves and the other half left bare, but there were always more pupae found in the former half.

The accompanying figures show the nature of the "artificial breeding ground" thus provided in the test

THE RAISED BEACH OF NGAMBA CLEARED OF VEGETATION UP TO THE EDGE OF THE FOREST BEHIND.

Two boys are searching for pupae under the shelter.

By permission of the Royal Society and the Controller, H.M. Stationery Office.



THE SHELTER ON THE RAISED BEACH OF TAVU, AFTER CLEARING.

The water lies beyond the reeds on the right hand.

By permission of the Royal Society and the Controller, H.M. Stationery Office.

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experiments on Tavu and Ngamba in 1914. When I returned to the islands after the war this question was much in my mind. It had seemed probable that in order to prevent the fly making use of *natural* breeding grounds and loci it would be necessary to clear them, but a most enlightening observation on Kimmi in December 1918 made it seem probable that clearing would be unnecessary. On a sand bank or raised beach the boys were set to find pupae, but found only a few except at one spot. This was under a little pent-house roof formed by roots of a tree that had been torn up by the wind but had been prevented from falling by its neighbours. The earth embraced by the roots formed a roof at an angle of forty-five degrees protecting from the sun and rain loose dry soil, and in an area a few feet square one boy found pupae at the rate of 104·5 per boy-hour. This proves that although there may be a large area of well sheltered sand apparently suitable for pupae, the fly will carefully search for the best spot and deposit pupae there in numbers rather than scatter them along the larger area.

I also found numerous other examples of the same thing : moreover, an experiment has been cited earlier which shows that the female fly does circulate round an island, partly no doubt in search of food but also no doubt to look for the best place for her young. Indeed, I feel sure that the mother fly searches as carefully as does a parent butterfly for the right plant on which to lay her eggs. That being so, there is no need to cut down the bush, *if the artificial breeding place is made tempting enough.* The construction is very simple. All roots are pulled up out of the loose dry soil. The roof covers an area some twelve by four feet ; at its back it is just high enough to allow a boy to creep under in search of pupae, in front it just clears the ground. There are no walls, to allow the free ventilation required. Creepers such as the

Ipomaea and others which grow abundantly in these localities are trained so as to make a thick mass of young greenery on the roof, and the soil is lightly strewn with bark, dead sticks or leaves. At regular intervals of a week or ten days these shelters can be visited and all pupae easily collected by boys searching in the sand.

Should the method prove feasible as a means of destruction on a large scale, it might be possible to put sieves or perforated trays in the sand under the shelter of a kind that would allow the pupae to be quickly sifted out. Or another method might be tried of destroying the pupae by the sun's heat. The roof could be made in two halves, and at regular periods one half could be lifted off so that the pupae beneath would be killed by prolonged exposure to the sun's heat, while next time that half would remain covered and the other half be taken off. The rainy season, however, would introduce complications into this method, for often there are days with very little sun, and if the sand was allowed to get wet, the flies would no longer deposit pupae therein. The method is a simple and inexpensive one, and should at least greatly reduce the numbers of the fly. There is no doubt whatever that these shelters are very attractive, and approved of by the fly as suitable for their young. Before I came away from the islands in 1919 for leave, a number of artificial breeding grounds were prepared on Bulago and Kimmi and are now being tested. The pupae are collected weekly from each, and also from an ideal natural breeding ground on each island for comparison, that on Kimmi being the upturned tree roots as described. From figures that have reached me so far, it is clear that my artificial shelters are just as attractive as, or sometimes more than, the natural shelters, for on some occasions not so many pupae are found under the tree as under one of the shelters close by. During July over two thousand pupae were destroyed on Kimmi by this method, Kimmi being barely a mile in diameter.

Seeing that the fly is such an abnormally slow breeder, and that this method destroys generations yet to come, it does seem possible that it will result in very substantial reduction in the number of flies. Of course a few pupae will continue to be placed in other spots, scattered "loci," but with the reduction in number of flies the number of these would be reduced in far greater proportion, until when there are only very few flies about it seems reasonable to suppose that the number of pupae not deposited in the shelters would be so small that the fly would be exterminated altogether. This would probably take some years, but the decline would be a steady one.

The method could be made applicable to *Glossina morsitans* also, only in this case the shelters would need to be placed not near the water, but near some well marked game track; for *morsitans* seems to place its pupae naturally near game tracks.

This chapter on the Tse-tse fly may fittingly be concluded with the following verses:

TO GLOSSINA: A CURSE!

Thou dipterous hexapod (by which I mean
Thou six-legged creature borne on pinions twain),
Thou tracheate arthropod,—in short, thou FLY,
With buzz importunate arousing my
Just wrath; may fiends innumerable rend
Thy quivering form in twain, and, ruthless, send
Its disunited fragments to the place
Where bad flies go, whate'er their name or race!
May my sanguineous fluid, y'clept blood,
Which thou desirest to extract for food,
Plunging thy sharp proboscis through my skin
To reach capillaries enshrined within,
Flow freely till thou burstest!
Or, again,
Lest this should cause thee insufficient pain,
May justice serve to thee another fate
That red corpuscles ne'er corpusculate
In thy capacious proventriculus,
So that, attenuate, ridiculous,

Thou'rt gnawed to death by cruel starvation's fangs!
Yet do I wish for thee severer pangs
Since none of the above are adequate
Or quite sufficient to express my hate!
May Bembex wasps (those skilful hunters) thrust
Into thy side the lancets which, I trust,
Will fail to paralyse thy sense of pain
While rendering thee inert, that sod, in vain
Thou strivest to escape from hungry jaws
Of Bembex' child, devouring without pause
Thy non-essential tissues; till, at length
When it shall have attained its perfect strength,
Thy shrinking vitals are devoured by it,
And there is left of thee no little bit
Whereof a man might say, "This was a FLY,
A noble creature that knew how to die"!
So that there shall not e'en be left of thee
So vain a thing as a fond memory!
Thus would I wreak my vengeance on thee, pest,
That oft hath bitten me with fiendish zest!

Addendum.

The first observations on the use of artificial breeding places were made in 1914, but were interrupted by the war.

During the war my friend, Dr. W. A. Lamborn, in Nyasaland, unknown to me, was experimenting on his own lines by cutting down trees to make artificial breeding places for *G. morsitans.* (See *Bulletin of Entomological Research,* May, 1916, VII, p. 38.) This method had been developed by him independently, for my report, delayed in publication by the war, was not published until 1919. (See Reports of the Sleeping Sickness Commission of the Royal Society, 1919, No. XVII, pp. 67–71.) I did not hear of Dr. Lamborn's work until after I had been able to develop and make first use of my scheme early in 1919.

CHAPTER IV

THE LAKE

SOME facts as to the great Lake Victoria will probably be found of interest before reading a general account of the scenery and life thereon.

The following data are taken from the eleventh edition of the *Encyclopædia Britannica* :

Lake was discovered by J. H. Speke on August 3, 1858 ; the Ripon falls, the only outlet, discovered by him on July 28, 1862.
Area over 26,000 square miles, only exceeded by Lake Superior.
Greatest length from north to south, 250 miles.
Greatest breadth, 200 miles.
Coast line of over 2,000 miles.
Height above sea level, about 3,720 feet.
Greatest known depth, 270 feet.
Largest islands—
Ukerewe, near Muanza on south coast, whose greatest diameters are 25 × 12 miles.
Buvuma, in the Napoleon Gulf on north coast, which has an area of 160 square miles. (The Isle of Wight has 147 square miles.)
The Sesse Archipelago contains 62 islands, of which 42 were inhabited.
Area drained by the lake, including lake itself, 92,210 square miles.
Rainfall over whole area averages 50 inches yearly.
Annual rise and fall from 1–3 feet : maximum height in July.
By far the greater part of the water that enters is lost by evaporation.

The largest affluent is the River Kagera, which enters on the west coast, and was crossed by Speke on January 16, 1862, on his way to the discovery of the Ripon falls.

He says of it : " Once over I looked down on the noble stream with considerable pride. About eighty yards broad, it was sunk down a considerable depth below the surface of the land, like a huge canal, and is so deep, it could not be poled by the canoe-men ; while it runs at a velocity of from three to four knots an hour."

This fine river, reckoned as 430 miles long, derives its waters ultimately from the south-eastern slopes of the

Mfumbiro range north of Lake Kivu, and from the country between Lake Kivu and the north end of Lake Tanganyika.

It is formed by the union of several other rivers, and at first flows northwards and slightly westwards and then turns abruptly eastwards, to flow eventually into the lake at about the middle of the western shore, a little north of Bukoba. It is of considerable geographical interest that whereas the main affluent of the Victoria Nyanja, and thus the chief ultimate source of the Nile, arises from the south-eastern slopes of the Mfumbiro Mountains, the other side of the same mountains gives origin to streams of which the most important is the Rutchuru, flowing into Lake Albert Edward.

From this lake the Semliki river flows into Lake Albert, adding its waters to those brought from Lake Victoria by the first part of the Nile, via Lake Kioga.

So a very large part of the waters of the Nile above Khartum have passed through Lake Albert.

The numerous islands among which I worked vary much in size, from Bugalla and Kome down to mere rocks or shoals of sand. The commonest type is composed of central grassy uplands rising a few hundred feet, with a belt of forest along the water of breadth varying according to the lie of the land. But some islands have practically no forest growth; thus, Kiuwa is conspicuous as being merely a conical, grass clad hill, with a thin fringe of bushes near the water. On the other hand, Damba is quite flat and almost entirely covered with dense forest. Wema has one peculiarity; one of its four hills is crowned with forest, the base and the surrounding terrain being grass clad. On the largest isles there is much park-like country; that is to say, the grass land is dotted with fine trees, or clumps of small trees and bush forming copses, and the grass being thin and only knee high, this is delightful country for walking. The shores of the islands vary much in appearance, but are rarely

THE KAGERA RIVER AT KIFUMBIRO (KYAKA FORT), ABOUT FORTY MILES FROM THE LAKE.

THE HEAD OF NAPOLEON GULF WHERE THE NILE ARISES FROM THE LAKE.
To the left of the tree a faint haze indicates the site of the Ripon falls.

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THE EASTERN CATARACT OF THE RIPON FALLS IN 1910.

THE BIRTH OF THE NILE.
Ripon Falls from below.

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anything but beautiful. The most picturesque scenery is the narrow channel between two islands where the blue water is bounded on each side by dense vegetation; for example, the lovely passage between Damba and Kome, only a few hundred yards wide.

Forest lies on either side, and in front a narrow belt of bright green papyrus, growing at the water's edge. A belt of reeds springs from the slightly deeper water, and in front of this again the still blue surface is carpeted with leaves of water-lilies, whose blue or pink flowers stand up a little out of the water.

An open shore, with beach of finest white sand or pebbles, is not uncommon, with a forest belt terminating abruptly some yards away from the water. Here there is always evidence of the subsidence of the lake level in the shape of raised beaches at the edge of the forest. Such a strip of shore is termed a "fly beach," since it provides ideal conditions of food and shelter for the Tse-tse.

In some places the shore is formed of bare rock of a spongy texture and red brown in colour, shelving gently into the water, or sometimes forming small cliffs. Here and there a stream of lava makes a strip of lighter colour, embedded in which are fragments of quite different rock, like plums in a duff.

A small headland on which was pitched my camp on Damba ended in a face of grey rock perhaps 20 feet high, in which was a crevice filled with water-worn pebbles at least 12 feet above the present highest level of the lake, showing how the water had receded.

On a flat rocky coastline the forest often comes quite to the water's edge, the trees actually overhanging the water, and there are usually abundant ferns. Long stretches of very low lying marshy shore are common, and are more or less under water during the high level of the lake in the heavy rains. Lush grass and reeds make these spots very attractive to hippos, and the soft soil is churned up along their regular tracks. A very curious plant flourishes here, for all the world like a small lettuce floating on top of the water. It propagates very rapidly, probably by budding, so that many square yards of water may be covered by it, and patches often are driven out to sea by a land breeze. The curious ambatch tree, with its short thick trunk of extraordinarily light, pithy wood, scanty leaves and yellow papilionaceous flowers, flourishes on marshy shores, and the graceful, tall, smooth "Makindu" (wild date) palm is plentiful. Only one other species of palm is met with on the islands, a species called "Ekibo" by the natives, having a short stem and very large dark green leaves, whose mid-ribs are often used as rafters for houses, or, when young, furnish the fibre used in sewing the planks of the canoes.

On low lying sandy or muddy shores a species of cane growing to a height of 10 feet sometimes forms thickets very unpleasant for one to penetrate owing to the sharp points of the narrow, hard leaves. Several bushes are very characteristic of the lake shore; one [1] is known to the Baganda as "Oluzibaziba," and forms dense thickets; it has leaves very much like those of a poplar in shape and setting, which are the favourite food of the Situtunga antelope. Another, called "Kinsambwe," has harsh, hairy leaves, with rather a rank odour; and a third,[2] with leaves much like ambatch, was called by the natives "Omuvuvumye." Several flowering plants sometimes made patches of colour; one like a small herbaceous sunflower grows in banks of bright yellow; another (*Ipomaea*) rambles over bushes and spreads wide its purple convolvulus-like flowers, while a third, called "Anyamberege" by the natives, sends up tall shoots on which grow flowers much reminding one of single hollyhocks; bright yellow, with a velvety patch of purple brown at the

[1] *Euphorbiaceae, Alchornea chordata.* [2] *Papilionaceae.*

YOUNG RAPHIA PALM ("KIBO") ON THE RIDGE OF KIRUGU ISLE.

WILD DATE PALM ON DAMBA ISLE.

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A TANGLED MASS OF *IPOMAEA* IN FLOWER.

A BED OF BRACKEN ON BUGALLA IN FRONT OF THE FOREST BELT.

To face p. 70 (second page).

base of each petal. One other characteristic plant may here be noted, known to the natives as "E'tungulu."[1] It grows in dense patches, throwing up straight green stems as much as 8 feet high, furnished with alternating leaves of very thin texture, with a smooth shiny surface, bright green in colour, elongated, and with pointed tip. The flowers are borne on short stalks coming up separately from the leaf stems; they are in shape somewhat like that of a pentstemon, in colour whitish or dull pink according to the species. The fruits are pear shaped, attached by their broad bases in a cluster, and are of a very bright shiny red. If the tough skin is torn open the interior is found to consist of a large number of round black seeds embedded in a white pulp with delicious acid taste; hence these fruits are much esteemed by the natives, and by monkeys. The fruit of the white flowered species is poor compared to that from the red flowers.

To return to the forest belt. A characteristic feature of its landward side is the abrupt margin; one suddenly emerges from forest to open grass land as though the edge had been cut by a landscape gardener.

It is possible that this edge owes its origin to former systematic burning of the grass by natives, so that no outlying, straggling fringes survived. Now that the population is no longer there, however, the forest edge seems in places to be gradually advancing over the grass, the vanguard formed by rambling bushes of low growth. The significance of this had not occurred to me until Fiske pointed it out in 1914.

On the smaller islets, if very rocky, the only trees are figs, which seem especially to thrive close to the water, and may sometimes be seen perched on a rock, which their descending roots embrace on all sides. These doubtless owe their origin to seeds dropped by some pigeon.

[1] *Anonaceae.*

Owing to the moist climate the foliage is always green, and at no time are the trees as a whole bare of leaves : it is quite common to see one tree shedding all its leaves while another near by is in the full glory of new foliage.

Flowers on the islands are disappointing ; they do not enter into the landscape, but there are many creepers which ramble over the tops of the forest trees and are covered with sweet scented white or yellow flowers : many trees and shrubs also have fragrant blossoms, some of which are beautiful, often of waxy appearance.

The colouration in the bright sunlight during one of the clear days characteristic of the heavy rains is really wonderful in its brilliancy. From high ground one looks over the top of vividly green forest towards distant purple islands set in a sparkling deep blue lake, which is stirred into white-capped waves by the prevailing south-east breeze. So clear is the atmosphere at this time, especially in the evenings, that from Bugalla Island some of the individual houses at Entebbe on the mainland, twenty-five miles away, could be distinguished with the naked eye, and the flagstaff at Government House could be seen with glasses, though I could never make out the flag itself.

The climate of the islands is more equable than at Entebbe, the water exercising its usual influence. Consequently, although the average mean temperature is degrees higher than at Entebbe, the maximum is lower, and the nights warmer. The rainfall also is more equably distributed than on the mainland, although it is greater. There was no month without some rain during the twelve of which I kept meteorological records on Bugalla, but the greatest fall came at the same two periods as on the mainland. (See Chart I.)

A striking feature is that, with extremely rare exceptions, the rain falls between midnight and noon, often between midnight and daybreak, so that afternoon rain

ABRUPT MARGIN OF FOREST BELT ON BUGALLA.
A flowering bush of *Haronga* at the angle was much frequented by butterflies.

PARK LAND ON BUGALLA ISLE.

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which occurs at Kampala on the mainland, a few miles from the lake shore, was unknown during my time on the islands. Another characteristic is that the rain is nearly always accompanied by thunder ; but though this is so frequent one never experiences the oppressive heaviness of atmosphere which precedes a thunderstorm in England. The following is a description of a typical, or as I used to call it a formal, thunderstorm, such as occurs with varying intensity every few days from mid-March to mid-June during the period of heaviest rains. The day has been brilliantly fine, with a hard blue horizon and vivid colouring, and an appearance of nearness of distant objects. There has been a steady breeze all day long, dying away towards sunset, which has perhaps shown for a brief spell a glory of flame-tinted cloudlets. After dark not a cloud is to be seen anywhere, and the stars shine brilliantly. Before turning in at about 8·30 one takes a look round, but there is nothing to note except a distant flickering of lightning to the south-east, which is practically a nightly occurrence in the rainy season.

Having seen that tent pegs and ropes are secure, and that the front of the tent can be quickly closed in an emergency, for these storms often give one little time, one turns in, to be not at all surprised at being awakened in the small hours, usually between two and three, by a rumbling of thunder. Stepping outside the tent one sees magnificent piled up masses of inky cumuli illuminated by almost incessant flickerings of lightning. Sometimes a flash stretching in an arc right across the heavens makes one start with the wonder and, almost, fear of it.

In the momentary intervals between the rumblings of thunder can be heard a faint musical sound, produced by the downpour of rain on the water, as yet far away. There is nothing to be done but to make sure that the tent is firmly secured, fasten up the door, enduring an "infinite torment" of mosquitoes which, aware of the coming storm, have thronged into the tent for shelter, and retire to bed again to await the onward march of the storm, for no more sleep is possible until it has passed. Overhead the stars are still shining brilliantly, and it is absolutely calm. Presently a faint murmuring of wavelets is heard; heralds of the disturbance produced by the distant storm, by the time they reach the island reduced to mere ripples. Now a faint breath of wind can be felt, which dies away, followed by another puff, and the sound of the rain and thunder grows louder, while the lightning increases in intensity until it almost hurts one's eyes, kept tightly shut. The ripples increase into waves, and the noise of surf on the beach is added to the distant sounds. A few fat drops of rain descend, and then with a rush and a roar the storm arrives. A hurricane of wind tears and shakes the tent until one expects every minute to be carried away with it; the roar of the sheets of rain on the roof is almost loud enough to drown the deafening thunder produced by flashes of lightning that seem to split one's very head in twain. This pandemonium lasts for about a quarter of an hour, when the wind moderates a little, the rain increases in intensity, and the thunder gradually passes away as the centre of the storm moves off. After an hour or so the rain slackens, but continues very heavily until shortly before daybreak, though sometimes continuing steadily until the morning is well advanced; the evening being again fine and clear. In one such storm two and a half inches of rain fell between 6.30 and 9 a.m. Such is the formal storm of the wet season, but quite frequently there are dry thunderstorms, when the lightning apparently discharges from one cloud to another, and there is no rain. The thunder on these occasions has a hollow, light quality, probably due to the rarified air of the upper regions in which the storm occurs. The clouds

MY SETTLEMENT ON BUGALLA ISLE, 1912-13.

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are greatly disturbed, and one seems to be looking upwards into a vortex. There is usually a central area to which ragged pieces of cloud drift from all directions, only to be torn into shreds and vanish as if they had gone up a chimney. These overhead disturbances may be accompanied by no disturbance whatever at earth level, where the sun shines and a fine weather breeze blows as usual. Sometimes the edges of the clouds at the centre of these storms may be wonderfully rainbow tinted, although no rain reaches earth. On Damba Island in June 1911 was seen one evening a wonderful cloudscape to the East. Low down, over the mainland, were the usual lumpy cumuli, and to the right these merged into nimbus. Converging to a point on the horizon between these were two broad filmy streaks, above and transverse to which were bars of cirro-stratus. This cloud complex was the forerunner of the highest wind I had experienced on the islands up to that time ; it began at midnight and repeatedly awakened me : by mid-day the blue lake was whitened with curling wave crests, and drifting purple and green cloud shadows made lovely contrasts of colour. Since I was very dependent on the state of the weather for my work outdoors, I took some interest in the signs, and an account of what was learnt may be of interest.

Firstly, the meteorological signs.

There were the usual general signs, such as cirrus or cirro-stratus clouds and clearness of atmosphere, heralding storms ; heat haze in fine weather, etc.

The approach of the rainy season is preceded by cloud funnels, which appear in all stages from a nipple shaped process at the lower edge of a ragged cloud, to a complete pillar connecting cloud and lake, called by the natives "Omusoke." From Entebbe, looking out over the lake, a great number of these are seen, and they are commonly called waterspouts, but I have never been near enough to make out whether they correspond to waterspouts at sea.

There is a great deal to be learnt from the wind, its direction and force, and so on. The daily wind blows from the south-east, being strongest in early afternoon and dying away towards sunset. Sometimes it blew so strongly when I was on Damba that canoes could not go out on account of the white capped waves and the surf on the shore. If this wind freshens again after sunset for a little while, it usually implies bad weather next day, especially if, during the night, a few fat drops of rain fall. Such a night followed by a very calm, clear, warm, clouded morning at daybreak invariably portends a storm before mid-day, and one would not think of going out in a canoe.

On the contrary, an early morning cold northerly breeze from the mainland, with thick haze, foretells a very fine hot day. This north breeze blows quite violently until 8 or 9 a.m., when it suddenly drops ; and, as suddenly, the south-east wind rises and impresses its mark on the lake before the waves due to the north wind have subsided ; so that one sees ripples travelling in a northerly direction superimposed on the swell running southwards. During the rainy season, when there is a calm, curious map-like areas of irregular shape and varied tints appear on the still water, and I came to the conclusion that they preceded a storm.

Occasionally during this time of year the sun appears surrounded by a misty ring at a considerable distance from it ; but this was not common, and I never was able to make out that it heralded any particular type of weather.

In the driest months at the end of one year and commencement of the next the sun's heat is powerful enough to cause grass to take light spontaneously. Fires seen on the islands are usually considered to be evidence of the presence of natives in the forbidden area, but I am quite satisfied, from the following instance, that they can be of " spontaneous " origin

On January 29, 1919, I was examining Nyenda Island, my camp being on the southern side of Wema. As we returned in the afternoon the grass all round the camp was seen to be burning, and I found when I got back to camp that it had had a narrow escape. The boys said that about 2 p.m., while in their houses, they had heard a sound like a gun-shot, and going out, saw a cloud of smoke arising to windward, and heard flames crackling. They only just had time enough to strike the tent and get my things further away from the edge of the long grass, and had there not been a space cleared for the camp, the huts would all have been burnt.

They showed me afterwards the spot where the fire had commenced. Among much bare red rock there was thin dry grass on light soil, and at one place was a hole looking as if the earth had fallen in over a termite's burrow. Here was an appearance that suggested that a quantity of dry debris lying at the bottom of the open pit had suddenly taken fire with explosive violence, for the edges of the hole had obviously just been disturbed.

Such fires are well known to the natives, who call one "Nakibengeyi"; they pointed out the red rock to me as a kind that is particularly associated with these spontaneous fires. It is of a spongy texture, apparently of igneous origin, and certainly does absorb and radiate a great amount of heat from the sun.

The signs of weather afforded by the island life are abundant, and doubtless many more than here recorded. Several birds give useful indications. A curious booming, hollow sound is sometimes heard during the rainy season preceding a storm, and it was a long while before I finally satisfied myself that it emanated from the crowned crane. The natives insisted that it was produced by the puff adder!

The large black and white hornbill is always much more vociferous on one of the clear blue evenings before rain, and gulls on the rocks scream and chatter much more vigorously. When terns appear off the coasts of islands, one knows that windy weather is coming, for under other conditions they were never seen ; presumably they then frequent the open lake.

The glorious fish eagle is much more vociferous, according to the natives, when the wind is rough, but I never satisfied myself of this, and think he screams more on account of brilliantly fine weather, which, of course, is often accompanied by a fresh breeze. One of the large, pale blue, insectivorous kingfishers, which haunts thick bush or forest, utters his characteristic cheerful cry with greater persistence when the early morning is particularly fine and brilliant. A species of woodpecker, like the "yaffle" at home, is only heard to cry before rain.

Frogs, of course, croak before rain, especially one species which inhabits burrows in the earth ; indeed, it is never heard to croak except in the evening, before rain, unless it is breeding. The green tree-frog, so abundant on herbage of the lake shore, sends forth its high-pitched, scraping note when it thinks there is rain about.

I had an amusing experience one day on the shore. It was about noon on a very fine day ; a small cumulus cloud slowly formed and emitted a single crack of thunder without in any way dimming the brightness of the day. This clap of thunder was immediately followed by a chorus of satisfied quackings from a host of concealed frogs, sounding ridiculously like applause of a well-meant effort! There was no rain, however, so the prophets were forsworn.

Fish also afford signs for a weather prophet to interpret. Thus, in my journal for January 30, 1914, is noted: "Off the south-west point of Ngamba Island little fish were leaping about in the water and also in shore, close under the bushes. About a hundred yards away from the island the glassy surface of the water was broken by a

AERIAL ROOTS DIPPING TO GROUND, BUGALLA FOREST.

GIANT TWISTED STEM OF CREEPER, BUGALLA FOREST.

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collection of the 'mălĕ' fish (see Chapter IX, p. 193) tumbling and wriggling about. The natives said they were mating." The next day was noted as "a beastly cold, stormy day, with black clouds, after a lot of thunder and rain at 1 a.m." On Feburary 21st the same occurrence was seen off Wema Island; the small fish hopping out of the water, and mălĕ tumbling about. The following day, however, was also fine and hot, and rain did not come until the twenty-third.

I think this behaviour of the fish is not of any immediate significance, but occurs just before the rains commence in earnest, in March.

It was again noticed very often when voyaging in January and February 1919; sometimes the canoe would be so close that the men could almost have netted the fish.

Insects, as might be expected, furnish many signs of coming rain.

The most obvious is the appearance of immense numbers of a non-biting gnat, of the family *Chironomidae*, called by the natives "E'sami" (pronounced Sammee). They appear as brown clouds drifting over the lake, along the horizon, like smoke from a distant steamer. Eventually they are blown ashore, where they seek shelter among trees. These clouds are most often seen just before and during the heavy rains. If Sami happen to arrive at one's camp after dark they swarm around the lamp and drive one nearly desperate. Other insects also come to the lamp before rain, particularly *Ephemeridae* of different sizes. One, about the size of the common English "may-fly," once came to the camp fire in such numbers, and their burnt bodies made such an appalling stench, that it was too much even for the natives, who put out the fire and retreated! A smaller, paler species has the extremely annoying habit of alighting upside down on one's table or writing paper, and flopping miserably about until he dies! Other still smaller species of two-winged flies have an extraordinary liking for singing their high-pitched song inside one's ears, until one can bear it no longer and retires beneath the mosquito net.

To these nuisances may be added an enormous male ant (*Dorylus*) with shiny, hard, light brown body over an inch long, who bangs himself against the lamp, and returns however often he be thrown outside with contumely, until one is forced to go against one's scruples, and bottle him. I have dispatched as many as twenty on one evening. They are a very reliable sign of coming rain if they are seen in any number: the workers also are much more often seen on the march before rainy weather. Termites, likewise, are much more harmful in wet weather, and cover the timbers of one's house with earth with surprising rapidity at such times.

The biting flies known as "buffalo gnats" (*Simulium*) are especially eager to bite in the early morning or evening before rain on the islands. Thus on July 26, 1914, on Kome Island, is noted in my journal: "I went down to the rocky shore before breakfast, and was set upon by a swarm of viciously biting *Simulium*. In the evening many *Ephemeridae* came to the lamp." Next morning, after daybreak, there was the worst thunderstorm I had ever experienced on Kome.

The night time on the islands, apart from thunderstorms, has charms of its own. A number of sounds are to be heard from sunset until the small hours, when for a while there is silence until the first glimmerings of dawn. The thunderous snortings of hippos, the muffled bark of the Situtunga, break in upon the continuous shrill tinkling sound, curiously suggesting sleigh bells, produced by thousands of small frogs along the shore. Crickets chirp all round and in the house, and during the rains one enormous species, sitting just inside the mouth of its burrow, makes the earth resound with a continuous high-pitched buzzing sound, which if at all near seems to penetrate through and through one's head, and renders sleep impossible until the performer has been silenced.

The chattering and quarrelling of gulls on the rocks mingles with the plashing of wavelets and the gaggling of Egyptian geese, which are restless at night.

Perhaps there passes overhead a flight of some kind of plover, whose cry has earned for them the native name "Empunya," and in the distance, over the open grass land, a hunting owl emits its drawn out quavering call, and a nightjar its "Tok-tok-tok-tok-tok" for long periods without a pause.

Occasionally an ibis, startled by something, disturbs the night with its raucous alarm cry, "Aa-aa-aa," or an awakened monkey in the forest says what it thinks of the disturber before settling down to sleep again.

With the first glimmerings of day the chorus of birds begins, and the forest resounds with their cries and music, for there are many songsters of merit. Soon the troops of monkeys awake and commence their hunting, and the loud "kubba-kubba" cry shows where they travel among the tree-tops; and for the rest of the day the forest is never silent. A species of forest francolin, living in the densest thickets, has a loud ringing, laughing cry which, taken up by one after the other, often resounds through the forest during the heat of the day when other birds are relatively quiet. Towards evening the hornbill waxes vociferous, and his "Nga-nga" cry, from which he gets his name, seems characteristic of that time; flocks of grey parrots flying home from the forest shriek in the familiar discordant way, and snow white egrets sedately wend their way with hoarse croakings across the blue water to their accustomed roosting places. The sunset chorus of songsters has hardly subsided before the frogs and crickets take up the strain, and with the rising of the moon owls add their melodious cry.

Life on the islands was soon reduced to a routine only interfered with by the weather. Arising shortly before the sun one pottered about for half an hour before a bath, or a swim, and breakfast.

At eight o'clock one set off for the fly ground. On Bugalla this simply meant a walk of about half a mile down from the open grass clad hill on which camp was placed, through the forest belt, and out on to the sandy beach.

When on Damba we cut across a shallow bay by canoe to the beach about a mile away ; from Kome camp we went by canoe to the other islets, and very pleasant going it was against the fresh north breeze and dancing waves, taking an hour or more. From this one returned at any hour between 2-5·30 p.m., after which there was a certain amount of work to be done with the microscope.

On Bugalla the afternoon was always spent over the microscope ; and a walk over the highlands in the evening gave one exercise and beautiful views.

Sundays were always given up to butterfly hunting and other changes of occupation. On Saturdays the big canoe with crew of fourteen men started off for Entebbe taking mails, returning on Tuesdays or Wednesdays according to weather, with mails and the week's supply of food for those of us who always remained in camp. Sometimes this canoe had very rough passages, and I well remember one night near the end of my residence on Bugalla. It was one of the exceptional occasions when there was a storm after sunset coming from the north-east. The crew as usual had announced their approach by blowing on a horn of the Situtunga antelope, and I was rather anxious, as a storm was threatening from the same direction.

Gradually the wind freshened until a gale was blowing, and the house rocked. I lit a lantern and went down to the shore to mark the landing place, as it was pitch dark. Above the roar of the surf on the coast could be heard the shouts of the paddlers furiously urging on the canoe in front of the storm, but they were not able to make the shore where I was on account of breakers. By great good fortune they were enabled safely to round a headland and land in comparative calm. Had the storm been from the usual south-east direction, they could not have faced it, but would have had to turn and run before it; but these early night storms came from a direction different from that of the formal storms described previously.

CHAPTER V

CANOES AND A VOYAGE

UNLESS one is very fond of the water and a good sailor, travelling by canoe becomes tedious or even unpleasant. If merely a passenger one sits right forward in the bows and, when the lake is anything else than smooth, very soon gets well splashed. I always took the steering paddle and found it great fun ; a good deal of skill is required to keep a heavy canoe true to its course when a strong beam wind persistently blows the bows round.

The canoe ("Eryato") made by the Basesse is of a peculiarly interesting type, since in the first place it forms a link between a "dug-out" and a built vessel, and in the second place shows how the keel of a modern boat represents all that is left of an original dug-out.[1] In the old days of warfare on the lake between the Basesse of the islands and the Baganda of the mainland, these canoes were of very large size, and I have heard it said that they could accommodate fifty paddlers.

The most important part is the keel ("Omugongo"), which is hewn from a tree of a particular species, found by experience to provide the best wood for the purpose. It is very thick and solid, with a rounded bottom and hollowed-out upper surface, so that in transverse section it is concavo-convex ; it is, in other words, a "dug-out." Seen from above, it is broader in the middle than at the ends.

[1] Mr. Henry Balfour pointed this out when I gave him a model for the Pitt Rivers collection at Oxford.

CANOE RETURNING WITH LOAD OF FIREWOOD.

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The after end is shaped so that the stern post ("Ekiwenda") can be fitted to it, and; similarly, a stem post is fitted near to the forward end of the hollowed-out keel, of which the extreme anterior pointed end has been left solid, to project beyond the stem post.

These stem and stern posts are inclined forward and aft at half a right angle, and are fastened at the bottom to the keel, whose hollow is shaped to embrace them slightly by palm fibre passed through holes ("Endagire") bored with a hot iron. The next step is the fitting of the lower side planks ("Amabasi"), one on each side, stretching from stem post to stern post, and secured to them and the keel by palm fibre ("Ensinga"). These planks are made from wood different from that chosen for the keel; the latter has to be rigid, but a measure of pliability is required for the planks. The upper edge of the lower plank is neatly bevelled off to fit the lower edge of the upper plank ("Olwero"). This, again of a different wood, for it has to stand exposure to hot sun in between occasional wetting by waves without cracking, is made of three pieces, for it has to take a considerable curve. The main piece runs along the greater length of the canoe, but a small length ("Eryungo") is required at bow and stern to take the curvature from the end of the main piece to stem or stern post. Where these pieces overlap they are neatly fined down so that the thickness of the two is no greater than the thickness of a single piece. At the extreme ends, bow and stern, the pieces of opposite sides are firmly pulled together by stout lashings passing across and across the interior of the canoe. The lines of junction ("Entabiro") between upper and lower side planks, and lower planks and keel, are covered by laths of wood cut by splitting sticks longitudinally; a strip ("Oluwamba") is laid with flat surface next the junction, and lashings of "Ensinga" pass through the planks on each side of it, and over its rounded surface.

These strips cover the lines of junction on inner and outer surfaces of the canoe, and all crevices are thoroughly plugged with fibrous material.

The thwarts (" Amanga ") on which the paddlers sit are fastened in a peculiarly ingenious manner, so that they also serve to brace the sides.

Each rests on the upper margin of the lower side plank, which is notched to receive it, as is also the lower margin of the plank above; the thwart itself is grooved, not quite at the extremity, so that its actual end is visible as a knob (" Empumi ") on the outside of the canoe. The grooves in the thwart and notches in the planks all correspond, so that everything fits as closely as possible, and leakage is prevented by plugging. All the holes through which pass the fibres fastening the planks are tightly plugged, and as the plugging swells in the water a good canoe leaks very little, although no resinous or tarry material of any kind is used.

A peculiarity of these canoes is that right forward a long spike projects out from each side, made by a thwart (" E'gami ") fitted exactly as are the paddlers' seats, with which it is serially homologous; but its outer ends are produced into spikes instead of being rounded off into mere knobs. This projection is of great use when a heavy canoe has to be hauled up on the shore, but I do not know if that is why it was designed in the first place.

Another feature is the upturned prow (" Ensanda "). It was said that the part of the keel left projecting beyond the stem post is not hollowed out, and gradually tapers off. Over this is fitted one arm of a large right-angled piece of wood, whose other arm therefore projects upwards into the air for two or three feet, and several feet forward of the real bow of the canoe, and makes an excellent breakwater against waves. The projecting keel gives an extra lift to the bow of the canoe, so that they are excellent sea boats, though the prominent prow and

A CANOE RACE.

A HALT ON THE EAST COAST OF BUGALLA.

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spikes manage to distribute a good deal of water over any one in the bows, unless there is a calm.

On top of the "Ensanda" is placed a decorative tuft of feathers, known as "Enkuli," and a string stretched between it and the top of the stem post ("Ekiwenda") has a series of plaits dangling from it vertically. This ornament is called "Akasenso." The top of the stern post is often also ornamented with a tuft of grass ("Engudi").

When the canoe is sufficiently loaded, the ends of the thwarts are just on the water line. The paddles ("Enkasi") are quite simply made, with no attempt at decoration; the blade is broad at the base and tapers to a point, its surfaces not being absolutely plane, for one side is very slightly concave, the other equally slightly convex. An essential part of the equipment of a canoe is the baler ("Olutiba"), made by hollowing out a rectangular block of wood into a shallow basin. One of the crew amidships makes it his business to free the canoe at intervals from the water that collects in the hollow of the keel ("Ekyuwo"); if the canoe is an old one so that the edges of the planks and keel are getting soft, it cannot be properly plugged, and one man is needed to bale continuously.

After two or three years the wood of the keel rots and the planks crack, so that the life of the canoe is finished; the natives require two or three months to make a new one.

With a good crew, each accustomed always to take the same thwart, and paddling well together to a rhythmic song, the motion is very pleasant, and considerable speed is attained. Sometimes each man, at the height of the stroke, knocks the haft of his paddle against the side of the canoe, and a good test of whether the men are well together is afforded by the noise: it should be as sharp and well defined as the rattle of eight oars in the rowlocks, and a paddler who is very much out of time with the rest of the crew is greeted with yells of derision.

The time is set by the two bow paddlers (" Balambi "), usually picked men. In my big canoe one was nearly blind from smallpox ; he was a native of the Sesse Isles, as are all the best canoe men.

The steersman (" Omugoba ") also is one of the best paddlers, and in a high beam wind has all his work cut out to prevent the canoe from falling off her course, as I have often experienced ! For any slight correction he uses a peculiar stroke ; putting the paddle into the water as far away from the canoe as he can reach, with powerful jerking movements, all his body and arms rigid, he pulls the paddle through the water towards him with a succession of rapid strokes. In a very heavy wind and sea, however, with a large canoe, this may not be sufficient, and the steersman then has to make a rudder of his paddle by using the projecting end of the thwart (" Empumi ") as a fulcrum, whereby great leverage can be obtained. The bowmen also help to pull the canoe's head round into the proper course by putting the paddle well away from the canoe and making the stroke towards the canoe, on whichever side it is necessary.

On March 1, 1913, I started off on a " joy ride " to see Nkosi, the southernmost isle of all the Sesse group, which I had long wanted to see. The party consisted of twelve paddlers, three boys and myself, with food for four days and camp equipment in one canoe. At 7·30 we got away, on a glorious, calm, sunny morning, in good spirits at the prospect of a change after over a year spent in the same camp on Bugalla. As we passed the north-east cape of Bugalla there was a fine Situtunga buck on the crest of the hill, but I could not see its horns, which the men said were of a good size. We went southwards down the channel between Bugalla and Bunyama, and it was so calm that one saw well the lung fish that came

PITCHING CAMP ON THE ISTHMUS OF KIRUGU ISLE.

THE WESTERN POINT OF KIRUGU ISLE AND THE ISTHMUS CONNECTING IT WITH THE CENTRAL RIDGE.

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up to the surface for a breath of air. They put their mouths right out of water for a second or two, and then turn on one side and go down with a peculiar roll, nearly always flourishing one of the filamentous pectoral fins out of the water.

Bunyama sends out a long point of rushes towards Bugalla, so that the channel is very constricted, and the scenery extremely beautiful. Bugalla here rises steeply from the water, the slopes being forest clad, as is the coast of Bunyama. Having passed this point we saw Fumve in front of us, appearing as a steep grassy hill rising rather abruptly about 350 feet, with forest at its base. We went straight south between Bubembe and the prominent south-east peninsula of Bugalla, and then between Fumve and the little islet of Banda, off the bay on its west coast. Here the scenery was lovely ; the densely forested shore of Fumve was reflected in the blue glassy water of the bay, and Banda was like an enormous rockery.

At 1 p.m. I thought a halt for lunch was indicated, as we had been going for five and a half hours, so we landed on the south end of Fumve and spent about an hour there.

We then made straight for the northern end of Kirugu islet, which we reached after another two hours paddling. There was a lovely place for camping : a sandy isthmus well sheltered by trees under which the men could sleep, and providing an excellent place for the tent. This narrow neck joined on to the main part of the island a little plateau with cliff-like sides. The main part of the island is a long narrow ridge of grass, falling steeply to the water by cliffs or precipitous slopes, clothed by dense bushes and trees wherever they could cling : the island rises 180 feet above the water.

Our choice of the sandy isthmus for camping was much resented by some hippos, who evidently had their resting places there, and grunted and snorted impatiently in the water, whither they had been forced to retire on our arrival. Eggshells of crocodiles were scattered about over the sand, so that it was also a favourite resort, or at any rate a resting place, of these reptiles, but none were seen, which was fortunate, as a bathe in the clear water was found most refreshing in the evening. The little sandy neck was so narrow that one could choose calm or rough water to bathe in, according to the time of day. In the early morning the usual northerly land breeze blew, and the water on the south side of the neck was absolutely calm, to be ruffled during the heat of the day by the southerly wind.

Next day I was awakened at 4 a.m. by the sound of waves breaking on the south side of the beach, the sign of a distant storm, which reached us about seven: the usual burst of thunder and heavy rain. At about nine the sky began to clear, and eventually the day became brilliant, but with such a steady strong wind that it was impossible to go anywhere in the canoe. I spent the morning taking photographs, and getting a view of the spacious distances from the top of the ridge of the island. The views were superb; it was wonderful to look south and see nothing but bluest water with white capped waves, and to think that there were ten score miles of it between oneself and the mainland.

In the near distance lay Nkosi, the southernmost of all the isles of Sesse, and to the east the long high ridges of Kuye and Buguye, with some smaller isles to the immediate west and north-west.

In the evening the strength of the wind abated a little and the white caps were no longer seen, so that I was able to struggle down the more sheltered west side of the isle and see the waves breaking on the point, although the wind was still sufficiently strong to make it very hard work for both paddlers and myself steering. The sky at sunset was full of wind and promise of rain to come,

ON KIRUGU ISLE.

ON KIRUGU ISLE.

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all the islands to the north being seen to stand out very sharply and clearly, and there being a thick smoky haze to south and west.

Next day at sunrise huge masses of black thunder cloud were seen over Bugalla, which evidently was getting a heavy storm : our camp got a sharp squall at seven o'clock, which nearly blew the tent away and split to ribbons the outer fly.

For a few minutes the rain fell in sheets, but soon passed, and by 8·30 a breeze cleared it up. The sun came out, and the day eventually turned out gloriously, with sufficient wind and waves to make the lake interesting. We had a stiff fight southwards against the breeze, and stopped for a brief rest among the pretty grottoes on the rocky fern clad islet Lukiusa, eventually reaching Nkosi at 10·30.

We first coasted along the south-east side, fully exposed to the breakers coming up from the open lake, so could not approach the shore very closely, especially as it was very rocky, and no risk could be run of staving in the canoe. Nkosi is a little over a mile long and a few hundred yards broad ; it is low, flat and bush covered, but the trees do not grow high, presumably owing to exposure to the constant winds from the lake. We rounded a tail of rocks at the south end, and got under the lea of the island into sheltered water, almost at once finding a most picturesque little grassy dell, with the lush green grass close cropped as if by rabbits. This was the work of Situtunga antelopes, of which one was soon seen quietly grazing. Their presence on this small, very isolated and exposed island is of considerable interest ; it is so covered with thick bush that open spaces are few and small, and they can only traverse the bush by definite paths. Since there can be no check on their increase save the amount of food available, disease and the physiological effects of in-breeding, the number on the island must long ago have reached its maximum, and the pressure is presumably relieved by migration of the animals from Nkosi by swimming across to Buguye and Kirugu Islands, and then by secondary dispersion to the large islands further north.[1]

It is an interesting problem how far this antelope can swim—for from the little islet Lukiusa, which could be used as a stepping-stone, it is at least two miles to the nearest neighbour, and open rough water has to be crossed.

Even more interesting is the possible presence on Nkosi of a species of *Cercopithecus* monkey; for as we gently drifted before the wind up the west side of the isle the voice of a monkey was heard among the trees. I much regret that I did not see the animal, for it is of course possible that the noise may have been made by a parrot, since I have certainly heard one imitate a monkey on Kisigalla Isle.

The return journey from Nkosi to camp was easy, for wind and sea followed and helped us along, and I got back at 4·15 after a most interesting day.

Next morning it was calm and clouded, and we broke camp and got away at 6·45, having an uneventful run as far as Fumve, taking a course this time along the east coast, which is very picturesque.

The whole side of the island forms a sort of huge amphitheatre backed by wooded slopes, and in the centre of the foreground rises extremely steeply from the water a flat topped, grassy hill, almost as high as the rest of the island, about three hundred feet, making one think of a great altar in the centre of the amphitheatre. As we passed Fumve a thunderstorm came up behind us from the south-east, and I had to alter course, for it had been my intention to return along the east side of Bubembe,

[1] Major R. Meinertzhagen, F.Z.S., who visited Nkosi in one of the lake steamers during the war, estimated that there must be two hundred Situtunga on the island, and that they were sufficiently different from the Bugalla forms to be called a sub-species. (See Chapter VII.)

OUTH END OF NKOSE ISLE.
Grass cropped by Situtunga.

CANOE SEEN "BOWS ON," KIRUGU ISLE.

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pass between it and Bugaba, and then to the east of Bunyama. The rough weather, however, now made it impossible to pass along the exposed sides of the islands, and we had to turn westwards and run between Bwiggi and the north end of Fumve.

As it was, we had quite sufficient wind and waves to make steering the canoe very hard work, for the wind coming from behind and on the side blew the canoe's head round, and it required continual effort to keep her more or less before the wind.

However, when we had passed through the narrow channel between Bunyama and Bugalla we got into sheltered water and were able to land on Bunyama for a rest and lunch, mid-day.

The storm soon passed, and the rest of the day was bright and sunny, and we eventually got home again at 2 p.m., where I found that only $\frac{1}{10}$ inch rain had fallen, showing that the storm was very local.

We had made the return journey in very good time, having travelled about forty miles between 6·45 and 2, with half an hour's rest.

CHAPTER VI

A TOUR OF INVESTIGATION AMONG THE NORTHERN ISLANDS

THE tour now to be described was made with Fiske at the commencement of 1914, its object being a comparative investigation of the chain of islands lying parallel to the north coast of the lake, so far as could be done from Entebbe as a source of food supply.

Besides our two selves and our four servants there were thirty-nine canoe men, nine fly boys, and a minor chief to act as headman, with his attendant. All these, with belongings, were stowed away in two large canoes and a small one holding five or six men only, which we subsequently found very useful. We left Entebbe at 9·15 p.m. on January 12th, having chosen the night time because of the high wind during the day, which would have made heavy work of paddling with well-laden canoes. It was a beautifully calm moonlight night, and we reached BULAGO at 2·15 a.m., and pitched camp there, as it was to be our base for some days. This is an interesting island of curious shape, having a long forest clad peninsula jutting out from the north-east corner, and a large bay on the north shore, along which is a belt of forest. The east coast is almost bare of trees or bushes, the west has a fringe of bush, and the south point ends in a sand-spit, much to the liking of crocodiles. Open grass land forms the centre of the island, and rather on the western side two rounded hills rise a couple of hundred feet.

BULAGO ISLE, NORTH BAY AND FORESTED NORTH POINT.
Damba Isle on horizon.

THE OPEN GRASS LAND INTERIOR OF BULAGO, WITH FOREST BELT ALONG SHORE OF NORTH BAY, AND ONE OF THE GRASSY HILLS.

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We saw a good deal of Bulago, and studied it thoroughly, but found nothing very characteristic in its fauna or flora. A notable tree was one called by the natives "Musali," whose fruits were like loquats: I had seen small specimens of this on Bugalla, but here they were good-sized trees.

A colony of the fossorial wasp *Bembex* was noted on crocodile point, where the sand was eminently suitable for their burrows.

We had decided to take careful note of the butterflies to be found on the several islands, as some sort of index to the general suitability of an island for insect life.

On this first visit fifty-two species were noted, and on the return journey in March twenty-two more were added to the list. It was on Bulago that I first met with the Acraeine species *Planema aganice* and *Pl. alcinöe,* neither of which occurred on Bugalla or Damba, though Damba's immediate neighbour Kome was subsequently found to have these interesting butterflies.

On January 14th we visited the islet of Kizima. This is only about 300 yards in diameter, and rises out of the water as a rocky, flat topped, grass clad eminence, with shrubs and small trees along the steep coast line, and one little bay with sandy beach on the west. A tangle of "Oluzibaziba" bushes sheltered a hippo; a large and a small crocodile and two large monitor lizards (*Varanus*, called "Enswa-swa" by the natives) were seen; the basking places of the latter on the rocks were very numerous.

Among the branches of a bush I found a small elapine snake, light grey with dark brown blotches, which had very obviously dined both wisely and well! Rodents, about the size of a water vole, were abundant on this isle; their runs were very noticeable, and also the debris of grass stems left where they had been feeding. Kizima was therefore alluded to as a "rat island"; several others will be described later.

The little hill of Kizima seems to act as a chimney directing a continual current of air upwards, for whenever it was visited there were always numbers of kites soaring round and round in narrow circles just over the island. Around it are fragments of rocks that have broken away and now form resting places for many cormorants and darters; snow-white egrets with black bills and legs, Egyptian geese, and a giant heron were also there, with a sacred ibis, not to be seen on every island.

Flycatchers were seen, and swallows were fairly plentiful.

Butterflies were few (see p. 125): *Glossina* was represented by an average catch per fly boy of 2·9 per hour (both sexes). No termite hills were seen; indeed, termites seemed altogether absent.

The Island of Tavu was first visited on January 13th. It is about a mile in greatest diameter, being low and flat and covered thickly with vegetation. The northern two-thirds are marshy, and only ambatch grows there, with a dense fringe of rushes; the southern end is very sandy and covered with cane, "E'tungulu," and bushes, with rushes growing in the shallow water. On the west coast is a large raised beach of sand, which was found to provide admirable breeding places for *Glossina*. The rest of the island has forest growth, and was at one time cultivated. Tavu proved to be a favourite haunt of crocodiles, of which nine were seen; some on a rock on the east coast, others in the shallow water off the sandy south point, on which they lay their eggs. No "Enswa-swa" were seen, and subsequent visits always showed them to be scarce.

Of snakes, the beautiful horned puff adder (*Bitis nasicornis*) was seen, and a large black elapine was rather common.

Birds abounded; giant herons, and herons of other species, glossy ibis, the open-billed stork, egrets and a stone curlew were seen, while cormorants and darters were numerous in the ambatch trees, on which they nest.

In the thick jungle, where we very easily lost our sense of direction, the abundance of insect life was shown by bee-eaters, flycatchers, coucals and other insectivorous birds.

Butterflies were numerous (see table, p. 125), and forest species such as *Planema macarista*, two species of *Charaxes*, and a large *Euralia* were noted. Three species of *Tabanidae* were noted on the shore, possibly the low lying and marshy ground is suitable for the larvae ; a common *Tabanus* (*T. variatus*), a *Haematopota* and *Chrysops brucei* were the species seen, the latter quite plentiful, and one was seen in the grip of a predaceous Asilid fly. Termites abounded, and the *Dorylus* ant was seen, while Culicine mosquitoes bit unpleasantly in the jungle.

Large *Achatina* snails were plentiful.

Glossina was very abundant, the island furnishing ideal conditions of food, shelter and breeding grounds. The average catch per boy hour was 39·2.

On January 17th I visited the sand bank south of Tavu, named Resuvu. Its north half is submerged at all times, and there is a dense growth of ambatch on which cormorants and darters nest. The south half, at this time, was above water, and measured about 50 by 20 yards, but is probably almost entirely submerged when the lake level is high. Notwithstanding, I found larvae of a very common Noctuid moth ; in the sand a small black ant was found, and I saw a nest of the *Belonogaster* wasp, which feeds its larvae on caterpillars.

On January 24th we moved camp to Nsadzi Island, pausing on the way to examine Kimmi, which we found extremely interesting, since, though quite small and flat, it contains portions of almost every kind of condition met with on the lake shore. We landed first on the south-west side, whose eastern tip is formed of sand left by the receding lake at the foot of a low cliff in which are caves, full of bats. Further westwards the shore is low, of flat rocks, with many holes kept full of water by waves; at a higher level is a sand beach now grown over by cane and bushes, and used as a nesting ground by crocodiles. The north-west shore is flat and marshy, with a thick fringe of rushes and bushes of "E'tungulu" and ambatch; the north-east part of the island is forested, but near the water is a large patch of open grass land, with very sandy soil, in which "Enswa-swa" burrow and lay their eggs. The south-east shore is marshy, with lush grass much frequented by hippos; this type of shore was dubbed "Hippo Grazing Ground."

The vegetation of Kimmi seemed to me much more varied than on Tavu, which is about the same size. A *Chrysophyllum* tree (*Sapotaceae*), known to the Basesse as "Omugalati," which was not seen on either Bulago or Tavu, an anonaceous shrub scarce on the other two isles but abundant here, and a shrub with clusters of fragrant white flowers, which I had not seen before, were noted. Butterflies were fairly abundant, a forest *Papilio*, with several forest *Planema*, were noted; the numbers counted will be found in the table (p. 125).

The most striking feature of Kimmi was the voracity of *Glossina*, which came off in a swarm to the canoe before we had touched land, and bit ferociously. It was found that more than half the number caught were females, which is quite exceptional; the significance of this has been discussed in the chapter on *Glossina*. We comforted ourselves with the recollection that former experiments had never shown the flies from Kimmi to be infective, and put up with the inconvenience as best we could. The average catch per boy-hour for this island reached the high figure of 60·9: on one day alone it was 81!

The hunger of the fly tallied with the fact that we found

LARGE FIG TREE ("OMUKOKO") ON SPONGY RED ROCK, NORTH-EAST CORNER OF NGAMBA ISLE.
A stone curlew on the right.

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no crocodiles or "Enswa-swa," the favourite source of food; although hippos are fond of the island I do not consider them of much importance as food for the fly, which has therefore to depend for food, on Kimmi, mainly on birds which frequent the shore.

On January 30th we visited NGAMBA, which lies between Kome and Nsadzi. This island, like Tavu, is covered with forest growth, but is more rocky and rises higher; it is roughly square, and of about the same size as Kimmi. The forest everywhere comes close to the water's edge save on the east side, where part of the shore is marshy, and at the rocky north-east point. The shore, on the whole, is either rocky or pebbly, and only at the north-west corner is there a raised beach of sand. Along the south coast the rock is grey, but at the north-east point is of the more common spongy red brown formation.

As usual we first circumnavigated the isle, and counted six crocodiles and three "Enswa-swa;" two others were also seen, and bushes of "Oluzibaziba" bore evidence that Situtunga antelope had been browsing on them: probably these had swum across from Kome, where they live, for none were seen on Ngamba. The forest trees were noted to be varied; one very fine fig tree with huge leaves, also occurring on Kimmi, was conspicuous here: the natives called it "Omululu." Another noticeable tree had sprays of greenish flowers like those of Portuguese laurel: the natives called it "Omuziru"; and another, with large white flowers, was called "Omukoba."

Here and there were beds of a magnificent herb which I took to be at least allied to *Salvia*, with spikes of large blue flowers, growing up to a height of four or five feet. This was subsequently often found growing in pebbly places near the water, and was quite a feature of some islands. Of birds, a sacred ibis and giant heron were noted, but no other notes were made. There were some features of interest in the insect fauna: a *D. chrysippus* was seen crossing the channel between Ngamba and Nsadzi, and nests of the interesting ant *Œcophylla smaragdina*, and the fierce little black ant called by the natives "Obusaji-saji," were found on leaves of trees; they are not by any means universally distributed among the islands.

The tubular cases of larvae of some species of Psychid moth were seen on the tree trunks in great numbers, and afforded the first example of the fact that a small circumscribed area may support only a few species, but that some of these may flourish much more abundantly than in larger areas where they are exposed to greater competition. During the course of this tour many other examples were noted, and will be mentioned as instances of "insularity" in the fauna or flora.

Glossina was scarce on Ngamba, the average catch being 9·9 per boy-hour. We remained at NSADZI camp until February 5th, but spent only a little time over the island itself, since it was too big to be thoroughly investigated on a short visit. It is about three miles long, but very narrow: four-fifths consist of a steep grassy ridge almost bare of trees but with innumerable termite hills, closer together than I ever saw anywhere else. At the centre of the south side of the island cliffs descend steeply to a sandy bay, with a strip of forest at the foot of the cliffs. There is another patch of forest on the north side, but elsewhere the shore has only a very narrow fringe of bush. The eastern fifth of the island is low and flat, and sharply marked off by the escarpment of the end of the main ridge; it is covered with forest, full of birds. On Nsadzi we found most interesting evidence of insularity. The grass on the uplands had been burnt off by Fiske on a previous visit some weeks before, and the new green blades were growing up among the burnt black stems of the tussocks. Over an area of a great many square yards

NSADZI ISLE.

The south beach of dazzling white sand. The line of débris marks the high level of the lake in 1917.

To face p. 100.

every blade had been eaten by caterpillars of a Noctuid moth,[1] whose green and black colours harmonized absolutely with those of the grass. These caterpillars were hurrying about in all directions looking for more food, and numbers of a brown "Ichneumon" were seen depositing eggs in them. While piercing the larva with its ovipositor the ichneumon grasped it firmly in its mandibles, a habit which is shared by the stinging fossors, who have adopted a somewhat more advanced kind of parasitism.

On Nsadzi were found, firstly by Fiske, the footprints of a large Situtunga buck; the importance of this has been alluded to in the chapter on *Glossina.*

We moved from Nsadzi on February 5th to a new base on the east end of Kome, whence we intended to examine the small islands of that neighbourhood.

It was a most lovely voyage on a calm and clear day, with much cloud of varied type and deep purple shadows. We left Nsadzi at 7 a.m., and travelled past the tips of the several peninsulae jutting out from the north shore of Kome, and then down the beautiful channel between Damba and Kome, where blue, pink and white water lilies were in full flower. A small cloud funnel was seen, giving warning of a short storm which came from the east at about 4 p.m., and burst on us while we were on Sanga Islet, but only lasted for half an hour. I was much interested in this, because while I had been encamped on Damba in 1911, only a few miles from Sanga, which could be plainly seen (see map), I had never had an afternoon storm there, but had noticed that the end of Kome often caught rain which missed my camp.

Sanga Islet was examined this day, and was found to be amazingly interesting. It only measures about 100 by 50 yards, is very rocky and well covered with forest, and shows abundant evidence of insularity.

[1] *Laphygma frugiperda* (*Xenobianae*).

The shore is composed of broken rocks, and the forest comes to the water, but there is very little undergrowth of bushes, so that we were able to walk about freely.

Glossina was absent : the other arthropod life was of great interest. The first thing noticed was the abundance of very large, long-legged black and yellow spiders (*Nephila*), which spin webs several feet in diameter. These great webs formed sheets, often in planes one behind another when the branches offered suitable support, so closely placed that the spiders on the central sheets could hardly get any insects on their webs, and looked starved. Sanga, therefore, was known as a "spider island," and others will be described later. The next feature noted was the unusual abundance of predaceous *Mantidae*, and this was associated with absence of insectivorous birds ; a very interesting example of the "balance of nature."

At the time of this visit, and we remained on the island several hours searching it thoroughly, I neither saw nor heard a single flycatcher, bee-eater, coucal, or any of the common small warblers ; parrots and weavers were the only birds noted in the forest. At a second visit, however, one "Kunguvu" flycatcher was noted, and the call of a common cuckoo was heard. Perhaps correlated with this absence of insectivorous birds was the fact, which Fiske and I noted independently, that the butterflies, especially the mimetic *Euralia* and *Aterica galene* which I have always found very difficult to catch on account of their shyness, were here much less shy and easier to catch. Fiske thought that it was on account of the multitude of spiders' webs, which had resulted in the butterflies flying more slowly and cautiously to avoid them ; but I noticed that when on the ground the mimics were more easily approached than is usually the case.

The numbers of butterflies found on Sanga are given in the table (p. 125) ; the most noteworthy feature was unusual abundance of the large Hesperid *Rhopalocampta chalybe,* whose peacock green and blue wings flashed in the sun as these beautiful butterflies darted about in the sunlight in typical " skipper " fashion. Acraeines were represented by two species among the tree tops out of reach, and one specimen of *A. egina* ; *Amauris niavius* was the only Danaine seen ; of Nymphalines, *Euralia dubia, E. dinarcha,* and a forest *Charaxes* were noted ; while the large and beautiful iridescent *Salamis,* its pale green wings suffused with a pink mother of pearl lustre, was very plentiful. Lastly, the caterpillars of an aposematic moth, *Aletis erici* (see description, p. 214), were very abundant on Sanga, which interested me more than any other island, because it was the first visited of those on which the great spiders were so abundant, and showed so many other examples of insularity.

On February 11th we visited the little isle KISIGALLA, lying close to Sanga, and, like it, rocky and covered with trees, but with one piece of sandy shore. It is about fifty yards in diameter, and, though so close to Sanga, differs from it in many respects. It was characterized by almost entire absence of the *Nephila* spiders so abundant on Sanga ; by abundance of a large black Scoliid, of cocoons of the gregarious caterpillars of Lasiocampid and Eupterotid moths, and also of a very large fawn coloured slug.

Birds were not so scarce as on the spider-haunted Sanga ; the " Kunguvu " flycatcher, sunbirds, weavers, pigeons, and the beautiful blue and crimson plaintain-eater were all noted.

Butterflies were quite plentiful, the most interesting being the large mimetic Lycaenid *Mimacraea poultoni,* and the Nymphaline mimics *Pseudacraea eurytus* forms *hobleyi* and *tirikensis.* A very fine Satyrine that was new to me escaped capture. *Glossina* was scarce, the catch per boy-hour reaching only the average of 2·3.

The islet LULA, close to Kisigalla, was visited on the same day, and was found to differ considerably from its neighbour. It consists of a small rocky ridge covered by bushes and not by large trees, and is much frequented by crocodiles, whose basking places are numerous. Of birds, a black and white flycatcher, not met with on any other of the five islets off the east end of Kome, was noted to be relatively plentiful. Neither the spiders of Sanga nor the slugs of Kisigalla were found on Lula. Butterflies were interesting (see p. 125); Acraeines were more numerous than any other group, forming seven-fifteenths of the total number of species found; *A. pentapolis* was noteworthy, as it is not found on every isle. The Nymphalines were rather surprising: a huge *Euralia*, looking very out of place among bushes on a tiny islet, *Pseudacraea eurytus* form *obscura*, *Ps. lucretia* and *Salamis* made up the total. The only Lycaenid found was a brown, black spotted *Pentila*, whose Acraeine appearance fitted in well with the prevailing group of the island.

Colonies of Eupterotid larvae were seen on Lula as on Kisigalla.

The average catch of *Glossina* was 9·1 per boy per hour.

On February 6th we worked DWANGA MKURU, the largest of three closely associated islands lying off the eastern point of Kome. This is about three miles long, and very narrow; generally speaking, its features are of the type associated with a clear, rocky shore.

The centre is a grass topped ridge sloping steeply on the east down to the rocky or pebbly shore, where at one point a dyke of red, spongy volcanic rock, stuffed with fragments of grey rock as a pudding is stuffed with plums, runs out across the pebbly beach. On the west side is a bold cliff, at the sheltered foot of which is a strip of thick fertile forest, with some huge "Omuvule" (African teak) trees, and an overgrown banana plantation. All along the shore on the east are thick beds of fern and *Salvia*, backed by thin and poor looking forest trees, swept by the prevailing south-east winds. Many of them were covered with spiders' webs, for this island is markedly a "spider island"; as on Sanga, this is correlated with great scarcity of insectivorous birds and abundance of *Mantidae*.

Butterflies were extremely abundant: the beautiful green, pinkly iridescent *Salamis* was more numerous than at any other locality visited, four might be seen at once. Of Acraeines, *Planema poggei* was of interest, and other Nymphalines besides *Salamis* were *Euralia dubia* and *Pseudacraea lucretia*, which latter Fiske, until it had been caught, thought must be a *Neptis* from its flight. I had often noticed that its flight was much more like that of a *Neptis* than the Danaine (*Amauris*), which it somewhat resembles in pattern.

Glossina was completely absent from Dwanga Mkuru.

Dwanga Mto, lying alongside the last named, was visited on February 9th. It is more or less covered by jungle, but there are some open patches, and it does not rise so high as its larger neighbour. The shores are mostly of pebble or rock, with much fern and *Salvia*, and the usual common bushes.

A species of bush was seen by the water which had not been met with before; it had very large heart shaped leaves and spikes of inconspicuous flowers: the natives called it "Omukwakula." Other features of the flora were a single specimen of the large "Ekibo" palm and a small patch of elephant grass ("Ekisagazi"), which is very unusual on the small islands.

Birds were not so noticeably scarce as on Dwanga Mkuru, for sunbirds and bulbuls were plentiful and the "Kunguvu" flycatcher was there.

Being markedly a "spider island," Dwanga Mto had abundant *Mantidae*; the large grasshopper called "E'jansi" by the natives was much more plentiful than on other islands hitherto visited.

Regarding butterflies, the most noteworthy feature was the abundance of the large Hesperid *Rhopalocampta forestan*, hitherto not encountered on the small islands; its near ally, the beautiful *Rh. chalybe* of Sanga Isle, was not seen here. The single Papilionine (see table, p. 125) was *P. leonidas*, whose Danaine model *Melinda petiverana* was also seen. Acraeines were so extraordinarily scarce that I only caught one specimen, and only one other species was seen. Nymphalines included *Salamis*, which was very abundant, *Pseudacraea eurytus* forms *hobleyi* and *terra*, *Ps. lucretia*, *Euralia dubia*, two *Charaxes*, a *Neptis*, and *H. misippus* and *C. cardui*, neither of which occurred on other islets of this group.

A curious Lycaenid was found here, a large grey species with angulated wings.[1] A feature of the island fauna was the number of long narrow cases of the larvae of a Psychid moth, attached to tree trunks.

Glossina was almost absent; the nine fly boys could only catch four males and a female.

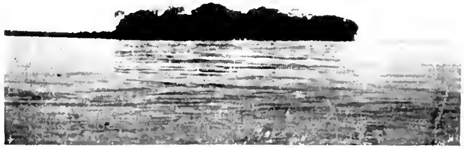
The third island of this group, DWASENDWE, was visited on February 10th.

It is covered everywhere with forest or overgrown plantations; almost everywhere the shores are rocky; on the north-east there is a dense bank of ferns. The main insular feature of Dwasendwe was the great abundance of the *Aletis* larva first met with on Sanga; these had defoliated the food plants over a large area.

Of butterflies, Acraeines were again very scarce, one *Planema* and one small *Acraea* only were seen; of *Hesperidae* the large *Gamia bucholzi*, with mottled underside, was noted: a Lycaenid was found which was never met with on any other island, and was apparently associated with the "Omukwakula" bushes on whose flowers it seemed

[1] *Aslauga purpurascens, Lipteninae.*

DWASENDWE FROM DWANGA MTO.



KISIGALLA ISLET.

SOUTH BEACH OF NSADZI ISLE.

SOUTH-WEST END OF WEMA ISLE.

To face p. 106.

to be ovipositing. Although this bush was abundant on the neighbouring island, Dwanga Mto, this Lycaenid had not been seen there.[1] It is a large white species with fine hair-like wavy lines on the under surface. On this island was found in a spider's web a second specimen of the West African Lycaenid, first caught on Dwanga Mto. Dwasendwe was markedly a " spider island " ; and *Glossina* was absent.

On February 13th we moved camp to Kerenge Isle, one of a group lying further eastwards. Fiske and I started at 6·30 with four paddlers in the small canoe, as we intended to visit sundry islets *en route*, leaving the big canoes with kit and men to find their more laborious way in their own time.

At daybreak there were very threatening clouds, with thunder to the south-east, and it seemed as if we must get caught by a storm. The canoe men paddled furiously to get to our first islet, and the small canoe seemed to leap out of the water at every stroke, so that the unfortunate Fiske in the bows got very splashed, as there was some swell from the distant storm. After one and a half hours' paddling for the distance of six miles, we safely arrived at MAUNGWE, a rock spit only about 80 by 30 yards in size, thickly covered with ferns, herbs, low bushes and *Ipomaea* creepers with a few fig trees, on a fork of one of which was an enormous nest, possibly of a heron or a bird of prey. A very common weed, with dull mauve flowers (*Erlangea tomentosa*, called by the natives " Obutwatwa "), grew very tall and in dense masses which sheltered a small bird with the habits of a flycatcher, brown, with white throat and belly and brown chest, which was subsequently found on minute islets only, nearly always in masses of the " Obutwatwa." It had a very sweet voice, and its song resembled part of a nightingale's repertoire, so I dubbed it for reference

[1] *Spalgis pilos.*

sake "Nightingale flycatcher." Swallows and weavers feeding on the "Sami" gnats were also plentiful, and small lizards were seen.

No *Lepidoptera* were noted, although a *Belonogaster* wasp was seen, which is known to feed its grubs on caterpillars. Two species of carpenter bees which bore into wood, and small ants, were seen, but there were no *Glossina* on Maungwe.

By the time we had finished with this little island all threatenings of storm had passed off, and we went on happily to ENKUSA Islet, merely a reef of red spongy rock for the most part broken into pebbles, with a dense growth of ambatch bushes at one end, inhabited by weaver birds. There was a great growth of a large yellow vetch,[1] which seems to prefer pebble beaches in the vicinity of water. One small and feeble Lycaenid lived on this islet, keeping close to the ground.

From Enkusa we went to ZIRO, going round Isentwa and through a break in a reef which almost joins the two, into a very secluded bay dubbed by Fiske "the Pirates' Haven." Here we lunched, and afterwards went up on to the central grassy hill to get a broad idea of this island and its neighbours.

The general appearance of this group was not at first sight inviting, after the beautiful, forested and friendly islands of the Kome group. They have grassy hills, but much less true forest growth : the pyramidal grass clad peak of Kiuwa was very striking, apparently rising straight out of the water, treeless, as high as the highest point of any island of the neighbourhood.

We did no work on Ziro this day, but visited it subsequently. The only notable feature about its coast is a rocky headland at the south-east point, with caves of weird fashioning quite suited for pirates' lairs !

I noted that the flora of the isle in some respects rather

[1] *Crotalaria striata.*

differed from that of the group we had just examined, for several flowers were seen that had not been previously noted but which had been noted at Jinja, on the mainland, in 1910. Two instances of butterflies similarly occurred; and these facts suggested that these isles had not been connected with the former group, but only with that part of the coast immediately to the north of them, the others perhaps having derived their inhabitants from the mainland more to the west. (See map.)

As regards birds, several giant herons, a dappled grey heron which I had not seen before, and open-billed storks in great numbers were seen.

Flycatchers were seen and heard in fair number; Enswa-swa lizards seemed fairly numerous, for nine were noted.

Ziro is markedly a "spider island," but *Mantidae* were not noticeably abundant. Of butterflies, Acraeines were very abundant; *A. encedon* in several forms was noteworthy. A Lycaenid[1] was taken which I found at Jinja in 1910, but had not been met with on any of the islands: this is notable after what has been said about the flora.

Glossina was far from abundant, the average being 6·8 per boy-hour.

We remained in our camp on KERENGE from February 13th–20th, using it as a base from which to visit neighbouring isles. There was nothing very characteristic about it; it is flat and has a good deal of open grass land, and there are remains of former banana plantations, now full of the great spiders' webs to a disgusting degree: to get one's face and hat, or bare arms, covered with the sticky clinging web was extremely unpleasant. So strong is the silk that a sunbird was seen in a web, having become so entangled that it could not free itself; we managed to reach up to it with a long stick and set it free. The webs

[1] *Lachnocnema bibulus.*

were so close that the spiders on those between others were quite starved and their bodies very shrunken.

Mantidae were not noticeably conspicuous; the large "Amajansi" grasshoppers were, and the beautiful kingfishers which feed on them were also abundant. Acraeine butterflies were not so abundant as on Ziro, indeed here they were almost absent; *Lycaenidae* were relatively so abundant as to be the main feature of the butterfly fauna. Of *Hesperidae* the large *Gamia bucholzi* was noted, and Fiske found a shady bank where large numbers of a Hesperid new to me were to be seen;[1] it seemed to be associated with a plant, probably of the Arum family, which carpeted the ground here. *Glossina* only averaged 5·2 per boy-hour.

We visited Lukalu Isle on February 16th, and found it very interesting. About half a mile long, but narrower, its greater part is a grassy plateau rising slightly in the centre, with large beds of bracken on the slopes; at the east end are some high rocks with caves, and here are a few big trees. One of these was like the common tree[2] called "Ekirikiti" by the Baganda, but the spiky flowers instead of being scarlet were of a rosy pink tint which I had not seen before.

From the eastern end of the isle stretches along the south shore a narrow strip of dense bush; the north shore, however, is very different, there being a belt of thick cane growing on sand, on which were marks showing that crocodiles had lain there, and hippos had made tunnels through the cane thicket.

Five Enswa-swa were seen. The only birds that attracted attention were a coucal and a grey plaintain eater; the "Kunguvu" flycatcher was not seen. No *Nephila* spiders were seen; of butterflies *Lycaenidae* predominated; *Lachnocnema bibulus* was caught; *Acraea encedon* was in great variety; the only Nymphaline seen was *Precis*

[1] *Andronymus leander.* [2] *Erythrina tomentosa.*

clelia. *Glossina* averaged 10·6 per boy-hour. There is a small accessory islet to the east of Lukalu, separated from the main isle by about 50 yards of water ; it measures about 100 by 50 yards, and is composed of red rock broken up into pebbles on its surface. There was a variety of flowering plants and low bushes at one end, and many ambatch trees, among which a species of moor-hen was noted. Weaver birds, sunbirds and wagtails were plentiful.

The only butterflies noted on this accessory islet were the Lycaenid *T. telicanus*, which was evidently much attacked by wagtails, for a large proportion had a Λ-shaped piece taken symmetrically out of the two hind wings.

On February 16th we visited Isentwa Isle, which is roughly triangular, having sides about three hundred yards long.

It is composed almost entirely of grass land, with a narrow fringe of bush or cane at those parts of the coast where the rock is not too steep. Enswa-swa were noted abundantly, but no crocodiles were seen ; indeed, as a whole the islands of this group had very few crocodiles.

Big spiders were absent from Isentwa, and also *Glossina* ; butterflies were very few, the feature being abundance of the woolly-legged Lycaenid *Lachnocnema bibulus*, of which at least half a dozen individuals arose together from one plant as I passed. The only Nymphaline seen was *Precis archesia*.

Kiuwa Island was visited on February 19th, and proved to be remarkably interesting from the point of view of the bionomics of *Glossina*, which was found to the extent of 18·2 per boy-hour, and yet we could not make out where were the pupae which kept the numbers at this level.

Search as we would, no more than an average of 3·3 pupae could be found per boy-hour, in spite of rewards offered.

As has been said, the island consists mainly of a steeply rising grass-clad conical hill, a little over a mile long and half as broad; its north-east end slopes less steeply, and here is evidence of former banana cultivation, the shambas now overgrown with bush and creepers; some of the rose flowered "Ekirikiti" trees first noted on Lukalu were seen. There were also thick bushes of the usual kinds, and beds of the *Salvia*-like plant. Along the south-east shore are bold cliffs, at the foot of which are two little bays with beaches of pebble; the south-west shore is formed of unbroken rocky strata rising steeply from deep water; the west shore slopes less steeply and is fringed by bushes, so that, on the whole, the island seems unfavourable for *Glossina*, which yet was numerous. Three crocodiles and one Enswa-swa were seen, but no traces of hippo. Fruit eating bats were abundant, and small rodents were very numerous in the tussocky grass, so that Kiuwa was called a "rat island."

In the old banana plantations sunbirds and weavers were very plentiful; flycatchers were scarce, and none of the black and white species were seen. A thrush was heard singing, which, though plentiful at Entebbe on the mainland, I had never heard before on an island.

Only one single specimen of *Nephila* spider was seen; no termite hills were seen anywhere on the island.[1]

The butterflies of Kiuwa were rather interesting (see table, p. 125); three species of small brown *Acraea* were extremely abundant, but *encedon* was not seen. Nymphalines were very scarce; a Pierine scarcely ever met with on the islands was quite abundant on the beaches on the south-east shore; two Lycaenids not common everywhere were noted as abundant; *Hesperidae* were very scarce in individuals, and only four species were seen.

On February 20th we moved camp from Kerenge to the

[1] Cp. Kizima, also a "rat island."

south side of Wema Isle, visiting Kibibi *en route*, and also the Islet of ZIGUNGA.

This consists of two small islets joined by an isthmus, so that the south-west coast forms a bay : it is composed of red rock, covered with grass and rising steeply ; there are a few fig trees.

A feature of the island was a plant with thick, sword shaped leaves, from which the natives obtain fibre. One crocodile and two Enswa-swa were seen.

Swallows, weavers and sunbirds were quite common, and it was interesting to find again the "Nightingale flycatcher" frequenting thick clumps of the plant *Erlangea* ("Obutwatwa") as it did on Maungwe Isle. No *Nephila* were found, nor were *Glossina* seen ; a single *Acraea* and a long-tailed Lycaenid, abundant on Kiuwa, were the only butterflies noted.

After visiting Zigunga we went on to WEMA, a large island on whose south shore our new camp was pitched, and used it as a base until March 2nd. It was much too big to be thoroughly examined in the time at our disposal, so we confined ourselves to the south shore.

The views of Wema itself obtained from the summit of the hill behind the camp were quite the most beautiful of any I have seen on an island.

There are four hills on the island, of which the one above alluded to, at the south-west corner, is grassy and flat topped ; another, at the north-west corner, is flat, with a patch of forest running nearly to the top ; on the connecting ridge between these two is more forest, which also runs up the third hill, the central one of the isle, grass clad on top. The fourth hill at the north-east corner has a grassy base and a cap of forest on top. The south-east coast of the island has a fine fly beach with forest at the back, and the eastern point shows a red cliff visible from the camp. From the top of the hill behind the camp a lovely panoramic view was seen on the first

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evening; looking eastwards across Yempata and Bus'ri one saw distant Buvuma, lying in the mouth of the gulf which gradually narrows down to the origin of the Nile at Jinja (see map); to the west, Damba lay long and low on the horizon, flooded with golden light from a lovely sunset.

The part of Wema that was investigated proved most interesting; *Glossina* was extremely abundant, averaging 55 per boy-hour, and at one spot the catch averaged 101·5 per boy-hour; one boy caught 78 in half an hour!

Monkeys were seen for the first time since we left Kome, and I was struck by the abundance of a black and white crow which flew about in flocks like rooks. Wema proved to be very markedly a "spider island," and as regards butterflies it was richer than any of the other islands investigated; I think that it has probably as many species as the much larger Damba or Bugalla, and several Nymphalines were seen there which had not been met with on the larger isles.

Of *Papilioninae*, *P. dardanus* and *P. ugandae*, with several other forest species, were noted; also, *P. leonidas* and *P. policenes* were very common. Of *Pierinae*, several species of *Terias* and one *Teracola* were noted. The following species of Nymphalines were especially noted: *Pseudacraea boisduvalli*, *lucretia*, and *eurytus* forms *hobleyi* and *tirikensis*, six species of *Neptis*, together with *Neptidopsis*, nine of *Charaxes*; *Salamis* was fairly abundant, while no *Euralia* was seen. Danaines were poorly represented by a few *D. chrysippus*, *Amauris echeria*, *A. niavius* and *A. psyttalea*. Only a few specimens of each were seen. Acraeines were surprisingly scarce; very few individuals, belonging to nine species, were found; noteworthy were *Planema alcinoe*, *macarista* and *poggei*. The *Hesperidae* included the peacock blue *Rhopalocampta chalybe*; among the *Lycaenidae* was an extremely beautiful large blue species, with long tails of snowy white hue (*Zeltus antifaunus*).

Perhaps the most interesting butterfly of the islands was a *Libythea* caught by Fiske; no species of this family had been met with previously on any isle. A total of 124 species was found on this brief visit to Wema, and probably half as many again would be added by further investigation (see p. 125).

On February 21st we visited two of the small islets lying east of Wema, going first to Marida, which consists of two flat, grassy portions connected by an isthmus along which is a pebbly beach. There is no forest growth, but low bushes and fig trees form a fringe along parts of the shore. A coniferous tree, *Podocarpus*, called by the Basesse "Omusĕnĕne," was here noted for the first time. A crocodile was seen, and a nest of eggs found, and two Enswa-swa were found on the island.

The only point noticed about bird life was that bee-eaters were there in some number, and they do not frequent every island; sunbirds also were quite common on the isthmus, and the "Kunguvu" flycatcher was seen.

Marida is very decidedly a "spider island"; *Glossina* was represented by an average catch of 4·6 per boy-hour. Of butterflies, it was remarkable that no Acraeines were seen, and while individuals of other species were scarce, a fair number of species was seen (see p. 125).

The feature of Marida was the abundance of a slug, broadly resembling the English *L. agrestis*, but with a little fleshy spike on the end of the body reminding one of the caudal horn of a Sphingid larva; this species had not been met with before.

From Marida we went on to Wavuziwa, a rocky islet with very little shade except from fig trees; ferns were abundant. One crocodile and one Enswa-swa were seen; of birds, weavers and sunbirds were plentiful, also the "Nightingale flycatcher," and one coucal was seen.

Glossina was very scarce, for all the fly boys together in an hour only caught seven; *Nephila* was not seen at all; of butterflies, *Acraea zetes*, of rather Eastern type, was notable, and no Nymphalines were seen. Insular features of Wavuziwa were two; a Lymantrid caterpillar new to me[1] was found in abundance feeding on the "Anyamberege" plant, on which plant I had never previously found any caterpillar, and fluffy white masses of some species of *Coccidae*, which thickly infested bushes and undergrowth.

On February 26th, SEGE was visited; a not very interesting island of the same size as the last named, rocky, covered with grass and without any beach. Rather conspicuous on this islet was the fibrous leaved plant found previously on Zigunga, and an aloe whose spikes of scarlet blooms arose from rosettes of fleshy, thorny edged leaves.

Two Enswa-swa were found on the island; one, the biggest I ever saw, was much less timorous than usual, and did not retreat into the water until I approached within a few yards of it, after which it remained close at hand with its head above water.

Of bird life the only notable feature was the "Nightingale flycatcher"; *Nephila* was absent, *Glossina* very scarce, for the nine boys in an hour only caught twenty-seven, all males; of butterflies, ten species were noted.

WAITWE was visited on the 26th; it has a central grass hill rising above the level of any of the neighbours, and sloping precipitously to the water on the west side. It is partly clothed with bracken, and the shores everywhere are steep and rocky; there is a fair variety of trees and, in contrast with Sege, abundance of ferns. Waitwe, like Kiuwa, is pre-eminently a "rat island," the tussocky grass being penetrated in all directions by their runs. Perhaps on account of this a small python was found on the island, in a cave.

Three Enswa-swa were seen; of birds, the "Kunguvu"

[1] *Eucoma atricosta.*

flycatcher was present, and the familiar notes of a common bulbul made one realize that it had not been found on every island. *Nephila* was absent ; ten species of butterflies were noted ; *Glossina* very scarce, for the nine boys only caught six in half an hour.

On February 24th we visited Yempata Isle, going first to a minute accessory islet lying off its southern end. This was noteworthy by the scarcity of the " Oluzibaziba " bush ; there were some fig trees and, on the eastern side, " Ekinsambwe " bushes. No ferns were noted, but *Ipomaea* was abundant, and the whole centre of the islet was covered with masses of a thick leaved aromatic, labiate herb with spikes of purple flowers, and the mauve flowered " Obutwatwa " (*Erlangea tomentosa*), in which, as on other small islets, the sweet song of the " Nightingale flycatcher " was heard.

Birds abounded on this islet ; on the rocks surrounding it were cormorants, gulls, egrets and giant heron ; moorhens were among the bushes on the eastern shore, and many swallows and weaver birds were noted. *Nephila* and *Glossina* were absent ; the only butterfly was a Lycaenid ; bees were seen on the flowers.

The main island of Yempata is rather flat, but there is a small amount of open grass land rising slightly at about the centre ; the rest is well covered with forest or the overgrown remains of former plantations.

For at least half the length of the western shore there is a pebbly beach, backed by dense thickets of elephant grass (" Ekisagazi "), an unusual feature on any but the largest islands. The remainder of the west coast has a dense wall of bushes ; along the north coast there are rushes and papyrus, and on the east side papyrus, ambatch, and other bushes right up to the water's edge, forming excellent shelter for the Situtunga antelope which the natives assert lives on the island. Along the southern shore is pebbly beach.

The old banana plantations bore evidence that monkeys live on Yempata, but they were not seen. Hippos, of course, visited Yempata, for old plantations are favourite resorts of theirs ; only one crocodile and one Enswa-swa were seen. Nothing is recorded in my journal about the birds of Yempata. Butterflies were numerous, but nothing of particular interest was seen, and in one visit to an island of this size no estimate could be made of their numbers. *Nephila* spiders were not seen ; *Glossina* was extremely abundant and as hungry as on Kimmi, and, as at Kimmi, came off to the canoe before we reached the shore. The average for the island was 67·6 per boy-hour ; but for the western beach only the figure was 79·5 !

On February 28th I visited SINDIRO alone ; an island about the size of Bulago, with a low grassy hill at the north end and a rather flat southern point, the shores all round having a belt of very thick forest coming down like a wall almost to the edge of the water. In front of the forest are thickets of cane, e'tungulu and papyrus, in places so dense that landing was impossible, and we had to go round to the eastern side of the south point ; here we found a hippo pathway up which we crept ashore and found ourselves in a large open sandy space, in which were numerous burrows of Enswa-swa, presumably nesting places, as on Kimmi.

Sindiro proved to be very decidedly a " spider island," and *Glossina* was represented by an average of 9·2 per boy-hour, in both of which respects this island shows interesting differences from its neighbour Yempata. Cicadas singing on the trees seemed to be more numerous than had been noted on other islands ; of butterflies, the *Hesperidae* seemed especially numerous in proportion to the rest.

On March 2nd we moved camp, since food supplies were running low and Wema was too far from Entebbe for conveniently replenishing. So, to my regret, we left

VIEW SOUTH-EAST FROM BUGALLA CAMP.
Bugaba, Bunyama, and Buvumira in the distance.

To face p. 118.

beautiful Wema and returned to the former camp on Kerenge, visiting KIBIBI *en route*.

This island, about a mile square, was too big to be thoroughly examined in the time at our disposal; it has a sugar-loaf, grassy hill rising to the usual height, and a good deal of park land with trees scattered singly or in clumps; on the north point is some really beautiful old forest, which is bordered at the water's edge by the tallest thicket of *Salvia* that had been seen on the islands. Crocodiles and Enswa-swa were both scarce on Kibibi. Song thrushes were heard singing sweetly in some number, and the fine blue and red plaintain-eater ("Fulungu") was noted; this is usually not found on the smaller islands, though one was seen on Kiuwa.

Only a single *Nephila* spider was seen. It was not possible to estimate the butterflies, but it was interesting to find a species of *Byblia*[1] which had not been seen on any other island, though it was found abundantly at Jinja on the mainland in 1910.

On March 3rd, KIUWA was again visited, and again worked very thoroughly without success in finding breeding grounds for the *Glossina*. I found three pupae, which were more than any one else found.

On this visit was noted another butterfly which had not been seen since 1910 at Jinja, a very beautiful milky blue Lycaenid which was quite abundant.[2] Next day, owing to supplies having run very low, we returned westwards to a camp on the north shore of the large, flat, forested island of DAMBA. The camp was pitched in one of the few open spaces, and was memorable for the myriads of mosquitoes.

En route we examined the Isle of DYAVODEMU, lying in a bay near the mainland, and I visited it again on the 6th. It is flat and without forest; at one time it had been much cultivated, but the shambas were quite overgrown.

[1] See p. 109.

[2] *Castalius isis.*

The shores generally are bordered by a thin growth of bushes ; on the south side is a pretty bay backed by a small cliff, at the foot of which bushes have apparently been used as a nesting place by egrets for many years. Birds were few on Dyavodemu ; no flycatchers, bee-eaters or coucals were found, and especially noteworthy was the complete absence of weavers, which had been found on almost all islands examined hitherto.

Abundant on this island was a lizard which had not been seen in such number before : a short-legged, grey species, longitudinally striped, with a bluish tint at the base of the tail.

Dyavodemu was emphatically a "spider island," not only the large *Nephila* being abundant, but also a smaller, reddish, thorny backed species with shorter legs being much more abundant than on other islands where it had been seen. *Glossina* was represented by an average of 10·1 per boy-hour.

Butterflies were interesting (see p. 125). *Papilio demodocus* was seen ; Pierines were much more abundant in individuals than on other isles. *Catopsilia* and a *Belenois* were plentiful, and the latter could be seen in numbers crossing over from the mainland. Only two Nymphalines were found, *Precis clelia* and *archesia ;* Acraeines were abundant in species as well as individuals ; the most conspicuous, and so unusually plentiful as to be a feature of the fauna, was the rosy pink *A. natalica pseudegina* ; *A. zetes* was scarce, *egina* was not seen, *encedon* was in some variety. Of Danaines, only *D. chrysippus* was met with ; Lycaenids and Hesperids were few, both in species and individuals. Other insular features were the great numbers of Asilid flies, and of two species of beetles (*Cassididae*). It is possible that abundance of the predaceous flies, in the presence of multitudes of spiders, corresponded with abundance of *Mantidae* on other spider islands, for *Mantidae* were not found to be numerous on Dyavodemu.

The beetles were on the *Ipomaea* creeper, much of which was stripped of leaves by the activities of them and their larvae. One was brown in colour with rough surface ;[1] the other smooth light brown, with very variable and irregular black spots.[2]

On March 5th Fiske went to Entebbe on business, and planned to meet me with supplies at the old camp on Bulago on the 7th.

I went to visit the small islets lying off the coast of Damba, close to the camp. The first, MTIOMU, of spongy brown rock, measures about 100 by 20 yards, and has a fine sand spit at the southern end ; in the water at the north end is a great grove of ambatch, which sheltered abundant cormorants and weavers. For such a small island the vegetation was extraordinarily varied ; except for " Oluzibaziba " all the familiar bushes and flowering plants of the lake shore were represented, so that several species of butterflies might have been expected ; but only *T. telicanus*, the cosmopolitan Lycaenid, was found. Sunbirds and wagtails were seen, and particularly interesting was the presence of the " Nightingale flycatcher." A small brown lizard was very abundant. *Nephila* spiders were absent, also *Glossina*.

Of *Hymenoptera*, several species of bees and *Scoliidae* were seen, and also the black and yellow *Sceliphron spirifex*.

The insular feature of Mtiomu Islet was the great abundance of two large, conspicuous, aposematic beetles ; one a black and canary yellow species of *Cetoniidae*,[3] evil smelling, and freely exposed on the flowers, the other a Longicorn,[4] black with transverse red bands, which fed on the green bark of sundry shrubs.

Both of these are common insects, but were never found elsewhere in such numbers.

The adjoining Islet TOKWI is much smaller, consisting

[1] *Aspidomorpha* near *mouffleti*.
[2] *Aspidomorpha* near *signatipennis*
[3] *Pachnoda sinuata*.
[4] *Ceroplesis signata* (*Lamiidae*).

merely of a few rocks and sand, with scanty vegetation. Except for one Enswa-swa and weaver birds and the "Nightingale flycatcher," there was little to note about the fauna.

The tiny islet named KAWAGA was visited next; merely a flat topped rock about ten yards in diameter, rising sheer out of the water and about three feet above it. All round the edge grows the "Omuvuvumye" shrub, but nothing else save grass. Even this tiny islet had its entomological feature; for, feeding on the leaves of the only kind of bush were great numbers of black larvae of a small Chrysomelid[1] beetle, brown and black. More interesting still was their complete absence from a precisely similar but slightly smaller rock about twenty yards away, and from a third a little further away still. I visited Mtiomu again, but could not find any of these beetles or their larvae on the "Omuvuvumye" shrub there.

On March 6th I visited MASOVWI, a diminutive neighbour of Dyavodemu, which, measuring about 200 by 50 yards and lying very low, is formed of grey rock and has a good deal of sand on it. The southern shore is marshy, and fringed for half its length with a dense thicket of ambatch, the other half is open, with lush grass and flowers like a small sunflower. The centre of the island is piled with sand, on which grow thick bushes of "Ekinsambwe," and in which a batch of crocodile's eggs were found, the crocodile also being seen. On the whole, the vegetation was not varied, and there was no "Oluzibaziba."

Birds were represented by a heron, many cormorants, and moorhens, with weavers, sunbirds and, since the islet was very small, the "Nightingale flycatcher." *Nephila* was absent, and *Glossina*, rather to my surprise, was caught at the rate of 2·1 per boy-hour. Pupae were found, so that Masovwi is the *smallest isle on which Glossina is known to breed*.

[1] *Mesoplatys ochroptera.*

On March 7th I moved camp to Bulago; the dawn was very stormy looking and there were spots of rain until 9 a.m. It then seemed as if danger of a storm was over, and I set off in the small canoe, heavily laden and low in the water, but hardly had we got well away from Damba when we were caught in a formal thunderstorm, coming, fortunately, more or less from astern. The small canoe plunged heavily and took a good deal of water over the bows, and it was necessary to shift some of the load further aft, rather a difficult procedure, as the canoe was full and far from steady. However, after this she rode better, and we proceeded on our way to Bulago, getting, of course, thoroughly soaked with the heavy rain.

In the evening there was great dissatisfaction among the men on account of the small amount of food available, each man's portion being only about half a dozen bananas. While ruefully trying to make two and two into five, to my great relief I saw Fiske's canoe in the distance returning from Entebbe, and all was well, for he brought abundant supplies and a huge mail.

March 8th and 9th were occupied with work on Bulago, on March 10th we went to Tavu, and on the 11th to Kizima, where I heard the "Nightingale flycatcher," not previously noted there.

The 12th–15th were spent on Bulago, and on the 16th we moved to our former camp on Nsadzi, visiting Kimmi *en route* and working there again on the 17th. Ngamba was re-visited on the 18th, and Nsadzi itself was worked on the 19th.

The results of these second visits to the above islands were most interesting, as the numbers of *Glossina* were found to have greatly increased.

On March 21st I visited Rumfua Island, which lies off the south coast of Kome. A rocky, bush covered isle, about half a mile long, but very narrow, the shore formed of boulders, except for a shingle beach at the northern end.

In the preliminary circumnavigation five Enswa-swa were seen, but no crocodiles. Rumfua is decidedly a "spider island," and the masses of their webs among the dense bush prevented one from walking over it. A great many hippo lairs were seen, so that the island seems to be a favourite sleeping place for them. Birds were scarce; there were no weavers or sunbirds, and only one "Kung-uvu" flycatcher was seen. A large flock of egrets was noted on the shore. Egg capsules of *Mantidae* were particularly noticeable, though the insects themselves were not abundant at the time.

The only butterflies noted were three Lycaenids and a Nymphaline, viz. the common *T. telicanus* and an equally common *Lycaenesthes*, and the rare *Aphnaeus orcas*; the solitary Nymphaline was a fine *Euralia*.

On March 22nd, with Fiske's departure, our joint tour came to an end. Apart from the results obtained bearing on the bionomics of *Glossina*, many extremely interesting facts had been noted regarding the predominance on certain islands of one or another type of insect; and it was very interesting to see how, when the great spiders abounded, insectivorous birds were absent and the "balance of nature" was maintained by an abundance of *Mantidae* or *Asilidae* keeping down insects which might otherwise have been devoured by birds.

NUMBERS OF BUTTERFLY SPECIES FOUND ON ISLANDS VISITED.

	Total.	Papilioninae.	Pierinae.	Danainae.	Acraeinae.	Nymphalinae.	Satyrinae.	Libythea.	Lycænidae.	Hesperidae.
Bulago (first visit)	52	—	4	3	13	8	1	—	13	10
(Added on second visit) ..	22	—	1	—	—	1	3	—	14	3
Kizima	7	—	2	—	2	—	—	—	3	—
Tavu	40	—	4	3	9	10	5	—	9	7
Kimmi	40	1	6	3	7	3	1	—	12	7
Ngamba	20	1	1	3	5	3	—	—	6	1
Sanga	35	1	3	1	3	6	—	—	10	11
Kisigalla	22	—	2	2	1	3	1	—	8	5
Dwanga Mkuru	65	1	4	3	6	13	4	—	19	15
Dwanga Mto	57	1	3	4	2	13	3	—	16	15
Dwasendwe	44	—	3	3	2	5	4	—	15	12
Ziro	32	—	3	1	7	6	1	—	9	5
Kerenga	45	—	3	2	3	8	1	—	15	13
Lukalu	15	—	2	—	5	1	—	—	7	—
Isentwa	7	—	—	—	—	1	—	—	5	1
Kiuwa	25	—	3	1	5	4	—	—	8	4
Wema	124	8	13	4	9	36	5	1	23	25
Marida	22	—	1	1	—	4	—	—	8	8
Wavuziwa..	10	—	1	1	3	—	—	—	4	1
Sege	10	—	1	—	—	3	—	—	6	—
Dyavodemu	25	1	3	1	6	2	2	—	5	5
Rumfua	4	—	—	—	—	1	—	—	3	—

CHAPTER VII

MAMMALS

The Hippopotamus.

An animal of such large size as the hippo, called by the Baganda "Envubu," must naturally come before one's notice from time to time, but one really did not see much of him. My first acquaintance with him dates from Jinja in 1910, where a number could be seen in a large pool about a couple of miles down the river below the falls. The steep banks leading down to the river were scored by the constant passage of these heavy animals over the same track, until lanes had been worn in the soft soil several feet deep, of the width of the hippo's body, bearing an absurd resemblance to miniature Devonshire lanes.

The bush on the banks was so thick that one could only get down to the water by using a hippo track, and wondered when so doing what a hippo would do if, when ascending, we happened to meet. For *he* certainly could not have turned. When on the islands one sometimes found the tunnels made through dense growth of reeds quite useful for getting about, though it was very fatiguing to walk half doubled up, and the soft mud was often unpleasantly odoriferous.

During the day time the hippo spends his time resting in shallow water, or else sleeps in his favourite quarters, for he seems to be very much attached to particular places, and one would usually find a hippo off certain low lying peninsulae, among the rushes. When passing such resorts in a canoe the men always paddled very quickly, but my experience was that an unmolested hippo showed no resentment at being disturbed, and I never had any trouble and never shot at them. On the approach of the canoe the hippo would gradually sink until only the top of the head, with ears and eyes and the nostrils, were above water, when, in spite of the seeming absurdity, there *was* a certain horsiness about him! He would watch the canoe suspiciously until it came too close, and then disappear altogether, when the canoe-men would paddle furiously until we were past what they considered a danger zone. When a frightened hippo comes up to breathe he expires the used up air with only a faint sound, but in the night their loud noises can be heard some miles away, and are probably used as a call. It is impossible to describe the noise, neither snorting nor grunting are completely descriptive; it can be imitated by making a noise at the back of the throat while indrawing a breath.

These calls at night have a fascination all their own; sometimes, however, could be heard other much louder and less pleasing noises that seemed to indicate a battle royal, perhaps between rival suitors.

Hippos have regular sleeping places in the forest or bush on the islands, from which they may sometimes be disturbed in the day time.

On Kimmi Island, when with Fiske one day, I heard him say, "Well, isn't this just cunning," and, coming up, found h'm looking at the sleeping places of a mother and baby hippo, where could plainly be seen the imprint of head, body and legs on the dead leaves, showing how they had slept side by side. The little rocky, bush covered islet Rumfua, off the south coast of Kome Isle, was evidently a favourite dormitory, for there were several bed places among the thick bushes and ferns; since there was nothing particularly tempting for them to eat they must have gone there expressly for sleeping.

I once found among some reeds near the water's edge a well marked bed place, with a mud wallow beside it; one was reminded of a house agent's advertisement, "bath room adjoining"!

Hippos wander about over the smallest islands; thus, the central conical grass clad hill of Isentwa Isle, rising steeply from the water to a height of a hundred feet or more, had a definite track across the top; but why they should visit an island apparently so unprofitable from a gastronomic point of view it is difficult to say.

The wealth of vegetation that springs up in deserted banana plantations on the islands is very attractive to these animals, whose tracks always lead to the plantations. On a very sandy stretch of shore on Damba, I saw tracks of a large hippo with a baby, leading from the water into the forest, and quite close by were the same tracks leading back into the water. It was quite obvious that on the return journey the poor baby had been very tired, for when he got on to the soft sand he had not lifted his feet sufficiently to clear it, and a furrow between each footprint showed how his weary toes had dragged over the sand. However, he very soon got into the water for a rest. It was quite possibly this same mother that I saw one morning when on the way to the day's work on the fly beach. As the canoe drew near we saw, lying off shore, a large hippo lying on one flank in the water, with the whole of the other flank exposed.

We naturally concluded it was a corpse, but as the canoe came nearer there was much difference of opinion among the men; finally, when we came closer still, the hippo proved to be very much alive, for she rolled over and sank, and then we saw the heads of two babies also in the water. None of us had ever before seen a hippo take up this attitude in the water; it seems possible that she was giving her babies milk.

One day in January 1919, I went across to Damba fly beach from the east end of Kome Isle, but as a high wind had raised a considerable sea, it was necessary to find a sheltered spot for landing, and then walk round to the exposed beach, where the noise of the waves and of the wind in the belt of forest behind the beach drowned the sound of footsteps. Consequently a hippo mother with her baby that was sleeping in the forest did not take alarm at first. I was standing on the beach, observing the changes that had occurred since the last visit in 1914, when suddenly a loud snorting was heard, and the huge beast rushed past me into the water, closely followed by the tiniest baby hippo I had ever seen. It bleated in a most comical manner, rather reminding one of a toy, and was so small that it was still quite weak, and stumbled on to its knees several times before it reached the water. Though so young it was not pink, but dark brownish grey. I was so taken by surprise by their sudden appearance that the chance of catching the baby was lost: but it remained in shallow water just beyond the breaking waves, putting up its nose at short intervals for a breath of air. The mother was further away, evidently rather anxiously watching the fate of her little one, and though the boys with me wanted to go into the water and catch the baby, I thought it better to say no, lest the mother should attack.

This was the same part of Damba coast as that where a mother was seen in the water apparently suckling her young, as described; perhaps it is a favourite nursery.

One night on Damba I woke up hearing a curious noise which, in my sleepy condition, I could not define at first. Presently it resolved itself into the grinding of teeth and I realized that a large hippo was grazing on the choice grass just by the tent. As I was afraid he might blunder into the ropes and bring down the tent, I went out with a towel and waved it vigorously, and the huge beast moved off; it was a dark night, and only a black shape could be seen. Hippos are very fond of lush grass which grows along low marshy or sandy stretches of shore, and these were dubbed "grazing grounds," for the grass was always kept short. A magnificent opportunity of photographing a grazing hippo was lost because a camera was not to hand. In company with the fly boys I was going down to the morning's work on the fly beach of Bugalla. As we emerged from the bordering strip of forest there was a hippo on the sand, grazing quite openly on the grass. I walked along the shore towards him to see how close he would allow me to come; he had his back towards me but turned round at once, saw me, stared, and went on grazing. I continued to approach, thinking it would be good fun to pick up a stick and give him an unexpected blow from behind. But his guardian angel was true to his duty, and when I was within about thirty yards an ibis suddenly took to wing with its raucous alarm cry, "Aa-aa-aa." The hippo turned round in a fright, made an angry face at me, and rushed into the water, leaving me lamenting. I should like to conclude my remarks on the hippo by the following. A new monthly journal was founded to deal with Colonial interests, and a specimen copy of the first number reached me on the islands. In it was an account of a lecture given by some one on Sleeping Sickness at a meeting of a photographic society, wherein were found these astonishing statements. The lecturer said it had been proved that the Tse-tse could not exist without a feed of crocodile's blood (!), and that it was well known that the hippo had an inveterate habit of destroying crocodiles' eggs (or was he supposed to *eat* them? My memory fails on this point). Here, then, said the lecturer, is the solution of the problem of Sleeping Sickness in a nutshell. Preserve the hippo, and he does the rest! One can picture the establishment of "hippo hatcheries" all round the lake, and schools where youngsters will be taught the difference in appearance between the eggs of crocodiles and fowls!

But perhaps the lecturer was a humorist? . . .

Monkeys.

One species of monkey, a *Cercopithecus,* lives on the islands, but only on the largest: they were found on Kome, Damba, Wema and Yempata out of those that were visited in the group lying off the north shore of the lake, and on Bugalla and the larger isles of the Sesse group. A very curious fact is their presence on the Isle of Nkosi, which is the southernmost of all the Sesse isles, quite small and in a very isolated and exposed position; when I visited this islet in 1913 I distinctly heard a monkey's voice, though he was not visible (see p. 92). The species is of a common type: greenish grey in colour, with black face and a white band across the forehead. It has been of very great service in the investigation of Sleeping Sickness, since the Trypanosomes which cause that disease are also pathogenic to the monkey, which can thus be used as a test for infected flies. Hence I had one with me on the islands for this purpose, and also two others as pets. The "official" one was dubbed Tommy, and, of course, had to be kept tied up, as also was the older of the two pets, named Wee Man. The third, Puffin, was a mere baby, and had not yet become sufficiently mischievous for it to be necessary to tie him up. When I first had Wee Man he was also allowed to run loose, but became so mischievous that when I moved to Bugalla he was tied up.

Being in very constant association with them, one soon became thoroughly familiar with their behaviour, their moods, facial expressions and language, and soon found oneself able to distinguish the meanings of their various utterances.

No less than fourteen sounds are used, although some of them would not be recognized as distinct by any one who had not carefully observed the monkeys, for they are often of the nature of an alteration in inflection, or accent, rather than a different word.

1. May be called a "*General remark,*" and is the commonest expression; used, seemingly, when a monkey is at a loss what to do, or when his attention is attracted by something, or when another monkey comes to him, etc., etc.

2. *Recognition.*—A slight modification of No. 1 was used by Wee Man whenever he caught sight of my servant, of whom he seemed particularly fond. Often I would hear this expression and, looking out, would see the man walking about a little way away, and so in time came to know what this sound meant, for it was never used on any other occasion. It may be expressed by "Wok."

3. *Eagerness.*—Another modification of No. 1 indicated eagerness; as, for example, when the monkey saw some one bringing a grasshopper which he particularly desired.

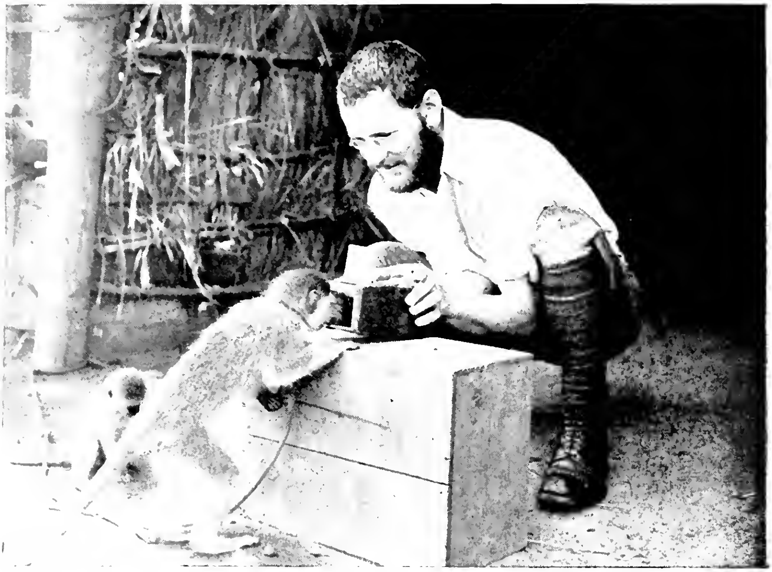
4. *Alarm* was expressed by still another modification of No. 1, and had two forms:

(*a*) For a bird of prey overhead, very unmistakable and emphatic.

(*b*) For a thunderstorm, or a bush fire, which they dread very much.

5. *Excitement,* as when a monkey sees a boy chasing a fowl, or two boys in play chasing one another. This is also derived from No. 1. I have heard one of the monkeys repeatedly make this noise when he saw a fish eagle chasing another away from its private fishing ground. He took the greatest interest in the occurrence, watching the eagles as they soared around, and being unable to restrain his excitement when one swooped down on the other.

6. *Rage.*—A quite unmistakable sound, possibly connected with 5.



WEE MAN CHOOSING A GRASSHOPPER FROM THE BOX.
Puffin, behind, has had his.

WEE MAN (RIGHT) AND TOMMY TAKING GRASSHOPPERS.

To face p. 132.

7. *Pain.*—A kind of squeak.

8. *Cry for help.*—A high-pitched squeak. Wee Man used to make this as a youngster when he became inextricably entangled in his rope.

9. *Melancholy.*—A very distinct, long-drawn wail, sometimes heard in the forest, presumably indicating that the monkey had become separated from the troop. A monkey seen in the act of crying thus has a most lugubrious appearance; the mouth is held in a peculiar fashion and one quite expects to see tears rolling down the cheeks.

10. *Hunting Call.*—One of the most distinct sounds in the monkey tongue. When a troop is searching the trees for food in the forest an old male sits in a very conspicuous tree top and utters a series of barking noises which can be most nearly imitated by repeating very rapidly "Kubba-kubba-kubba." To this the junior members reply by high-pitched squeaks, and the whole troop is thus enabled to keep together, as the total amount of noise produced is considerable.

11. *Dislike.*—A short, expressive word, which may be represented by saying beneath one's breath the first two letters of the word "come."

12. *Intense dislike and fear.*—The last mentioned sound is repeated very rapidly and with great energy when a monkey sees a snake, or anything that seems to savour of a reptile.

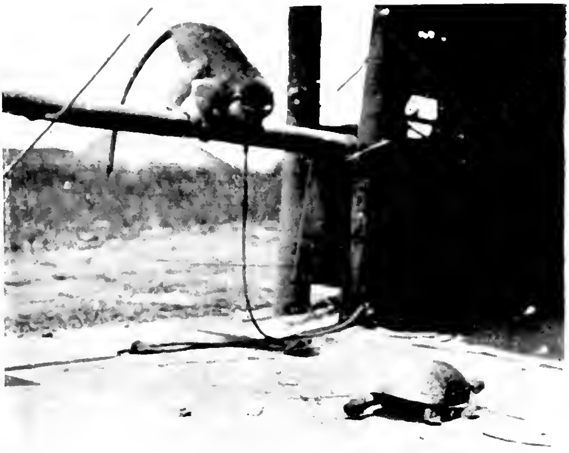
13. A "*baby*" noise, only made by young monkeys when they have been frightened or hurt and run for comfort to be cuddled by their mothers or friends. It can be represented by the noise "Qurra-qurra-qurra-qurra" repeated beneath one's breath.

Having been for months in close association with the pet monkeys, I found their different natures extremely interesting, and they were most charming companions, but it was necessary to keep them tied up owing to their mischievous dispositions.

At one time, when very young, Wee Man had been allowed to run loose, and whenever I left the house he would be unable to resist the temptation of working havoc among papers or anything else that took his fancy which he could destroy, although he knew quite well he would be punished, and showed it by his guilty demeanour when I returned. At this time he would frolic around the huts of the canoe-men when they were away, and make little holes through the grass walls, so that he could, if chased when the time came to tie him up for the night, dodge in and out of the huts. It was a great game every evening to try and find him, and if he managed to hide himself away and go to sleep before he was found, it was considered that he had won the game; and he did, quite often! Mischief was a very marked feature of the monkeys' games with each other, which were delightful to watch. One would be sitting on the bar, a couple of feet above the ground, his tail hanging down, and another, with a broad grin on his face, would steal up and, seizing the tail with both hands, tug furiously in the endeavour to bring down the other, who, quite appreciating the joke and also grinning, would cling on with all his might.

They were of a very affectionate disposition, and if one was beaten or threatened the other would do its utmost to bite the enemy, shrieking with rage the while. The baby Puffin, on Bugalla, was not tied up, and occasionally got into mischief in the house, when I chased him out with threatening gestures. He would at once run to the others, who would receive him anxiously and carefully examine him to see what damage had been sustained, while he made the baby noise to which they responded.

When the three settled down to sleep for the night, all cuddled together, they would give each other a long kiss, lip to lip!



WEE MAN BEING RUDE TO A TORTOISE.

TOMMY (LEFT) AND WEE MAN IN AN INTERVAL OF A GAME.

To face p. 134.

But their affection for each other never went to the lengths of unselfishness as regards food; if choice were given, a monkey would of course take the largest piece, but very often afterwards would drop that and endeavour to take from the other the piece which he had himself passed over. In fact, their maxim seems to be "the other's piece is always better than mine"!

Wee Man was the most intelligent of the three, and had a more capable-looking head. When his rope became very much entangled with that of Tommy, he would look at the tangle for a while and then deliberately try to disentangle it by picking up a loop and, as it were, unthreading himself by walking through it. Often, if the tangle was a simple one, he would succeed, but if the first method was not successful he would try walking through the loop in a reverse direction. Tommy, however, though he might make futile attempts, never succeeded, and seemed to do it mechanically because he had seen Wee Man do it. This is the only instance I ever saw of the reputed imitativeness of a monkey. A certain intelligence was also shown in the recognition of zoological affinity. The noise made for a snake has already been described, and the same was also made for a fish; and, one day, having found a tortoise, I brought it back to see what Wee Man would say to it.

At first the tortoise withdrew itself within the shell: Wee Man came down to look very cautiously at it, intensely curious and interested, but when it put its head out he hastily retreated to his perch with loud utterance of the snake noise. When it began to walk he could not restrain his excitement, and danced round and round it, chattering, though keeping at a safe distance. I am quite sure that this was the first tortoise he had ever met, for he had been a captive ever since, as a baby, he was clinging to his mother.

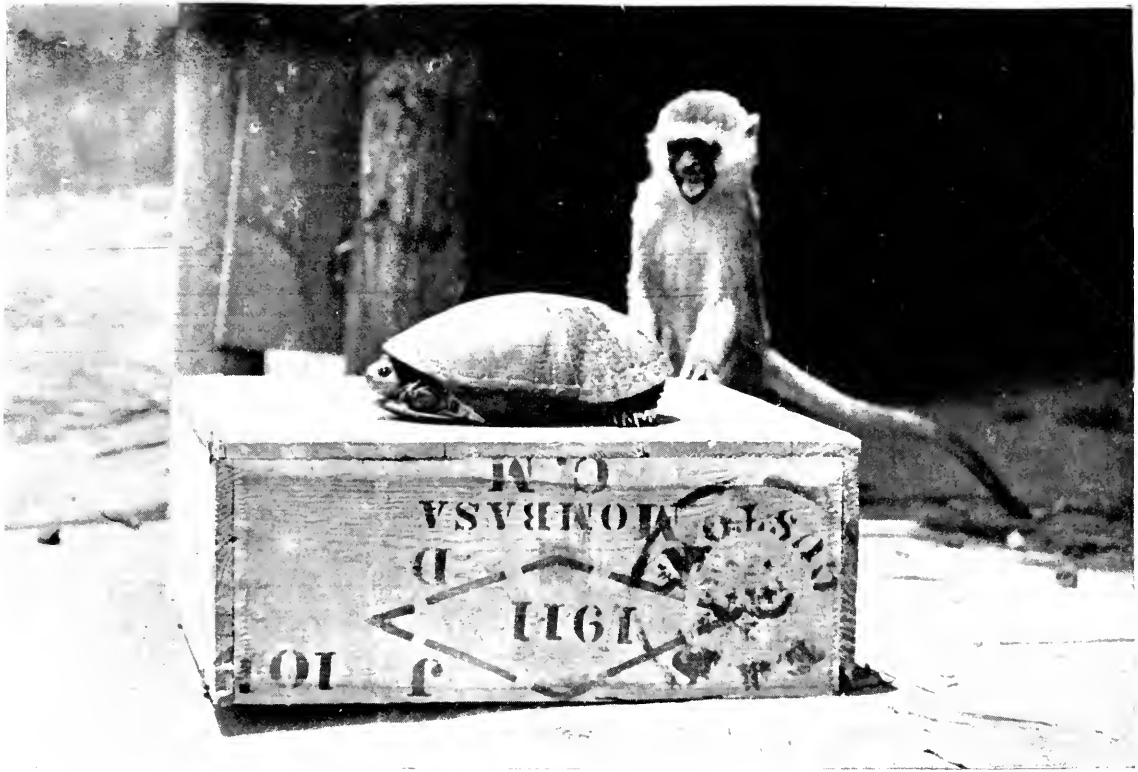
On Bugalla Island, where there was much open grass land as well as clumps of bush and continuous forest, when walking in the evening I often came across a troop of monkeys among the long grass hunting for grasshoppers, which are a great delicacy. A monkey would walk slowly and intently through the grass until a grasshopper took to flight just in front of him, when with a quick snatch he would catch it in his hands. The monkeys always bit off the head first, and then the powerful hind legs, if the grasshopper kicked much, and the rest was eaten at leisure. Even the largest *Acrididae*, three or four inches long, with formidable spines on the hind legs, were eaten with gusto. It always made me think of a man eating a live lobster, shell, legs and all, and not one only, but half a dozen in succession.

I once saw a small young monkey in a patch of papyrus reed, apparently hunting for insects. He climbed up one of the tall stems, but just as he reached the top it slowly bent over with his weight and he disappeared from view. Fortunately for him the papyrus was not growing in water.

In Damba forest I came across a troop, on the ground, very busily engaged in turning over dead leaves, looking for insects. So pre-occupied were they that I was enabled to creep up quite close and watch them before one looked up and gave the alarm.

The captive monkeys were always ready to eat insects, and if a species was offered of which they were afra d, such as a large bee or powerful ground beetle, they would paw it on the ground with rapid strokes of one hand after another until it was disabled, when it would be quickly picked up and nipped between the teeth, to be subsequently eaten at leisure, if desirable.

One evening on Bugalla I surprised a troop hunting in the long grass some little distance away from the nearest trees, to which they hastily retreated. A tiny youngster who had been put down by his mother was unable to



PUFFIN "HATING" A TORTOISE.

To face p. 156.

escape and took refuge in a small bush, where I easily caught him—a dear little fluffy beast, all head and tail, that sat easily on the palm of my hand. Unfortunately for him the bush was occupied by a species of very powerfully biting ant, and when I got him the poor little monkey was being severely bitten by the ants deeply embedded in his fur. So I took him on my knee and soothed him while I picked out the ants with forceps, the youngster sitting quietly as if my attempts at the "cuddling noise" were quite intelligible. His parents and friends on the neighbouring trees were naturally much alarmed for his safety, and danced up and down in impotent rage, with shrieks of defiance that could plainly be interpreted as "Hurt him if you dare!" When I had freed him from the ants and smoothed him down, I showed him his friends on the trees and put him down in the grass; he ran off more or less in the right direction, and I could see him thoroughly overhauled by his parents, anxious to see what damage had been inflicted, and then conveyed by the whole party into the forest. These very young monkeys are carried about beneath the belly of the mother, their limbs embracing her body, and hands and feet firmly grasping the hair on her back.

The Situtunga.

The only antelope on the islands which I visited is the Situtunga (*Limnotragus* or *Tragelaphus spekei*), known to the natives of the islands as "Enjobe." This interesting buck was discovered by J. H. Speke in 1862 in the Karagwe district, south of the Kagera river. He gives it the native name of "Nzoe" and says of it: "It proved to be closely allied to a water-boc found by Livingstone on the Ngami Lake, but instead of being striped was very faintly spotted, and so long were its toes it could hardly walk on the dry ground; whilst its coat, also well adapted to the moist element it lived in, was long, and of such excellent quality that the natives prize it for wearing almost more then any other of the antelope tribe. The only food it would eat were the tops of the tall papyrus rushes ; but though it ate and drank freely, and lay down very quietly, it always charged with ferocity any person who went near it."

The Enjobe is about the size of a donkey. The male has beautiful horns, long and spirally twisted, with almost translucent tips ; the females are hornless. The colour varies considerably ; the young males are bright foxy red, marked with white, adult males are darker brown, but I have seen an adult female of the same colour, although typically they are more brightly coloured like the young male.

This antelope with its elongate hooves is well known to haunt swamps for which its deeply cleft feet are suitable, in the same manner as are those of the reindeer for snow or of the camel for sand.

It is mentioned in books as spending its days immersed in water among papyrus, etc., and is apparently considered as an animal confined to swamps. On the islands, however, it is a creature of different habits, possibly owing to the entire absence of enemies, human or otherwise, from which on the mainland it takes refuge in swamps. Indeed, it now behaves much like its close ally the bushbuck, called " Engabi " by the natives. On some of the islands which it inhabits there are no papyrus swamps, and during the day time I often disturbed Enjobe from their resting places in the forest belt near the water.

In the evening they could be seen coming out on to the open grass covered spaces and browsing on bushes, especially " Oluzibaziba," the Euphorbiaceous *Alchornea chordata*, of which they eat the young tips.

The bushbuck may well have had similar habits on the larger islands in former days until it was exterminated. The Situtunga, on the other hand, could have taken refuge in the water, as it now does on the mainland. Since the removal of the islanders, however, which was completed in 1909, its habits have become changed, and it is multiplying very quickly in the absence of all enemies.

Major R. Meinertzhagen, F.Z.S., visited Bugalla from a steamer during the war in October 1915, and examined several Situtunga, finding interesting differences from the mainland type; the horns diverged more widely. But the specimens from the much smaller and more isolated islet of Nkosi showed further deviation to such an extent that they are given sub-specific rank.[1]

The feet show a slight return from the specialized narrow hoof of the type, for in the Nkosi animals the hooves are proportionately broader, and in a young animal were "no longer than one would expect to find in a young bushbuck of his age."

The horns also are more like those of a bushbuck, and the colour of the adult male was noted as "of a uniform dull mouse colour and not a dark brown"; the animals are also larger than the typical mainland forms.

It is remarkably interesting that this change in structure can be noted together with the change of habits; the Nkosi animals are losing the high specialization, correlated with the peculiar mode of life among swamps, which characterizes the Situtunga discovered by Speke.

The Situtunga could frequently be heard barking at night, the call being somewhat like that of the bushbuck but distinct from it, rather more muffled and less dog-like.

The following may be cited as evidence of the effect of the removal of all inhabitants from the islands.

Nsadzi, the long narrow isle lying due south of Entebbe, was free from this antelope when inhabited, according to native testimony, although the densely forested eastern end provides ample shelter. When I visited it in 1914 with

[1] *Proceedings of the Zoological Society*, June, 1916, pp. 375–81.

Fiske he found footprints, and later on I found abundant evidence that Situtunga at least visit Nsadzi. I have also found bushes browsed by them on Ngamba, between Nsadzi and Kome, on which latter large island they abound, so that it is probable they had crossed to Nsadzi from Kome, using Ngamba as a stepping stone, for it is well known that they swim readily. The importance of these movements from the point of view of Sleeping Sickness has already been discussed in Chapter II, pp. 28–29.

The smallest island on which I have seen Enjobe is the previously mentioned Nkosi, lying to the extreme south of the Sesse archipelago, and very exposed. Several were seen there on a visit (see p. 91), and areas of grass were kept close cropped by their grazing. It seems almost certain that they must swim to and from this tiny island from the larger isles to the north.

Otters.

Otters abound in the lake, as might be expected, and one is glad to feel that their numbers are steadily increasing now that they can no longer be destroyed for their skins by the islanders. There can be few animals more beautiful than otters in the water; they are so lithe and graceful and sleek, and so full of the *joie de vivre.* I remember well one very hot day when I was visiting the little islet Kizima. Looking down from the top of a little cliff into the water I saw below some half dozen otters sporting in the water and tying themselves into knots, but in a very leisurely way, as if it was too hot for much exertion. On another occasion off Tavu Isle there were about a dozen, fishing and playing with their catches in a very delightful sportive mood; throwing the fish up into the air and catching it again. One lay on his back in the water in a most ludicrous attitude, with a fish in his mouth and hind feet and tail sticking up out of the water.

The size of fish that otters can tackle is very surprising. On Ziro Isle, in 1919, I saw the remains of a very large Silurid fish, which had evidently been dragged up on to a rock high above water by one or more otters which had eaten all except the shoulders and the large flat bony head, measuring 12 by 9 inches. This part that remained was taken to camp, and was found to weigh twenty pounds! So the fish, which the natives called "Akasonzi," would probably have weighed forty pounds at least. It was the largest one the natives had ever seen.

The otters in Kingsley's *Water Babies* are described as making a queer chorus of squealing noises, but I never heard a sound that could be ascribed to an otter, even at night, save when one comes up to breathe close by, and emits a short grunt before diving again.

Leopard.

The larger carnivora were not met with on the islands save for one exception. On Kibibi, in January 1919, fresh spoor of a leopard was seen on the wet sand on two successive visits nearly a week apart. The leopard must have swum from the coast of the mainland across at least $2\frac{1}{2}$ miles of open water. (See map.) The spoor was seen very fresh on both January 17th and 22nd, there having been heavy rain between the two visits. So it would seem that the animal was there all the time, although there cannot have been much food for it. On Kibibi there are neither buck nor monkeys, and there are no game birds (save an occasional bustard, quail, or forest francolin) on any island that I have visited. Presumably the leopard managed to catch fish or ate crabs that it found on the beach!

Mongoose.

Animals of the civet cat tribe (*Viverridae*) were not often met with on the islands, and then only on the very largest. A pair of genets was once seen on Kome, their long snaky bodies, with spotted coats, and short legs being quite unmistakable, even though they were only seen darting away in alarm.

On Damba one day in 1911, I had a delightful experience. I was sitting quietly by a clump of bushes, watching for bee-eaters at the edge of the forest, some 30 yards away, and keeping as motionless as possible. A beautiful mongoose, of a rich red-brownish green colour, with tail all fluffed out, walked across a little grassy bay in the edge of the forest, very full of vigour, but not in a hurry, and disappeared again among the bushes. Shortly afterwards there was heard an agitated quacking and cackling from the jungle on my left, and an Egyptian goose came across the grass in front of me, and only a few yards away, followed by the mongoose.

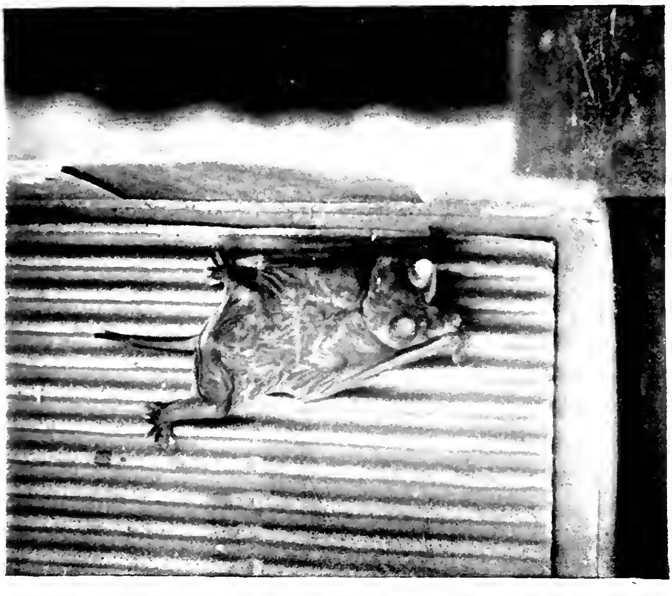
The goose fluttered along making a great fuss, apparently just keeping out of reach of the pursuer. It seemed to me, however, that the mongoose was not exerting himself very much, as if he thought that the obviously disabled bird in front must very soon fall an easy prey. The two passed into the jungle on my right, and the deluded mongoose lost his prey. Shortly afterwards I saw him again, walking across the little bay, but the ruse had been successful ; the goose had drawn him away from a brood of babies, and while he had been chasing one parent the other had led the goslings away in another direction, and I could see them swimming away to a marshy bit of land where they were safe for the time. But a few days later I saw that the number of goslings was much diminished, so the mongoose may have been more successful a second time, knowing the trick that had been played on him.

It was very interesting to see this old, old trick actually succeed.

A FAVOURITE HAUNT OF SITUTUNGA ON BUGALLA.

They feed in the evening on the bushes at the edge of the forest belt which slopes steeply to the water.

By permission of the Royal Society and the Controller, H.M. Stationery Office.



A BAT CAUGHT ON TENT AT JINJA.

To face p. 142.

Bats.

Bats abound among the dense vegetation of the old banana plantations, and may often be seen in the day time hanging from the midrib of a banana leaf. The caves found on Kimmi, Damba and other isles shelter numbers of the smaller species, named "Akawundo" by the natives. I shot a few of these one morning in order to investigate the contents of their stomachs, but although it was only about 9 o'clock, their stomachs were quite empty. The noise reverberating in the cave was so distasteful to the bats that for a long while they did not return; possibly their instinct warned them that such a noise could only, in the experience of the race, have been caused by rock falls making the cave unsafe.

I had a curious experience at Jinja one evening in 1910. Hearing an animal scrambling about over the roof of the tent and being unable to drive it away by repeatedly striking the canvas, I went out with a lantern and found to my surprise that it was not a mouse but a bat, whose photograph is reproduced (p. 142). It was a more active walker than others that I have encountered, and seemed quite unwilling to fly. It had possibly been crawling about on the roof after insects that were attracted to the light.

The much larger frugivorous bats, commonly called "Flying Foxes," and by the natives "Ekinyira," occasionally gathered together in great numbers, possibly for breeding purposes. This was first noticed on Bunyama in January 1912, and, later, on Ngamba in March and April 1914.

They assemble among dense creepers, and may be heard chattering, and also smelt, before a landing is made.

When disturbed they made a prodigious noise, scrambling about and squeaking loudly before taking to flight and circling round looking for a new resting place.

Although I visited Ngamba every week between March and August 1914, I did not find these bats congregated after April.

Since the expanse of wings is about two feet, they look large creatures in flight, and the beating of the wings makes a considerable noise when one disturbs a large congregation.

At night the " Ekinyira " in the forest keeps up a most insistent loud noise at intervals of about a second. For a long while I thought it was produced by a large frog. It is a sharp note, between a high-pitched croak and a grunt, with something of a bark in it. It may be heard from shortly after sunset for hours on end, and, if one awakes in the middle of the night, may still be heard coming from the same spot !

CHAPTER VIII

BIRDS

ORNITHOLOGY is a subject to which I have devoted less time and observation than entomology, so that I have not so much to say about birds because of my ignorance of their identity.

In writing this chapter I have been much indebted to Mr. C. F. Belcher, of Uganda, who has kindly given me the scientific names of such species as are dealt with, and also some of the native names which I had not found out.

The arrangement and nomenclature is according to Reichenow.

Perhaps the most striking ornithological feature of the islands is the difference of their fauna from that of the adjoining coast of the mainland.

I am, of course, only speaking of the islands that I know well, those lying parallel to the north coast of the lake between Entebbe and Jinja, and Bugalla in the north-west corner of the lake. The differences that have been noted will be mentioned as the various groups are alluded to.

Gulls are some of the first birds noticed by the traveller on the lake, and while I was on Damba Island in 1911 I saw a good deal of them. Some low rocks in the water lay off the point on which I was camped, and for some reason these were a favourite resort of gulls and many other birds, so that there was a bigger collection there than at any other place I know among the islands.

At least two species of gull (*Larus fuscus* and *cirrhocephalus*), one, larger, with black back, the other grey, were always chattering and screaming there, together with terns, cormorants, darters, pratincoles, sandpipers, goliath herons and other herons, amongst them a magnificent snow white species seldom seen, but there in some numbers (? *Herodias alba*), white egrets and the white egret-like buff backed heron, the open-bill and another stork, Egyptian geese, and sometimes ibises, either the black and white sacred species or the dark greenish black Hagedash ibis.

The gulls are much more noisy before stormy weather, and were quite useful as weather prophets. It seemed to me, also, that one did not see much of the terns except in windy weather, when they were noticeable flying about close to the land. Gulls are known to the natives as "Enkobyo-kobyo," and terns (*Hydrochelidon leucoptera*) by a name that sounded like "Akalerwe," but I would not be certain of its correctness. Two species were noted. It often seemed curious to me that I never met with the nests of gulls on the coasts of the islands; possibly they do not breed close to the water.

They feed on dead fish and other flotsam on the surface of the lake, but one has been seen in close attention on a number of cormorants that were fishing in shallow water. When one came up to the surface with a wriggling fish in its mouth the gull swooped down upon it, and in self defence the cormorant had to dive again with the fish unswallowed. This happened repeatedly until the passing of the canoe disturbed the birds, so that I could not see whether the gull had made the cormorant give up its prize.

Cormorants naturally abound among the islands, and soon become familiar sights. One is much puzzled by the variety of markings of the larger birds (*Phalacrocorax lucidus*). They may be black without any white, or with snow white throat and breast, with or without a round white patch on the side just behind the angle of the wing.

A smaller species (*Phalacrocorax africanus*) is all black, and nearly always very ragged looking ; indeed, one cannot feel any affection for the cormorants, they are smelly and unattractive. Natives call the smallest specimens "Semirindi," the larger ones, without much white, "Ensogwe," and the largest white breasted specimens are named "Engadāla," but most natives class them all, together with the darters, as "Ensogwe."

These birds have their regular "rookeries" where they breed year after year, so that the ambatch trees on which they continually perch and build their loose nests of sticks become flattened down and often look very unhappy. The birds when sitting on the nests have a curious habit of rapidly moving in and out the loose skin of the "chin," in somewhat the same way as a fowl when gasping for breath in very hot weather. It is possibly due to the same cause in both cases, as the cormorants sit on the nests exposed to the full blaze of the sun.

I first noticed this when watching the nesting birds on the islands of the Nile at Jinja, below the falls. Cormorants abound here, and swim fearlessly about amidst the turbulent eddies immediately below the actual cataract, where one would think they must be beaten against the rocks.

About sunset large numbers of these birds return from the lake, flying up the narrow gulf until they reach the falls where the gulf becomes the river. Here, in 1910, I often noticed a very curious trick of flight.

When the leading bird of the flock arrived over the falls it would suddenly close the right wing so that it fell down sideways for some twenty feet or so, to recover with perfect ease and resume its former steady flight. Often several would do this in succession, as if playing follow-my-leader, but I have never seen this trick played anywhere else.

Occasionally a single bird winging its way home utters a rhythmic croak at intervals, strongly suggesting a man loudly panting for breath. They are not exactly songsters; their noises are more of the nature of quackings than anything else. Except for the trick above mentioned one does not see much sign of the *joie de vivre* in cormorants; they seem to find life a serious business, and have to work hard for a living. When resting, and possibly digesting, on the branches of their favourite trees, they often spread their wings out on each side of the body, as if they felt the heat, or were holding them out to dry, although so oily are their feathers that they cannot really get wet. It always amused the canoe-men, when we were going along, to see one of these birds suddenly appear on the surface, often with a wriggling fish in its beak, hastily look round, and either dive again or take to flight. Being heavy birds, they have to paddle their feet along the surface for some distance before their wings have developed enough momentum to lift them up.

Closely allied to the cormorants, and grouped with them by the natives under the name "Ensogwe," are the snaky-necked *Darters* (*Anhinga rufa*), often erroneously called Divers, which name belongs properly to the marine *Colymbi*.

These are not nearly so abundant as the cormorants, from which they are easily distinguished by the much smaller head and very long slender neck, bent upon itself with a curious kink. Like the cormorants, these birds take life very seriously, and are equally unattractive, though their quaintness is interesting. They are certainly most efficient water birds and fly well, but are ungraceful and malodorous—at any rate in quantity. They are, however, of somewhat less dingy plumage, and in the breeding season become almost brightly coloured with yellowish and brown tints.

Pelicans have only been seen in the narrow channel between Bugalla Island and Bukakata port on the Buddu coast of the west of the lake.

They may also be seen in Kavirondo gulf, which is very shallow and muddy, but why they do not occur elsewhere on the sheltered waters among the islands it is difficult to explain.

Geese are, of course, numerous on Lake Victoria, but I confess not so numerous as I expected to find them, and ducks were very rarely seen. I never saw on Lake Victoria anything approaching the hosts of brown ducks seen in 1916 on Lake Bunyonyi in the Kigezi district of the south-west corner of Uganda, or in 1918 on Singidda Lake at the southern end of the East African rift valley, or on the marshy land along the central railway of ex-German East Africa, near Dodoma, in 1917. The native name "Embata" applies to both geese and ducks. The Egyptian, or Zambesi (*Chenalopex œgyptiacus*) goose, well known over so large a part of Africa, and on ornamental waters at home, is the species most often met with, and is usually found in little companies of two or three, or sometimes half a dozen. It prefers especially an open shore of flat rock or sandy beach—the white sand of Nsadzi beach was a very favoured spot, and one could always reckon on finding at least a pair there.

They are handsome birds with their mottled brown and grey plumage, and green and white speculum on the wings, and walk easily, carrying themselves well without waddling. As one moves along the beach towards them their agitation shows itself by loud cacklings, until they finally take to flight and make a half circle over the water, returning to shore a little further away. A wounded one that had been shot and was pursued by a canoe endeavoured to save itself by diving, but I think this bird only does so in its utmost extremity.

A nest was found on July 25, 1914, at the foot of a tree behind a bank of bushes and reeds on Kimmi Island; excavated in a bed of dead dry leaves and beautifully lined with warm down, it contained four white eggs. About a week later, however, I found only two eggs in the nest, so that possibly some had been devoured by *Varanus* or a snake.

I have related elsewhere how a mongoose that ardently desired a gosling was frustrated by an old, old trick played upon it by one of the parents.

The large black and white spur-winged goose (*Plectropterus gambensis*) is not so plentiful as the Egyptian goose, but is a much better bird for the table. I saw it so seldom that I have no notes about it.

Similarly with the brightly coloured dainty little pigmy goose (*Nettopus auritus*), which is found sparsely along rush fringed stretches of shore, such as the north coast of Bugalla and the channel between Damba and Kome.

Rather curious little birds are *Pratincoles* (*Galactochrysea emini*), which may be seen sitting on small rock islets. They seem very sluggish birds, and are not very interesting or attractive. Short legged, with rather slender bodies of grey colour, the rounded heads bearing a short beak, the pratincole is called "Akasalu" by the natives.

Of the *Plovers* and their allies the most noticeable species on the islands is a stone curlew (*Oedicnemus vermiculatus*), known to the natives as "Mutunwa." Almost every beach of gravel or sand or flat rocky shore has a pair or more of these birds, which lay their eggs there, placing the two in a slight hollow, without any attempt at a nest.

If one interferes with eggs or young they are apparently removed by the parents. I first noticed this on Damba beach, where I found a pair of eggs lying on the shingle and examined them; but next day they had disappeared. Again, on Ngamba, I came across a young bird, with the other just beginning to make its way through the shell. I helped it out, a poor little bedraggled feebly chirping

NEST OF EGYPTIAN GOOSE UNDER TREE.

NEST OF STONE CURLEW (*OEDICNEMUS*).
Two eggs lie in front of the stick lying obliquely across the left centre of the picture.

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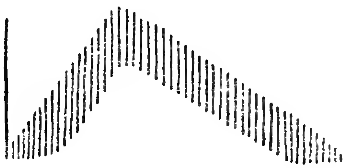
object, and left it there ; but a few days later both had disappeared. It is, of course, possible that they had really been eaten by a *Varanus* lizard ; I have elsewhere described how one seized a bird I had shot. The Mutunwa has a most curious habit of, as it were, shrugging its shoulders, a habit shared by many of the kingfishers, of which the meaning is quite obscure. They are certainly decidedly procryptic birds, and this unnecessary movement helps to reveal them when they might otherwise escape notice.

Their characteristic cry is often heard at night, especially in bright moonlight. It begins with a single high-pitched note, sharply accentuated, and then a series beginning lower than the first, rising to the same level and falling again—a very mournful cadence. It may be represented graphically thus :



One stone curlew that I shot on Nsadzi in order to investigate its stomach contents had eaten a cricket and apparently a small frog, so far as I could tell from the slender bones that were all that was left.

The common *Sandpiper* (*Tringoides hypoleucos*) is abundant on beaches or flat rocks, very often singly, sometimes in small flocks.

It may be seen at the Ripon falls paddling about in the water at the very edge of the cascade, occasionally having to leap away from an unusually large patter of spray or a rush of water. Possibly it feeds upon the *Simulium* larvae which adhere to the rocks in abundance in such localities.

I once saw on Damba some extraordinarily long legged birds that presumably were Stilts, but they are far from common. The locality was a very marshy piece of shore, also frequented by snipe.

On Kome, in 1914, were seen some plovers which had not been met with previously, nor have I seen them since, although there are large areas of marshy shore similar to the locality where they were seen.

The colouration was roughly as follows: Back grey, belly white, chest and back of neck black, face and front of neck white. When flying the bird shows black and white wings. Subsequently, in ex-German East Africa, a bird of something the same type was seen commonly on open grassy plains. This was termed "Kibiki" by South Africans.

Another species of the plover group was heard flying overhead at night time on Kome. Its cry became very familiar, and was apparently responsible for the name "Empunya" given to the bird by the natives. Since the meaning of this word would be something connected with the word for "to smell, or emit an odour," it is probably merely onomatopœic, and is quite descriptive of the cry.

Cranes are represented in Uganda by one species of crowned crane (*Balearica regulorum*), a most ornamental and graceful bird which would be a splendid addition to the peacocks and pheasants often kept to ornament a park. The soft brown and grey and yellow hues, with velvety black head furnished with scarlet wattles and erectile crest, make it a most lovely bird, and its quaint antics when with others of its kind give it additional interest.

Unfortunately they are very seldom met with on the smaller islands, and even on Kome and Bugalla are rare; and I never saw a flock such as may be seen at Entebbe or Jinja. Their cry has earned for them the Luganda

NEST OF STONE CURLEW (*OEDICNEMUS*).

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name "E'ngali." The booming noise which they make at night, before rain, has been already alluded to, and the curious ignorance of the natives, who assign the noise to the puff adder!

Next come the *Bustards*, of which a single species (*Otis melanogaster*) known as "Olunyonkante" occurs on islands where there is a sufficiently large open grassy area. This species shows black and white wings when flying, and has a most ridiculous little call note. One hears first a very short low whistle, followed after a few seconds by a single sharp but very quiet note like a bubble bursting. The peculiar native name would seem to indicate that the native considers it to suck cows, so that this bird holds a place in folklore analogous to our "goat sucker" in England.

Birds of the Rail family were plentiful among the reeds and rushes of the lake shore. One, looking much like our English moorhen, was responsible for making a most extraordinary noise among thick cover—a sort of grunting, squealing and whining, quite indescribable and very unlike a bird noise. The pretty brown, yellow and black Lily trotter may conveniently be placed here, "Akatassa" (*Actophilus africanus*). It is seen where there are enough water lily leaves or thick vegetation in the water for it to run over, its very long toes supporting it by distributing its weight over a large area. It is a very quiet bird, and one rarely heard it make any kind of noise unless it was angrily scolding at and driving away a trespasser on its private hunting ground.

We next come to the *Ibises*, of which I only know two species on the islands, the most conspicuous being the dark greenish black Hagedash ibis, known to the natives as "Empavana," the word being an attempt to reproduce its very characteristic cry, which can be indicated by "Aa-aa-aa." This is a very annoying bird if one is anxious to approach an animal without being noticed, for it is very nervous and quickly takes to flight with noisy beating of wings and raucous lamenting cry, frightening everything within earshot, so that it must be a great nuisance to sportsmen. I have already related how one of them frustrated my hoped for interview with a hippo. Sometimes these birds perch on a tree top, at other times sit among the rushes and bushes on the shore, but wherever they are their wailing cry betrays them. When flushed they make a great noise with the hurried strokes of their wings and have a characteristic flight, interposing an extra quick beat here and there until they feel steady in the air. Presumably the main object is to rise quickly from the ground, and not to place a great horizontal distance between themselves and the disturber of the peace.

The other species is the handsome sacred ibis (*Ibis œthiopica*), whose plumage, half black, half white, makes it easy to recognize. It is very far from common, and is only to be seen occasionally here and there, so that it is unfamiliar to the natives, and I could obtain no native name for it. During 1914 there was usually to be seen one on a rock off Kizima Islet, and it was noted to be a very silent bird, thus contrasting strangely with its relative. I did not notice the hurried flight, with interposed beat, so characteristic of the Hagedash ibis.

Of *Storks*, several species are noticeable, particularly the curious "open-billed" species (*Anastomus lamelligerus*), the two halves of whose beak do not meet along the middle of the bill, giving the bird an unusual appearance. It is rather an uncouth and ungraceful black bird, met with along the shore, where it is said to feed on the large *Ampullaria* "water snails," its curious bill being adapted to enable it to deal with their strong shells. The natives call it "Enkonamasonko," which shows that they know its habits, "E'sonko" (plural Masonko) meaning "shell," and "Oku-kona" meaning "To knock."

It is quite a common bird, but only at certain places, usually an open rocky shore where the *Ampullariae* are easily found.

Another all black stork of about the same size (*Ciconia nigra*) is often mistaken by the natives for the "Mpavana," so that at first when one asked its name one always got the name for the ibis. However, a more observant native distinguished it as "Sombabyuma," a curious name which implies that this bird collects pieces of iron!

Another stork of about the same size, but black and white (*Abdimia abdimii*), appears from time to time in large flocks that, after soaring round and round high up in the air, descend to open grass land and eat grasshoppers. The natives call it by the name "Enunda," which is apparently their equivalent for the English "stork," for they applied the same name to a specimen of the fine saddle-billed stork (*Ephippiorhynchus senegalensis*), which I once, and only once, saw on the shore of Buvu, in the Sesse Archipelago, in 1912. It is a fine bird, with blue-black and glossy bottle-green and white plumage, the huge bill being crimson and black with a "saddle" of yellow. The European stork, curiously enough, was never met with on the islands, and I had never seen it until I found it numerous in the Singidda district of ex-German East Africa, at the southern end of the great East African Rift valley—this was in February 1918. The remarkable Nilotic whale headed stork (*Balæniceps rex*) was also absent from the islands, perhaps because there was not a large enough area of papyrus swamp.

The *Hammer-head*, or Tufted Umbre (*Scopus umbretta*), is not uncommon along the shore, although one never sees more than one at a time, for it appears to be a solitary bird. It is of a dull dark brown and has a large head, tufted as its name implies, with a heavy bill. It is found standing in the shallow water of a sheltered pool or bay, apparently watching for fish as do the herons, but possibly also dozing, for I think it is more crepuscular or nocturnal than diurnal.

Flamingoes, somewhat to my surprise, were never met with on the Victoria Nyanja, but I cannot say why. The lake abounds in shallow bays and quiet sheltered waters, where one would think flamingoes would find all they desire.

Herons and their allies are numerous on the islands, as might be expected. The finest bird to be seen on the lake shore is the goliath heron, which, like many other species of the Uganda fauna, extends its distribution to the west coast.

This magnificent bird is known to the natives as "Kimbala,"[1] and may be seen standing at the edge of the water or on rocks on every island. I should think there may be one to every two miles of coast line. Such large birds would, of course, require extensive fishing grounds, and I have twice seen disputes between a goliath heron and a fish eagle.

On the first occasion I was examining the coast of Buvumira Isle, in 1912, when one of these great birds was seen flying over the surface of the water with a fish eagle in hot pursuit. When the eagle came uncomfortably near the heron dropped on to the surface of the water and sat there with his beak in a defensive position ready to jab at the eagle should it be unwise enough to attack, and turning round as so to keep facing the eagle from whatever direction it threatened, erecting a crest of feathers on top of its head when the eagle came near. The eagle did not venture to attack, and drew off a little, whereupon the heron took to flight again, its enormous wings beating the air with slow strokes. Seeing its enemy again on the wing the eagle made another dash at it, whereupon the

[1] Some less observant natives call this bird "Balwa," but I think this name belongs to another heron, possibly the *Ardea purpurea*.

heron repeated its defensive tactics, dropped on to the water, and took up the same attitude as before.

As soon as the eagle drew off the heron took to wing again and this time was not pursued; the eagle, being satisfied that the trespasser had been driven from the private fishing grounds, returned victorious to its favourite perch, while the heron slowly disappeared into the distance.

On the second occasion when the two birds were seen in conflict, the heron had the best of it. This was in 1913, when I was going down to see Nkosi Islet, the southernmost of all the Sesse group. While passing down the channel between Kirugu and Buguye, I saw, on the islet Lula, a fish eagle swoop down upon a goliath heron that was standing on the shore, but presumably trespassing on the eagle's preserves.

There was some rough and tumble business, and then the eagle was seen on the ground, and whenever it moved the heron jabbed viciously at it with its formidable beak, and, I think, had one foot on the eagle to hold it down. A considerable noise was made, but I think the heron was chiefly responsible for the very savage snarling and grunting sounds that came from the pair. I confess my sympathies were with the eagle, who seemed to be getting much the worst of it, but eventually managed to disengage and fly away, and the heron did not pursue.

It would seem as if the eagle was superior on the wing, and the heron knew it, but was in the stronger position on the ground. In the case first described the heron was at first seen on the ground, but took to wing at the approach of the canoe, when the eagle gave chase; presumably it had not dared to attack before. The hoarse, raucous cry of the Kimbala is quite startling when one suddenly gets up, frightened by a gunshot, from a thick bed of rushes where it had been standing unperceived. It is a handsome bird, coloured with various shades of brown and purplish grey. It is curious that I have never seen one actually feeding, but presumably it catches fish and frogs like other herons.

Several other species are to be seen. A grey one is known as "Sekanyolya" (*Ardea melanocephala*), but I have nothing to say about them.

An extremely beautiful but seldom seen species was noted in 1918 on rocks off Damba Island, a locality that has been alluded to before. There were seen, among many other birds, half a dozen great white herons (*Herodias alba*), collected on one small low rock, their pure white plumage and graceful build arousing intense admiration. Subsequently, some were seen on other islands, but they are by no means abundant, and the natives have no name for them other than "Enyange nene," i.e. large egrets.

But the *Egret* (*Egretta garzetta*) is more slender, smaller, and has a black bill and legs. It is quite common on the islands, and may constantly be seen paddling at the edge of the water on the beach or on flat rocks where the waves are breaking, picking up small fish from the water, or investigating small pools for frogs, its pure white plumage making it very conspicuous.

Although they usually fish by themselves, egrets may often be seen at sunset in small flocks wending their way home, flying slowly over the surface of the blue water with hoarse croaks.

They nest in much the same situations as are chosen by darters and cormorants, namely, ambatch trees growing in shallow water. In January 1919 I found some young almost ready to leave the nests.

A bird that is often mistaken for the true egret is the white buff-backed heron (*Bubulcus ibis*), which is extremely abundant at Jinja or Entebbe, where flocks may be seen in attendance on cattle, ready to pounce on the grasshoppers and other prey disturbed by the movements of the grazing beasts. But they are not so slenderly built as the more graceful egret, and their shorter, stouter bills are yellow instead of black, as also are their legs.

Curiously enough they are, on the islands, no more plentiful than the true egret, perhaps because there are no cattle to collect them together in flocks.

Doves were common, but several notable species found on the mainland were never seen on the islands—for example, the small, long tailed *Æna capensis*, seen at Jinja. A forest species, whose long drawn out call was heard coming from the tops of tall trees when I examined patches of forest on the Kyagwe coast, was never heard in the island forests. The beautiful green fruit pigeon (*Vinago*), with red bill, was quite common, as might be expected from the abundance of fig trees growing on the rocky shores. It has a long and rather complicated call, which one soon got to know, but found impossible to imitate.

Game Birds are chiefly remarkable for their absence. No guinea fowls were ever seen or heard, nor any of the larger "bush-partridge" (species of Francolin). It is possible that they had been exterminated by natives trapping them in the old days before the outbreak of Sleeping Sickness.

A certain loud, ringing cry was so frequently heard from the depths of the forest belt on Bugalla that I soon became thoroughly familiar with it. But it was long before I found out what was the bird responsible for it. One day in the forest a bird that at the time was noted to be of the partridge type, ran out from a clump of thick undergrowth, but seeing me almost at once dived back again. It was undoubtedly the bird that was responsible for the well-known cry that had been coming from that spot. Further knowledge of birds made it obvious that this must have been one of the forest Francolins.

I believe that this bird has much increased its range on the islands since those days. Between December 3rd, 1918, and mid-February 1919, I examined thoroughly a chain of islands which I had visited in 1914 with Mr. Fiske. On the second tour this forest Francolin was heard calling on every isle that had forest to shelter it, where it was not noticed in 1914.

The only other game birds of the islands are *Quails*, of which two species were met with; but save that one is much larger than the other there is nothing to be said about them.

Birds of Prey.—The most conspicuous bird of prey is, of course, the glorious white breasted Fish Eagle or "Empungu" (*Haliaetus vocifer*), which is literally quite a feature of the landscape. Its pure white head, neck and breast, set off by rich red brown and black on body and wings, render it visible afar when perched on a tree top or prominent branch hanging over the water. Its joyous scream, uttered when soaring round and round high in the air, or when perched on the tree, is a most delightful noise, full of life and vigour. When screaming the bird throws back its head until it almost touches the back, and the loud cry is responded to by its mate, for they seem to live together in couples.

The noise made by the rush of air between the pinions when one of these superb birds sees a fish at the surface and stoops to secure it can be heard before one has actually seen the bird, and amounts to a loud roar. Sometimes the bird chooses a fish of such size that it cannot lift it. An officer of the Uganda Marine told me that he had seen one taken under water by a fish in which its talons were presumably inextricably fixed. It was probably one of the large lung fishes which had come to the surface for a breath of air.

So far as I can remember, however, the eagle does not usually plunge quite into the water, but checks itself before the impact, neatly picking up the wriggling prey with its feet, and carrying it off to a favourite perch.

During brilliantly fine weather, when there is usually

NEST OF OSPREY ("MAKWANZI")

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a steady southerly or south-easterly breeze, the eagles soar round and round high up in the air and scream frequently and loudly.

A native told me that this was a sign of high wind coming, but I do not think it is of any more significance than an indication of the fine breezy weather as aforesaid.

The nest of the fish eagle is a conspicuous structure in the fork of a large tree. In October 1910 I saw a bird carrying in its talons a mass of building material up to the chosen nesting place.

A certain large "Muvule" tree at Jinja was in use as a nesting place in 1914, and I found it still in use in February 1919, so that these birds would seem to choose the same spot year after year.

The fully fledged young bird has a rather untidy appearance, its dark blackish plumage being irregularly spotted with dull white, and it only gradually acquires the magnificent snowy breast of its parents. The young, two in number, remain at the nest long after they have begun to fly, and are apparently driven away by the parents to look after themselves. At least this is the interpretation I put on what was seen on Kerenge Island in January 1919. Two adult birds were soaring round and round, and a third, in immature plumage, was apparently objectionable to them, for they kept swooping down and obviously trying to drive it away, yet not really endeavouring to hurt it, and desisting from their attacks when it went a sufficient distance away.

Another fish eating bird of prey is the common Osprey, but I have unfortunately nothing particular to say about it. The natives call it "Makwanzi," and a nest photographed on the small Islet of Wavuziwa in January 1919 was attributed to this bird.

After the fish eagle the most conspicuous bird of prey on the islands is a brown, yellow billed Kite, "Akamunyi"

(*Milvus ægyptius parasitus*), which is really extremely abundant. It was noticeable that the hills on certain islands, such as Kizima, always had a number of kites soaring over them, and it seems probable that the small area of heated lands surrounded by cooler water caused a continual up-current of air on which it was easier for them to soar.

Their shrill, quavering cry is very characteristic and quite pleasant to hear. I think there are in proportion to area many more kites among the islands than on the mainland, at any rate the cry is not nearly so often heard at Entebbe or Jinja. Possibly this is because they are in a manner scavengers of the surface of the lake, and will swoop down and pick up small fish, or dead fish mangled by gulls, or other objects floating on the surface. But their appetites are all embracing. A grass fire will attract numbers of them, as well as of other birds, who sail round and round ready to pounce on grasshoppers and other insects fleeing before the flames.

When winged termites swarm out of the ground in times of rain, kites speedily collect and circle round and round, catching the feebly flying termites in their feet. It is pretty to see one while on the wing stretch his foot forward and take the food from it with his beak in an easy, leisurely manner. The kite is not above trying to rob other birds of their prey, and will swoop down upon one in the endeavour to make it drop the fish which it has picked up for itself.

Another smaller kite, known as "Ma'ga" by the natives (*Elanus cœruleus*), is quite common on certain open grassy islands. It is of a soft dove-grey and white. Its habit of hovering vertically over one spot with rapidly beating wings deceived me into thinking it was a species of kestrel, but I was put right by Mr. C. F. Belcher. While in camp at Jinja in 1910 I used to watch these birds carry the mice which they had caught on to a certain tree in front of the tent, and noted that they usually pulled out the viscera and let them drop to the ground below.

A fairly large grey bird that may have been a buzzard was noted at Jinja under rather peculiar circumstances.

I was walking along a path thickly bordered with castor oil bushes, when I heard a great fluttering coming from one, and saw a large grey hawk hanging by its feet from something yellowish on a stem of the bush. It appeared as if the bird had caught its feet in a tangle of creeper, and I went up to release it, wondering how I was going to avoid its sharp bill.

When I approached within a few feet the hawk suddenly flew away, leaving a yellow object hanging from the branch. Only when a bright red drop slowly trickled down did I realize that the object was a chamæleon.

The hawk had pounced on it and was trying to drag it from the branch, but the chamæleon had such a firm grasp with its prehensile tail that all the flutterings of the bird had not succeeded in dislodging it. However, the grip of the talons had so injured the chamæleon that it died almost immediately, so that the bird would have been able to carry it off in the end.

I examined the stomach contents of the chamæleon and found a small snail and remains of orthopterous insects, probably tree dwelling *Locustidae*.

A propos this observation, it may be said that the small brown lizards that run about on the grass roofs of native huts appear to be a desirable food, for one often sees birds of prey swooping down on them.

I once saw a large cock peck at one till it was disabled and then swallow it whole, a disgusting sight!

Owls.—The cries of two species of owl are very familiar. One is a melodious quaver, heard on moonlit nights, the other a deep soft "*Hoo*-hoo," probably uttered by a big "long eared" owl (*Bubo lacteus*). During the day time one often hears quite a different noise proceeding from a thick shady tree, obviously emanating from an owl, but whether from the latter species or another I cannot say.

As with other groups of birds, notable absentees from the islands may be mentioned among birds of prey. Vultures were never seen, but this is perhaps what might be expected from the absence of game. The beautiful Bateleur eagle (*Helotarsus ecaudatus*), so noticeable on the mainland, was either absent or so scarce on the islands that I cannot remember having seen it there.

Another fine species, the Black and White Crested Eagle (*Spizaëtus coronatus*), known to the Baganda as "Wonzi," was only very occasionally seen. I first became acquainted with this handsome, fierce looking bird at Jinja, where its rather weird scream was often heard, and the bird was often seen to perch on the summit of a dead tree.

The next family to be mentioned is that of the *Parrots*, about which I have not much to say, since I have only met with one species on the islands. This is curious, because at Entebbe and Bukakata and Jinja may be seen quite commonly one of the small green parrots with yellow shoulders.

The well known grey parrot with red tail occurs on many of the larger forested islands, and its discordant shrieks were familiar. At daybreak and eventide they fly to and from their favourite feeding grounds in small flocks, and, like no other bird, chatter and whistle continually as they go. Often one hears the well known noises high overhead before the birds have come into view.

On Sanga Islet one day, there were some parrots feeding in the trees which took alarm and flew off as I walked underneath. One of them gave a call which seemed to be an imitation of the monkey's alarm, the only example I can cite of a wild parrot copying other sounds.

After the parrots come the *Plaintain Eaters* (*Musophagidae*), one of which (*Musophaga rossae*), known to the natives as "Fulungu," is one of the loveliest birds of Uganda.

Somewhere about the size of a rook, but with much larger tail, this bird has deep purplish blue plumage with bright crimson patches on the wings, making it very conspicuous when it flies. It also makes itself conspicuous by its voice, for it is a noisy bird. A company of them will be heard apparently working themselves up to concert pitch, with short cacklings and gurglings, and then they suddenly all burst out together into loud, not unmusical cooing in a most pleasing manner.

These birds are typically forest species, and are only seen where the forests are of some size, so they do not occur on the smaller islets.

Another species of very different appearance has much less gaudy plumage, being ashy grey, and showing patches of black and white on wings and tail when flying : probably it is *Schizorhis*. I often used to see a pair on Damba, where a marshy piece of shore had ambatch trees in flower that were highly attractive to these birds, which were frequently seen pulling off the bright yellow flowers and devouring them.

They, like the *Musophaga*, are noisy birds, and attract attention by their vociferous habits.

One, presumably the cock bird, used to do what airmen call "stunts" in the air, shooting vertically upwards and then dropping headforemost to join the other in the ambatch bush, with the accompaniment of loud cackling and crowing noises. Though so frequently seen in the ambatch bushes they always came from the forest, to which they retired when alarmed.

The *Lark-heeled Cuckoos* or *Coucals* (*Centropidae*) abound among the forests and patches of bush on the islands, but there are differences from the mainland in the proportions of the species. Their liquid gurgling notes, descending and ascending again, have earned for them the native name "E'tutuma" and the English "Bottle Bird," the latter name because of the resemblance to the noise made by water being poured out of a bottle with long narrow neck.

Generally speaking, they are skulking birds, avoiding the open and concealing themselves among bushes, undergrowth or papyrus, whence they fly heavily away with broad tail outspread.

Heavily built, with large stout beaks, they cannot be considered attractive, though their rich brown, black and white or yellowish plumage is often beautiful.

A species that was unusually abundant on Bugalla (*Ceuthmochares æneus*) was of a dark greenish black all over, with the large bill bright yellow. Its note also was somewhat different from that of most coucals, being a harsh screech. I saw one fly away from a clump of bush with a butterfly held in its beak, but another that I shot had fed largely on hairy caterpillars, as is the cuckoo custom. So much less common is this species elsewhere that I cannot remember having noticed it on other islands or the mainland. On the other hand, a certain large species, whose deep booming call is heard in mainland forests, was absent from the islands.

Next to be mentioned are the *Cuckoos*. I am familiar with the notes of only two species of cuckoo on the islands, one of which (*Cuculus solitarius*) is very common and from its cry has been named "Sekoko" by the natives. The frequently reiterated call is a descending sequence of three notes, and during the rainy season is very noticeable, the bird sitting perched in a conspicuous place and calling again and again as does our English species.

Though its colouring is different from that of the latter

VIEW FROM CAMP ON KOME, LOOKING EASTWARDS.
Damba Isle in far distance.

VIEW TOWARDS BUVUMIRA FROM BUGALLA CAMP.

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bird, the Sekoko is very obviously a cuckoo, both when seen perching and on the wing. It seems to call only during the two periods of greatest rainfull, when it is presumably breeding.

The other cuckoo whose note is familiar is the "Ekirimululu," (*Chrysococcyx caprius* or *C. klaasi*), one of the bronze cuckoos, a small species, metallic green above and whitish beneath. The native name, like so many others, is doubtless onomatopœic.

Another group, the *Barbets*, is strangely unfamiliar on the islands. One of the commonest of all, the little Coppersmith (*Barbatula leucolaima*), has never been heard on any island, although its monotonous "Tonk-tonk-tonk" can be heard all day long in the Entebbe gardens. Their absence from the islands was made more noticeable when in January 1919 I went across to the Kyagwe coast from the camps on Kerenge and Wema. Almost immediately one landed on the mainland one heard the well known metallic note in the forest, together with the notes of other birds not present on the islands.

Larger, red breasted barbets have not been noticed either there, but they do not force themselves upon one's attention as does the persistent coppersmith.

The next family, *Coliidae*, is easily dealt with, for they are absent from islands that have been visited, and since I was quite familiar with them at Jinja before I first went on to the islands, they would certainly have been seen or heard, for I know the twittering sound they make very well; it is constantly heard in the gardens at Entebbe.

We now come to the *Rollers* and their allies. Rollers themselves may be dismissed in a few words, for I never saw one on the islands. I had seen them at Jinja in 1910, and thus knew their appearance, and, having seen them in numbers during the East African campaign, was on the look out for them when I returned to the islands in December 1918, but the result was the same.

This seems very curious, and I should like a practised ornithologist to confirm or contradict the statement.

Other members of the sub-order now being considered are the *Hornbills*, one of which (*Bycanistes subcylindricus*) is one of the most characteristic birds of the Uganda forests, and abounds on the islands. This great black and white bird with its curious bill is known to the natives as "E'nga-nga," from its nasal, raucous cry. It is a noisy and conspicuous creature, clumsy and grotesque in its habits, and is perceived both by ear and eye from a considerable distance away. The flight is heavy, and the beating of the wings for a few strokes is followed by a pause during which the bird sails through the air with wings outspread, making a loud roaring noise presumably owing to the arrangement of the feathers. When an "E'nga-nga" flies past, I am always reminded of the noise made by a puffing locomotive as one hears it coming from a distance, the noise rising in pitch and getting louder as the engine approaches, falling and dying away as it disappears in the distance. The bird also frequently screams while flying, as if to let all the world know where it is.

I believe that there is an explanation of this noisy flight as aposematic—the conspicuous bird makes itself perceived by ear as well as eye in order that enemies may recognize it. It is of interest that Dr. G. A. K. Marshall records that the flesh of an allied species was found distasteful by a mongoose, and that natives look on it as so poisonous that it will render water unfit for drinking if the carcase falls into a stream.[1] The subject of aposematic flight will be brought up again in the chapter on the *Hymenoptera* in connection with the fossorial *Pompilidae*.

Foolish looking as is the "E'nga-nga," it is surpassed in that respect by a more slenderly built smaller species,

[1] *Proc. Ent. Soc. Lond.*, 1902, pp. 378–9.

without any casque on the bill, whose appearance always fills me with resentment that it should exist at all (*Lophoceros melanoleucus*). It has a floppy flight, rising and falling as it flaps its way along with inane, shrill cries. Its dull whitish and black plumage has not the pure tints and arresting appearance of the "E'nga-nga," and indeed I find it difficult to say anything nice about this bird.

No other hornbills than these two species have been noticed on the islands.

Next to be mentioned are *Kingfishers,* and it is curious that the natives have the same name for one very common black and grey spotted species as for Bee-eaters ("Mujolo"), but other kingfishers are known as "Akasimagizi."

The "Mujolo" kingfisher (*Ceryle rudis*) is extremely common along the lake shore, where shallow water with sandy bottom provides good fishing grounds. Its habits are somewhat different from those of other species, such as our familiar one at home, which plunges into the water from some commanding perch. *Ceryle rudis* hovers over the water, head hanging down with beak pointing vertically to the surface, wings rapidly beating like those of a kestrel. Often it has to wait a long time, and change its position till some unwary little fish comes near enough to the surface, when the kingfisher plunges in head foremost and secures it. This bird is rather vociferous, and its twittering cry is very often heard as it flies across the water, keeping close to the surface. Another species of *Ceryle* (*C. maxima*) is scarce, and of solitary habits, very much larger than any other kingfisher on the islands. It lurks among bushes overhanging the water, and is usually first noticed flying away when it has been disturbed, uttering a loud unmusical bleating cry.

Beautiful little species of the genus *Ispidina* (? *picta*) are often seen among the rushes growing in shallow water or on low twigs of ambatch trees just above the water, whence they plunge in to secure their prey. Their feeble little piping note is much like that of our English kingfisher, but though very soft it often directs one's attention to these lovely little birds as they dart past.

About the size of a sparrow, but, of course, of different appearance, with short tail and enormous bright red beak, these birds have lovely orange and deep blue plumage.

Natives say that if one comes near their house it is an omen that some one is going to die; and it was a curious coincidence on Bugalla that when one of my canoe-men was ill with pneumonia one of these birds was frequently noticed in the camp, although I had not seen it there before.

I did not know the superstition until some time after this. Fortunately the canoe-man recovered; perhaps if he had known the bird of evil omen was there the issue would have been less satisfactory!

Another kingfisher, of different habits, is *Halcyon senegalensis*, whose large beak and legs of crimson contrast beautifully with its sky blue wings and back and grey under surface. This is a forest or bush frequenting species which has given up a fish diet in favour of large grasshoppers.

Sitting on a branch it watches the grass for movements and then pounces down on a "Janzi" grasshopper which it carries back to the perch. Here the unfortunate bulky insect is banged against the branch until it is in the right condition to be swallowed whole. This kingfisher has a loud and cheerful cry. It commences with a sharp high-pitched note which is followed by a churring descent down the scale, and on a bright sunny morning this familiar sound may be heard over and over again.

I saw an interesting little incident on Kerenge in 1914. One of these birds was angrily scolding on a perch which he considered to be his, but the justice of the claim was

NESTING PLACE OF KINGFISHERS (*CERYLE RUDIS*), NGAMBA ISLE, 1918.

The little cliff, about a foot high, shows dark patches where damper sand has been thrown out from the burrows
The ledge was left by the recession of the lake since 1917.

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disputed by one of the Paradise flycatchers, which kept trying to get at the kingfisher from behind. The other, however, spun round on the perch just as quickly so as always to face the angry flycatcher.

But at length another flycatcher came up, and the kingfisher made off, thinking discretion the better part of valour.

Another species of *Halcyon* may here be mentioned on account of its remarkable absence from the islands. This dull mottled greyish bird, *H. chelicuti*, is abundant both at Jinja and Entebbe, where its "cheer-oh" cry may often be heard in chorus, and yet I never heard it on the islands, although Van Someren gives "Sesse Isles" as a locality for this species in his check list.[1]

The absence of the insectivorous Rollers seems to be compensated on the islands by great abundance of their allies the *Bee-eaters*. These graceful birds, known to the natives as "Mujolo," soon attract attention from their habit of perching on the tip of a dead bough in a commanding position and swooping down on their prey, returning with it to the same perch. Two species, *Merops superciliosus* and *Melittophagus meridionalis*, became very well known, and the liquid twitter of the former was one of the most familiar bird sounds.

When a blustery wind is bringing up storm clouds, this bird often soars overhead in numbers, braving the buffeting of the gusts of wind and possibly catching the insects that are driven before the storm.

Melittophagus is found more often in grassy places, or at the edge of the forest perched on an especially tall stem of grass or rush. It keeps nearer to the ground than does its larger, long-tailed relative. Neither of these birds is brilliantly coloured, but their green, yellowish, and brown hues are very pleasing, and their long bills and graceful shapes give them a very attractive appearance.

[1] *The Ibis*, 1916, p. 244.

I noticed particularly that Dragon-flies are a very favourite food of both species, as well as the bees and other *Hymenoptera* on which they are well known to feed, which were constantly found in the stomachs when I was searching for evidence that the Tse-tse fly was eaten by birds. (See vol. xiv of Sleeping Sickness Reports of the Royal Society, 1913, pp. 15–16.)

STOMACH CONTENTS OF BEE-EATERS.

Merops superciliosus.	*Melittophagus meridionalis.*
1. Mainly dragon flies.	1. Mainly dragon flies.
2. Dragon flies and honey bees.	2. Dragon flies and honey bees.
3. Dragon flies and honey bees.	3. Dragon flies.
4. Dragon flies and honey bees.	4. Dragon flies.
5. Dragon flies and honey bees.	5. Dragon flies and small beetle (Lamellicorn).
6. Dragon flies and honey bees.	6. Winged ants and one small dragon fly.
7. Dragon flies and honey bees.	7. Dragon flies and bees.
8. Dragon flies and honey bees.	*8. Winged ants only.
9. Dragon flies and honey bees.	*9. Winged ants and one Agrionid dragon fly.
10. Dragon flies and honey bees.	*10. Winged ants and a small species of *Chrysididae*.
11. Dragon flies and honey bees.	*11. Winged ants.
12. Dragon flies, bees, and a *Belonogaster* wasp.	
27. Dragon flies.	* These were all shot on the same day (11·12·11).
28. Dragon flies.	
29. Dragon flies and bees.	
30. Dragon flies and bees.	
31. Dragon flies and bees.	
32. Dragon flies.	
33. Dragon flies and bees.	
34. Caterpillars and young *Mantidae*.	
35. Eleven bees.	
36. Twelve bees, one wasp, one dragon fly.	
37. Twelve bees, one male Stink ant (*Paltothyreus*).	

Frequently one would hear a loud tapping noise, and looking up would see a bee-eater with a large dragon fly in its beak banging it against the perch on which it sat, finding the long body and wings rather unmanageable, for they swallow the dragon flies wings and all.

Butterflies appear to be eaten by *Melittophagus*, for I have found on the ground, under a grass stem on which one had been sitting, wings of the little yellow *Terias* butterflies, although I have not actually witnessed the capture in this case.

Another group of birds allied to the Rollers may be dismissed in a few words, namely, the *Wood hoopoes* (*Irrisorinae*), for I have never met with them on the islands, and first saw them when on active service in German East Africa.

Such noisy and conspicuous birds could hardly have escaped notice had they been on the islands, and when I returned in 1918 they were watched for, but never seen.

The family of *Goatsuckers*, or *Nightjars*, is represented on the islands by a species of *Caprimulgus*, whose native name is "Olubugabuga," presumably an attempt to reproduce one of the noises that it makes. On moonlit nights, when owls are also heard, these birds keep up a continual "Tok-tok-tok-tok-tok," varied occasionally by the melodious cry from which their name is derived.

The bird itself is often flushed during day time from its resting place in places that may sometimes be quite open and fully exposed to the hot sun, or sometimes shaded and among bracken. There is nothing about the bird to call for remark, unlike the East African species with long floating plumes, which has not been met with on the islands.

It is, of course, highly probable that there is more than one nightjar on the islands, but I am familiar with only one cry.

We now come to the great order of *Passeriformes*, embracing large numbers of small birds, which I must perforce pass over in silence, not being sufficiently familiar with the comparatively inconspicuous species.

Certain species, however, call for notice, and first among them are the *Flycatchers* (*Muscicapidae*), of which two species particularly attract attention. The first, *Tchitrea emini*, is illustrated from a photograph which shows well a very beautiful feature, namely, the long snow white tail plumes assumed by the cock bird in the breeding seasons. The rich chestnut brown, black and white plumage of body and wings is set off by slaty blue black crested head, and it is a delight to watch the vivacious bird, as it is for ever flitting among the branches and chasing another from perch to perch. The insistent call, quite impossible to describe, loud and ringing, was the first bird note to be heard in the early morning from the forest around the camp on Bugalla. As soon as the darkness began to lighten these delightful birds were awake and filled the forest with their call. The native name for this bird is "Kunguvu." When I left Bugalla I went home, but the memory of the call there has persisted clearly, and I am sure that the Bugalla race of the Kunguvu has its own call, i.e. a geographical race is being developed. The bird is plentiful enough on many other islands ; indeed, it is one of the species which is far more abundant on islands than on the mainland, but nowhere has its call quite the same character and finish as on Bugalla. I particularly noticed this during the tours of 1914 and 1918–19, during the latter of which several forests on the mainland coast were visited.

It is not surprising that the birds on a large island such as Bugalla should be forming a local race—they are confined to the forest and do not take long flights.

One was never tired of seeing the cock bird pursuing the hen among the branches, excitedly calling to her, with snow white plumes trailing in the air as he flitted from branch to branch. The nest is a small shallow cup-shaped structure ; I have seen it fastened to the end of a dependent creeper, quite exposed in the open, but in such a position that nothing without wings could reach it. The hen bird was fully exposed as she sat.

"KUNGUVU" FLY-CATCHER (*TCHITREA EMINI*).
Foot-rule on right.

NEST OF CROCODILE.
The marks of the mother's body and tail on the sand can be plainly seen.

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Another delightful little bird that soon became very familiar on Bugalla was the black and white flycatcher, with bright red wattle over the eye, probably *Platysteira jacksoni*, whose call note is very characteristic. Two birds were often heard calling one to another. The first, with high-pitched pipe, would sing " How *are* you ? " to which the other responded, " I'm *pret*-ty well, thanks." By whistling the first phrase I could often get the answer and bring the bird near. Like *Tchitrea* this bird seems to be forming a local race on Bugalla, for the call elsewhere is not *exactly* the same, although one can recognize it as coming from the same bird.

It is not so much a forest frequenter as *Tchitrea*, being found more among the clumps of bush and copses that make the park like country on the larger islands.

A third very pretty little flycatcher (*Elminia longicauda*) is worth noticing here, because I have not seen it on the islands, save once on Kizima, though it is often seen in the gardens of Entebbe. It is a light blue bird which has a habit of spreading out its tail fanwise, and hence attracts one's attention.

Shrikes are noteworthy because several species familiar in the gardens of Entebbe and Jinja have never been seen on the islands. Conspicuous among these is the beautiful black bird with scarlet breast (*Laniarius erythrogaster*), pairs of which haunt *Hibiscus* bushes, whose red flowers exactly correspond with the breast of the bird.

They have a call note which may be crudely represented by " What-ho." This is uttered by one, and simultaneously the other of the pair makes a harsh scolding or churring noise, not at all musical. It is curious that many shrikes have this habit of uttering a joint call ; for instance, the long tailed black and white species, whose very musical notes I have often heard on mainland but never on an island.

A brown shrike (? *Pomatorrhynchus*) that was shot on

Damba Isle was found to have eaten only grasshoppers in two cases, in the third grasshoppers and one beetle.

Very noticeable absentees from the islands are the black, fork-tailed, insectivorous *Drongos* (*Dicruridae*), which were never met with there. The first ones I ever saw were on the frontier between German East Africa and Uganda in the early days of the war, and later in various parts of German East Africa they were seen abundantly, so that I became thoroughly familiar with them. When I returned to the islands in 1918 for about three months, I should therefore certainly have seen Drongos had they been present. It has seemed to me during my wanderings that where Drongos were abundant Bee-eaters were scarce, and since Bee-eaters appear to be unusually plentiful on the islands and Drongos are absent, it is possible that these birds of similar habits take each other's place to a certain extent.

The Starling family is also notable for the absence of conspicuous species from the islands, viz. the *Glossy Starlings*, which certainly could not escape notice. These birds have the typical shape and noisy habits of our home species, but their dark plumage is resplendent with metallic purple and green. Their harsh voices are very familiar at Entebbe among the tall trees, and their noisy flight also renders them conspicuous to the ear. Directly I entered the forests on the Kyagwe coast opposite the islands where I was working, these noisy birds attracted attention, so that I am quite sure they do not exist on any island I have visited.

Weaver Birds (" Endegeya ") are abundant among the ambatches which overhang the water ; but some species, that make their nests in colonies on large trees on the mainland, so that the noise of them at a little distance is like the sound of a waterfall, have not been met with on the islands.

Neither have I seen the Bishop and Widow finches, beautiful brightly coloured birds, which could hardly escape notice.

The *Fringillidae*, or Finches, would doubtless be of much interest to an ornithologist, but I have little knowledge, and less to say, about them. Noteworthy varieties on the islands are Sparrows, " Enkazalugya " (*Passer griseus*), of which very few were ever seen ; possibly the absence of mankind has something to do with this. Another notable absentee is a curious rotund little grass finch, which is abundant at Jinja and Entebbe. The cock bird when adult is black and white, and has very long floating tail feathers which appear to hinder his flight. He flits for a short distance over the grass with an up and down motion, uttering feeble chirps, accompanied by a flock of brown, insignificant looking individuals, which I always took for females. Mr. C. F. Belcher, however, tells me that most of them are immature males.

A very common and pretty little finch is often seen hopping about on the ground at Entebbe and Jinja ; of a reddish pink or old rose colour, it is often nicknamed the " animated plum." It is about the size of a red plum, and agrees with one very well in hue.

Another species, much like it in habits and shape, is grey and blue. Neither of these have been met with on the islands.

The pretty little *Sunbirds* (*Nectariniidae*) are abundant on the islands, though I know not how many species are found there. On certain very small islets they and wagtails are the chief part of the bird fauna, but this depends upon whether their favourite food plant is there. This is a labiate, which sends up tall stems bearing scarlet flowers arising from a knob. These knobs are set at intervals up the stem, and when the flowers are withered and the seeds develop are unpleasantly spiky to knock against.

Wherever a cluster of these plants grows, a sunbird is sure to be seen clinging on to the stem and thrusting its slender bill down the tubes of the flowers one after another.

There is no doubt, however, that they also eat insects, or at any rate spiders. I have seen one hovering in front of a web spun amongst tall stems of grass and delicately picking off the spider that sat in the centre of it.

On the other hand, a sunbird was once found hopelessly entangled in the strong sticky threads of a web of a *Nephila* spider, the sheets of whose webs are so unpleasantly abundant on many of the islands. Fortunately, I was able with a stick to reach up and set the bird free. The cock bird is a beautiful little creature, the prevailing hue being rich metallic green, but different species have the throat and breast of brilliant scarlet or other bright colours; the hen bird is dull brown or grey. As is usually the case with brilliantly coloured birds, the song is not musical, but it is quite a pleasing, lively little twitter.

They are pugnacious birds, and may often be seen chasing each other with angry scoldings, and I have watched them chasing away the huge Carpenter bees from the attractive flowers of a bush.

The *Warblers* must be passed over, since I have no ornithological knowledge of them; but there is one species that is very familiar, since it inhabits the low bushes in the forest and its sharp chirp is heard everywhere. It has the appearance and manner of a wren, with short upturned tail, and is constantly in evidence climbing about among the branches on which it hunts for sedentary insects, or angrily chasing away another which is trespassing on its feeding grounds. It is, I think, more abundant on the islands than on the mainland.

The *Thrush* family deserves mention on account of the fine songster *Cossypha*, (possibly *heuglini*,) or Robin Chat (E'nyonza), which abounds in the forests. It is a handsome bird, but one seldom seen, as it is of retiring habits and rarely leaves the sheltering bushes. Occasionally one gets a glimpse of its bright orange under side, with dark back and white streak on the head. Its mellow voice reminds one in a way of the blackbird; but it has a unique method of singing as if for its own enjoyment, quietly and in a thoughtful way; there is no "fine careless rapture." It is an extraordinarily clever mimic, and in the evenings one can hear it copying the notes of fish eagle, owl, blue kingfisher, cuckoo, and doubtless many other birds as well, introducing the well known notes into its own steady flow of music.

Song thrushes, obviously closely allied to the English songster, are abundant at Entebbe, where their music brings up memories of home; but they are only occasionally heard on a few of the islands. Kibibi, Kiuwa and Kizima were noted as having these birds.

CHAPTER IX

REPTILES AND FISH

A BOOK about life on the Victoria Nyanja may reasonably be expected at least to mention the crocodile, known to the natives as " E'gōnya."

His scarcity was what one noticed most, for which a reason will be suggested later. One had read so much about crocodiles in tropical rivers lying thickly on the mud, and in great numbers in the water, that one had expected to see the same in the lake. This was far from being the case, and it soon became clear that one or two could usually be seen on any day frequenting the same haunts, but that it was possible to go long distances and never see a crocodile, and young specimens are rarely seen.

Their favourite haunts are of two kinds—a stretch of coastline fringed with rushes and reeds growing in shallow water, wherein they lie with only the top of the head and scaly ridge of the back and tail showing, or an open shore of rock or sand on which they warily bask. Near my camp on Bugalla the northern bay furnished a haunt of the first kind, and a large crocodile could nearly always be seen there. Ngamba and Tavu Islands provided rocky basking places, and a favourite large rock on the east side of Tavu was seen, whenever visited, to have one or more crocodiles basking on it, and on one occasion seven were seen there, which was the greatest number ever seen together. It was amusing to see these huge antiquated reptiles take alarm as soon as the canoe drew near, and plunge headlong into the water; they were always off before one got near enough to take a photograph.

It seems strange that such a huge and well defended creature should be so nervous. On the only occasion when I have got within camera range, of course I had no camera with me. On the northern coast of Ngamba I was pushing my way through rocks and dense bushes when I suddenly heard, apparently right in front of my feet, a horrid noise, half hiss, half snarl. Hastily stumbling back, I saw I had nearly stepped on the head of a large crocodile lying on the ground. I remained still and watched, noting Tse-tse fly feeding on him, and wondered why he did not, as usual, rush headlong into the water. Before going away I threw a lump of rock on to his back, but that did not move him; he merely hollowed his back, raising head and tail in the air, and with mouth wide agape gave a sort of bellow. Possibly he was sick or was exhausted from fighting, for there was an ulcerated wound at the base of his tail. On the same island at a later date I saw another large crocodile with a similar wound, but on the opposite side, and wondered if this had been the partner of the duel.

Crocodiles deposit their eggs in a hole scooped in a dry sandy beach; these are afterwards carefully covered over to a depth of about a foot, and one often sees the imprint of the body of the mother on the soft sand, even the pattern of the scales on the belly being clearly shown, so that it appears that the parent returns to visit the nest, though she does not seem to be very successful in protecting the eggs, as will be seen later.

During 1914 numbers of nests were found, of which a list is given below: the number of eggs varies little, averaging sixty in one nest. No evidence was obtained that more than one crocodile lays eggs in one nest.

The period required for development is stated to be twelve weeks.[1]

Where Found.	Date.	Number of Eggs.	State of Development.
1. Marida ..	Feb. 21	58	33 almost ready to hatch. 25 shrivelled and undeveloped.
2. Masovwi	March 6	59	Embryos about $\frac{1}{3}$ grown.
3. Kizima ..	March 11	60	Embryos about $\frac{1}{4}$ grown.
4. Bulago ..	March 14	64	Embryos about $\frac{1}{3}$ grown.
5. Tavu ..	June 17	60	Freshly laid.
6. Kimmi ..	June 30	59	Laid between June 23–30.
7. Kimmi ..	July 6	69	Laid between June 30–July 7.
8. Bulago ..	July 24	66	Laid between July 17–24.
9. Bulago ..	July 24	57	
10. Bulago ..	July 24	76	
11. Tavu ..	August 18	65	Laid between July 30–August 18.
12. Tavu ..	August 18	48	
13. Tavu ..	August 18	38	

Note.—Only in the first case was every egg examined, and the number that had failed to develop is surprising. In view of this fact it is to be regretted that subsequently only a few from each nest were broken open.

The Monitor Lizard.

By far the most notable reptile on the islands is the enormous Monitor Lizard (*Varanus niloticus*), called by the natives "Enswa-swa." It is of a dull grey colour speckled with yellow, and its long tail is flattened from side to side for swimming. This fine creature may measure almost six feet from nose to tail tip. It is never found far from the water, into which it rushes headlong when disturbed, so that its panic-stricken flight is very often heard as one pushes through the dense vegetation bordering the shore. In the water the Enswa-swa swims with vigorous strokes of the flattened tail, and may often be seen lazily sculling itself along with the top of the head just above the surface. When alarmed it hastily dives, and can remain under water for a

[1] Gadow, *Cambridge Natural History*, vol. Reptiles, p. 465.

A CANOE-MAN AND AN "ENSWA-SWA" JUST CAUGHT.

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surprisingly long time. Like the crocodile, *Varanus* has favourite basking places on the rocks, choosing preferably a place where ferns grow, on which it lies; but curiously enough if one is *tethered* in the sun it dies, apparently from exposure, in an hour or so.

Crocodiles are, as has been said, scarce among the islands, but *Varanus* is very abundant, and must have increased in number very greatly since the removal from the islands of the natives, among whom skins of Enswa-swa are in great request for making the long narrow "Engabi" drums, which are beaten by the hand at convivial gatherings or weddings. But though the Enswa-swa are abundant enough, one does not often meet with their nesting places; the only three that I ever saw were a sandy patch of open ground on the north side of Kimmi Island, where burrows and fragments of old eggshells were found, a regular warren in sandy soil on Busiri, and a similar place on the south end of Sindiro Isle. Occasionally I saw very young Enswa-swa close to the water sunning themselves on little branches like any other lizard, but I do not think the adult climbs up trees; it appears to be an instance of the losing by an adult of an ancestral habit retained in youth. A curious inverted ratio was found to exist between the members of crocodiles and Enswa-swa on any particular islet: during the tour at the commencement of 1914 it was noted that if many Enswa-swa were seen there were very few crocodiles, and *vice versa*. Thus, on Tavu Island, where more crocodiles were seen than on any other island, Enswa-swa were exceptionally scarce; this was verified by many visits and work on the island. On the other hand, when Rumfua was visited, during the examination of its shores from a canoe five *Varanus* but no crocodiles were seen. It must be admitted, however, that Rumfua was only visited once. Isentwa was noted to have abundant Enswa-swa, but no crocodiles were seen there. Although it will be shown below that *Varanus* has a profound influence upon the number of crocodiles, yet it is not clear how the reverse can be the case. *Varanus* seems to enjoy a varied diet. The stomach of one was found to contain two slugs and the shell of an operculate fresh-water mollusc, and collections of shells of the large water snail *Ampullaria* are often seen on the shore broken on a rock as garden snails are broken by thrushes.[1]

I have seen a young *Varanus* biting off the juicy lower part of the stems of rushes; natives say they eat fish, and on one occasion when my boys were walking a little ahead on the shore, one of them saw an Enswa-swa run away from a piece of dead fish. On one occasion at Jinja a small bird that I had shot fell down almost on top of an unperceived Enswa-swa, who at once picked it up and ran away with it, shaking the struggling bird as a terrier shakes a rat.

The most important food of *Varanus*, so far as man is concerned, is the egg of the crocodile, and there is no doubt whatever in my mind that the increase of *Varanus* on the islands since the depopulation must eventually have a powerful effect in reducing the number of crocodiles there. Thus on July 30, 1914, on Tavu Island, two crocodiles' nests previously noted there were found to have been disturbed; holes had been dug and a crushed egg was lying on the sand. On Bulago Island, on August 1st, two nests previously noted were found ravaged and crushed eggs lay all round. At another point a nest of seventy-six eggs that had been found, freshly laid, on July 24th, had been absolutely cleared out and not one was left. In seven days eggs had been accounted for at the rate of eleven a day, which would seem to be more than one Enswa-swa could accomplish! *In fact, no nest of crocodiles' eggs which I visited a second time*

[1] This may, however, be entirely the work of the open-bill stork. See Chapter VIII.

was found to have been left undisturbed. Though I have not actually seen *Varanus* devouring the eggs, there is no doubt of it from the tracks they leave in the sand all round and over the nest, and my friend Dr. Lyndhurst Duke told me that he had actually seen one digging away at a nest. It therefore appears that strict protection of *Varanus* against slaughter by natives should be an effectual method of keeping down the numbers of crocodiles. The importance of *Varanus* as a food supply of *Glossina* has been alluded to in the chapter on the Tse-tse.

A fine large lizard of the family *Agamidae* is known as "E'konkomi" by the natives. It has a brightly coloured male partly sky blue, the female being grey. They particularly frequent open places, but prefer to have a large tree in the neighbourhood, up which they run when alarmed. The E'konkomi seems to feed very largely on ants, judging by the remains found in its excreta, and from the contents of the stomachs examined in several specimens. It has to a marked degree the habit that may be seen in many lizards, alternately raising and lowering the body between the fore limbs, as is done by a man lying prone on the ground in a common gymnastic exercise. I could never make out the significance of this habit, though I think it is developed to a greater degree in the male sex.

Smaller, more slender lizards (*Lacertidae*) played on the roof of my tent, and from inside I could watch their shadows as they scuttled about. It was most amusing to see them playing: one would stealthily creep up behind another and bite his tail, and then there would be a pursuit and a rushing about all over the tent.

They would dispose themselves for the night somewhere among the folds of the tied-back doorway, and on one occasion I was awakened by hearing their well known pattering feet on the roof. Realizing that something must have turned them out from their sleeping place, I lit a lamp and found that a column of the "Safari ant" (*Dorylus*) had directed its attention to that part of the tent, but fortunately for my night's rest they did not investigate my bed.

The little grey *Gecko*, with discs on its toes enabling it to run upside down on ceilings and walls, was not seen in my huts on the islands, although common enough on the mainland; but I do not mean to state that it did not exist on the islands.

Tortoises.

Like crocodiles, tortoises are less plentiful than might be expected. The numerous isles of varying size furnish abundant areas with marshy shore and shallow, rush-grown water, which appear eminently suitable for water tortoises, yet it was many months before I saw one—a flat, black, short tailed species that wanders about near the water's edge. One species of land tortoise is occasionally seen; the natives call it "Enfudu," a name that seems to carry with it a suggestion of blundering stupidity not altogether foreign to a tortoise. It is somewhat larger than the European species kept in gardens, and has a high domed shell, with the anterior and posterior portions of the ventral plate hinged so as to be capable of a little movement. I once found a specimen that had apparently been dropped from a height; it was a large one, and the highest part of the dome of the shell had been fractured, a portion being depressed. It had probably been destined to be eaten by some bird of prey, which had been frightened away at my approach, for the blood on the wound was still fresh. So there may be, after all, some truth in the old legend which ascribes the death of a Greek sage to the impact of a tortoise dropped upon his bald head by a bird of prey, which mistook the shining cranium for a stone!

Snakes.

During one's wanderings through thick grass and among bush and rocks one frequently came across snakes hastily retreating as one approached.

It seems to be a fixed idea with some people that a snake's main object in life is to find a human being and bite him. I take the opposite view, that so far as man is concerned the snake is chiefly occupied with avoiding him lest he do the snake harm!

From the snake's point of view, what possible object can there be in wasting valuable poison by biting a huge creature who cannot be eaten, and could, even when mortally wounded, crush the life out of a snake before he dies? So, hearing some heavy footstep come crashing through the grass, the wise snake departs as quickly as possible lest he be trodden upon.

This is where a booted man has the advantage of a silent-footed native, who gives no warning, so that a snake half asleep, or languorous after a meal, or stupid and half blind owing to an approaching shedding of skin, suddenly finds a large animal almost on top of him, and strikes in a panic of self-defence.

Once only I very nearly trod upon a large black snake, a species common on the islands, and reaching up to six feet in length. I was walking through very thick, high tussocks of grass, which made it necessary to go slowly and to lift the feet high. In the middle of one step, while my foot was in the air, the snake crawled out from a very dense tussock across the very spot for which my foot was destined. It was fortunately just not too late to put the foot down elsewhere, and all was well, for the big snake vanished as suddenly as it had appeared, obviously bent on escaping being trodden upon.

Puff adders, being very sluggish, will not get out of the way until forced to do so. I have literally pushed one off the track with a stick because it would not move; a lovely species, the glossy skin marked with carpet pattern of different shades of purplish greys and pinks, soft browns and creams, harmonizing exquisitely with the lights and shades among the dead leaves surrounding it.

This was *Bitis nasicornis,* the puff adder of forests, with a little horn on each side of the nose formed by clusters of upright scales. Beautiful as is its colouring, the shape is so thick and squat that this species loses considerably in beauty from this cause. The much less ornamental *Bitis arietans,* well known in South Africa, was once found on Damba Island by my canoe-men hidden among the rocks at the very place where the canoe was kept. Somehow they managed to get a rope round it, and dragged it up in triumph to my house. It was 4 feet 6 inches long, and one could not but be glad to be rid of so dangerous a neighbour for the bare-footed men.

Mention has been made of the booming noise uttered by the crowned crane during the wet season. My boys, when asked what made the noise, always replied, "E'sa-lambwa" (puff adder). Some puffing!

The python is another fine snake, handsomely marked, and when in good condition his glossy skin is really beautiful. I only met with him once, on Kimmi Isle, when I came upon a small specimen about six feet long lying on a marshy bit of shore. I watched him for some time, noting two *Glossina* fly up from him, one obviously full of blood. After a while he became aware of me, and moved slowly away, absolutely silently, with the dignity befitting a king of snakes.

On Ngamba Island a place was found where the dead leaves in a circular area were flattened, and there was a trail of flattened leaves leading to and from it. The natives said this was the resting place of an "E'timba" (python), which was probably the one previously seen on Kimmi, for they swim well, as do most snakes.

One day when going round Tavu Isle in the canoe preparatory to landing, I happened to look over the side and saw a snake swimming very gracefully, with the top of its head just above water. It soon took fright, dived, and was lost to sight in the deep water. It appeared to be a young python about two feet long.

Another snake which on account of its beauty particularly calls for mention is a harmless, slender, grass green species often seen on the lake shore hunting for frogs, whose pitiful cry when once heard is always recognizable again. The brilliant grass green colouration and very graceful movements of this snake always evoked one's admiration.

A similar bright green species might sometimes be seen high up among the branches of trees, sometimes travelling rapidly and almost leaping across gaps too big to be spanned. The manner in which it seemed to spring across from one tree to another is very interesting, seeing that in the Malay Archipelago certain snakes have carried the process further, and take gliding flights from a high to a lower branch.[1]

The last snake to be mentioned is a very curious and interesting species, which was once found deeply buried in the base of a termite hill which was being demolished. It was about twelve inches long, greenish grey in colour, very smooth, and could move backwards or forwards equally well. The eyeless head was so small that the slightly swollen posterior extremity, ending in a blunt spike, was larger. When handled the snake pressed this blunt spike forcibly against one's hand; doubtless an ignorant person would have dropped it, thinking it was biting or "stinging." These snakes are entirely subterranean, and are found both in Asia and Africa; presumably they live on worms and burrowing

[1] Shelford, *A Naturalist in Borneo*, pp. 79–82.

insects, possibly on termites also. This specimen much resembled one of the legless lizards found under stones or logs of wood, which the Baganda call "Namugoya," and the English "blind worm" or "slow worm," in spite of their bright eyes and often quite active movements. The "Namugoya" is, of course, regarded by the natives as a snake, and therefore on no account to be touched.

Frogs and Toads.

Frogs have already been mentioned as contributing to the sounds heard on the islands. The species most often seen on the shore much resembles the European "Green tree frog," and may be found freely exposed to the sun on leaves or branches. It adapts its colouration to the intensity of the illumination, and in very light surroundings becomes very light golden green or even milk white. Among dark surroundings it is greenish black, but does not assume brown tints. Another tree frog, very much smaller, seems to be responsible for the shrill tinkling noise, like sleigh bells, always heard among reeds and rushes after sunset. The green frogs are devoured by the green grass snake previously described, and their cry, when caught, is pitiful, and surprisingly like that of a child.

Another species—possibly a toad—which is also much to the liking of snakes is larger, and has a rough brown skin; it lives by day in burrows which it digs where the soil is suitably light. A green snake was seen one day with its head down one of these burrows attempting to swallow the occupant, and as the mouth of the burrow was large and the snake thin, I was able to look past the snake and see how the toad had distended itself with air to such an extent that the snake, with mouth wide agape, could not get a grip on the spherical surface. Though it persevered for an hour, with jaws so widely apart that upper and lower jaws were almost in a straight

A SMALL "ENSWA-SWA."

A VERY ABUNDANT TREE FROG.

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line, it could do no more than merely apply itself to the toad's side, and eventually had to give up the attempt to swallow such an unmanageable victim! I got the toad out, and save for a few scratches made by the snake's teeth it was none the worse, and, having deflated itself, crawled away quite calmly as if this were no unusual experience!

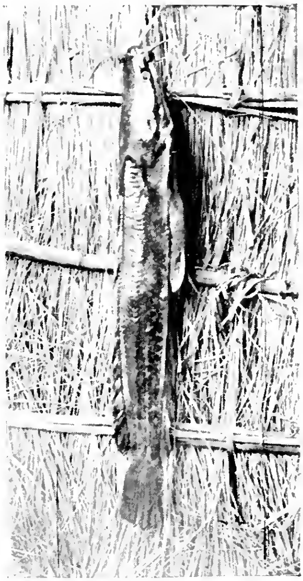
It was interesting to see the toad actually save its life by its power of increasing its size, and one wonders why the snake had not caught hold of a limb. Had the snake been a poisonous species, the prey would have been killed by contact with the fangs, and even had it been able first to inflate itself, its subsequent death would have ensured its return to normal size.

This brings up a point which had always been a difficulty to me until I meditated over this and other observations. If the poison has been evolved by slow degrees from the ordinary non-poisonous saliva, how could this have been brought about? What use could *slightly* venomous saliva be to a snake? For a creature thus bitten might still be able to go away a long distance and die later, where the snake would not find it. A clue was given me during active service in German East Africa, where I first met with the handsome snake called "Boomslang" by the Boers, and was discussing the debated question whether or no it is poisonous. One old Boer told me he had seen one bite a man's arm, which afterwards swelled up dreadfully, although the effects were not serious; but many Boers said it was not poisonous. This snake is an "Opisthoglyph," i.e. it has not the long fangs of a viperine snake, but some of the back teeth are grooved in part of their length, and a fold of mucous membrane forms a pouch round the groove to conduct the slightly poisonous saliva while the snake mouths its prey, for it does not strike and let go. Now it is easy to see what an advantage it would be to a snake if, whilst it was holding on to struggling prey, the latter should be weakened, even only a little, by injection of slightly poisonous saliva, for the prey would then be more easily swallowed. Having started thus one can see how the poisonous quality could be developed. For the more quickly the struggling animal succumbed, the less time would the snake need to hold on to it, and the less chance would there be of its escaping, until, with the increasing strength of the venom, a stage would be reached when the snake would only need to strike once, and quietly wait a few minutes until the prey, at once seriously poisoned, falls helpless and dies.

An extremely interesting observation is here quoted from a letter in *Nature* by Professor Poulton, dated January 2, 1918. Professor Poulton quotes the observation for another purpose, but it is so exactly illustrative of my point that it is here repeated. Dr. G. A. K. Marshall says: "When happening to look over a low stone wall near Estcourt, Natal, in 1897, I chanced to observe a small snake in the very act of striking a frog. After being bitten the latter hopped off at a great pace, and I was rather surprised to see that the snake made no attempt at pursuit, but *merely followed in a very leisurely manner*" (the italics are mine). "Seeing that the frog had come to a standstill at a considerable distance off, I crept along under the wall so as not to disturb the snake, and on getting near the frog I looked cautiously over the wall to see the end of the tragedy. The snake was still some way behind, approaching steadily, and on reaching its victim stood watching it for some moments with its head raised, the frog meanwhile sitting trembling in front of it. At last the snake seized its prey and succeeded in swallowing it *after but feeble resistance*. It seemed clear that the trembling and inability to escape on the part of the frog were simply due to the action of the poison injected at the first bite."

ONE OF THE FLY BOYS HOLDING A SMALL "MAMBA" (LUNG FISH).

"SEMUTUNDU."
Foot-rule to show scale.



"MĂLĔ."

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The only remark I would pass on this most apt observation is that we have no statement from Dr. Marshall whether the snake really was a poisonous one : it is only presumed to be so from the effects of the bite.

Fish.

The most noteworthy fish of the lake is the Lung Fish (*Protopterus*), known to the Baganda as " E'mamba," and a favourite article of food with them. It attains a large size, up to five feet long, and has a flattened body with broad tapering tail, furnished with a wavy fin along both dorsal and ventral edges. The Baganda spear the mamba in shallow water, but it may frequently be met with in deep, open water, coming up to the surface to breathe in the same way as does a tadpole. On one occasion a mamba appearing just behind the stern of the canoe in which I was sitting emitted the used-up air from its lungs with such a loud grunt, that I turned round expecting to see a hippopotamus !

Having taken a new breath, the mamba turns on its side and gives a peculiar heave of its flat tail as it dives down again, but, being very conspicuous, it is quickly perceived by a soaring fish eagle, who stoops to secure it.

Probably they spawn during the rainy season in shallow water, for shortly after the heavy rains the young may be found there. I did not find the tough flesh of the mamba worth eating, but that of a species of *Siluridae*, called " E'mălĕ " by the natives, is as good as any fish I know. It is commonly called " Mud-fish " by the English, but specimens caught in the open waters around the islands had no suspicion of muddiness, and the firm, boneless white flesh was most excellent eating. The Mălĕ has a flat, broad head covered with bony plates (see Fig.), and has long barbels round the mouth. The body is somewhat cylindrical ; it may measure two feet or a little over.

The Baganda are fond of eating a small, very bony fish that haunts shallow water; they call it "E'nkeje," and fish for it with rod and line, and then spike a number on a sharp stick and dry them in the sun. This fish is also much relished by kingfishers; it may be a species of perch. I saw one in shallow water off a sandy shore very busily excavating a funnel shaped pit in the sand. With great vigour it would push its snout along the bottom until its mouth was filled with sand, and then swim a little way away and discharge the load. Whether this was destined for a spawning place I know not, but the fish furiously drove away any too inquisitive neighbours.

A very curious fish is termed "E'mbĕgĕde" by the natives. It has a tubular snout turned down at right angles, and presumably obtains its food from mud. I saw the remains of one on Kimmi that had probably been caught by an otter.

Other fish well known to the natives are the "Semutundu," a fish with long barbels, smaller than the Mălĕ, but much the nicest to eat; a very large Silurid, called "Akasonzi"; a species commonly sold in the market, and much eaten by the English population at Entebbe, called "Ensoga," which somewhat resembles the roach; the beautiful but bony "Ekisinja," a barbel of deep olive-green colour, usually caught with rod and line in shallow water where ambatch grows; and a small, very beautiful silvery species netted in shallow water, called "Omukĕnĕ" —it is about the size of a minnow.

CHAPTER X

THE COLOURATION OF INSECTS

THE study of the colouration of insects has been attracting more and more attention from evolutionists, whether of the Darwinian or Mutationist school, since Bates [1] and Fritz Muller [2] in South America, Wallace [3] in the Malay Archipelago, and Trimen [4] in South Africa gave the first explanation of the phenomena now known as Mimicry, and interpreted by these naturalists on the lines of Darwin's hypothesis.

In this chapter examples will be given which have come within my own experience on the Sesse Islands, and an attempt will be made to show how the Darwinian explanation is more satisfactory than that of the Mutationist.

In 1890 Poulton classified the colours of animals in one scheme, embracing Apatetic or "Deceitful" colours; Sematic or "Warning" colours; and Epigamic or "Courtship" colours.[5] The first two headings only will be discussed.

Apatetic colours are divided into *Cryptic* and *Pseudo-*

[1] "Contributions to an Insect Fauna of the Amazons Valley." H. W. Bates, *Trans. Linn. Soc.*, vol. xxiii, 1862, Pt. III.

[2] *Proc. Ent. Soc. Lond.*, 1897, p. xx.

[3] "On the Phenomena of Variation and Geographical Distribution as illustrated by the *Papilionidae* of the Malayan Region." A. R. Wallace, *Trans. Linn. Soc.*, vol. xxv, Part I, 1865.

[4] Roland Trimen, "On Some Remarkable Mimetic Analogies among African Butterflies." *Trans. Linn. Soc.* xxvi, 1870, Part III, 1869.

[5] *The Colours of Animals*, 1890.

sematic groups. *Cryptic colours* are divided by Poulton into Procryptic and Anticryptic. Procryptic colouring conceals its wearer from danger, causing it to resemble either the general surroundings or some particular part thereof (Special Procrypsis). Instances of the former, such as a green grasshopper among grass, or a mottled grey-brown weevil on earth, are so numerous and well known that no further examples need be mentioned.

Special procryptic colouring never fails to arouse wonder from its extreme perfection; indeed, it has been said that these resemblances are so minutely perfect that Natural Selection cannot possibly have produced them.

This complimentary doctrine has been termed Hypertely.

Even in the British Isles stick-like caterpillars abound, which are quite indistinguishable until they move. Here one must urge a point which is often overlooked. Natural Selection, in producing special procrypsis, has not only altered the shape and colour of the insect, but has produced deeply seated changes in the neuro-muscular system. A stick-like caterpillar needs to maintain itself motionless for hours in an attitude very unusual for the majority of caterpillars, and one which must require great developmen of muscle for that special purpose.

As an example of another attitude, very unusual, but associated with an especial scheme of colouring, the following is of interest.

In 1910 I found at Jinja, on the north shore of Lake Victoria, a moth,[1] allied to our English *Lucania*, among some very dry dependent spikes of grass flowers, of a light silvery grey tint. The moth was hanging in an inverted position with wings brought together over the back; their *under* surfaces thus exposed were of a silvery grey hue closely corresponding with that of the dried glumes of grass. But this colour was only shown on those surfaces that were *visible*; the part of the fore wing

[1] A species of *Cirphis*.

FULL FED CATERPILLAR OF THE NYMPHALINE BUTTERFLY *ATERICA GALENE* HANGING FROM THE TIP OF A FERN FROND JUST BEFORE PUPATION.

Photographed in Damba Island Forest.

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concealed by the hind wing was of a more usual dull grey-brown colour. The moth when disturbed flew away to another similar tuft of grass and adopted the same attitude again, which was most certainly procryptic, and very unusual in a moth of this group, the members of which usually rest with the wings brought closely against the body. The fact that the silver grey colour was confined to those parts of the wings where it was necessary for the concealment of the moth by procrypsis is a very important point. Many other examples of this nature exist, and are arguments against such protective colouration being the result of mere chance. Natural selection produces no more than is necessary: this is contrary to the doctrine of Hypertely. Exactly similar limitations are to be met with when studying mimicry.[1]

Another beautiful instance of special procrypsis is afforded by a rare Notodontid moth,[2] of which I found a specimen at rest on a bush on Damba Isle. The only specimen known up till then was the type in the British Museum.

This moth so closely resembled the tube formed by a dead, dry, rolled-up leaf, that I was for long in doubt as to its nature, and finally had to pluck the twig on which it sat and examine the object most minutely before I could decide.

The wings were closely folded round the body; the inner margins of the fore wings meeting over the back were of slightly darker tint than the rest of the wing, so as to resemble the thick midrib of a dried leaf, whose petiole was represented by a curved tuft of long hairs projecting upwards from the top of the head.

The colour of the wings was the shining brown of a crisp, dry leaf, and on each side there were several lines representing venules, and three doubly ringed markings

[1] *Essays on Evolution*, Poulton, p. 240.
[2] *Scalmicauda niveiplaga*.

like fungus spots. Near the tip was an absolutely pure white marking, shining, which probably represented a silvery patch such as is often seen on a dried leaf. The most realistic portion of the resemblance was the deception produced by the very dark brown of the anterior surface of the head, which appeared to be the dark shadow of the interior of the tube formed by the supposed dead and rolled-up dry leaf.

The completeness of the likeness cannot be realized when the moth is seen set in the cabinet, but it was one of the most perfect examples of special procrypsis that I have ever seen.

Precisely the same attitude is made use of by the "Buff-tip moth," but in this case the colouring causes it to resemble a short piece of very dry stick with light grey bark, broken off square at one end and obliquely at the other. In the case of this moth there is again to be noted the profound change necessary for the complete success of the deceptive resemblance. The deeply rooted instinct to escape when alarmed has been modified into a stronger instinct to remain motionless at all costs in order to maintain the appearance of a dead leaf, for the slightest movement would attract the eye of an enemy, who would certainly investigate the object more closely and perhaps handle it roughly. The Mutationist who believes that this deceptive appearance, so minutely perfect, was produced more or less complete in one step, will have to admit that the sudden modification of instinct, by a strange coincidence, took place at the same time, or that at least it occurred in connection with the other. The Darwinian, on the other hand, believes that both modifications took place by equally slow gradations.

Very interesting examples of special procryptic colouration are the resemblances of insects to bird droppings on leaves. There is a beautiful example in England—the little moth *Cilix glaucata* at rest fully exposed on a

FOUR PUPAE OF *PAPILIO DARDANUS* ON A SPRAY OF THE FOOD PLANT.

They much resemble pieces of leaf.

THE AGARISTID MOTH *AEGOCERA OBLIQUA* AT REST ON LOW FOLIAGE.

Note how the white bar breaks up the dark area of the wings.

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leaf.[1] The resemblance may be either to a dropping which, fallen from a height, has spread out to form a white and mottled grey patch on a leaf, or to one which has kept its cylindrical shape, and appears dark grey or grey-brown and white.

The young caterpillars of *Papilio dardanus* much resemble the latter object, and their very sluggish habits contribute considerably towards the illusion.

The former class is well exemplified by a beautiful Geometrid moth [2] which rests with outspread wings fully exposed on the surface of a leaf. The wings are of a chalky white hue, with wavy darker lines, and in the centre of the fore wing is a dark, irregular patch of black and brown, glistening here and there with silver. The whole produces an effective likeness, which must be seen in its natural surroundings to be believed. If the moth is frightened it flies away, but takes up the same exposed position on another leaf.

A propos the silver marking, it is curious how rare silver is on insects ; gold is perhaps commoner. Besides the above case, the under surfaces of Fritillary and some other butterflies, and the marks on some *Plusia* moths, I have only seen one other insect with silver—a large Saturnid caterpillar, green, with humps on the back covered on one side with pure silver. The attempt to rear this beautiful caterpillar was unsuccessful, so the name cannot be given.

Certain insects which resemble bark, and are to be found on tree trunks, are very wonderful examples of procrypsis, though whether it is special or general procrypsis is a matter of words only.

Many *Lasiocampidae* have caterpillars which are seen with difficulty when at rest, so closely do they lie against

[1] First recorded by Sidgwick in the *Journal of the Rugby School Natural History Society*.

[2] *Problepsis œgretta*.

the bark which they resemble. On Damba Isle one of my natives came to tell me he had found some caterpillars on a tree trunk, and when I went to look he showed me three Lasiocampids, lying flat on the bark at a point where its surface was somewhat irregular. While looking at them and marvelling at the minute detail of the resemblance, I gradually became aware that the immediate surroundings of these caterpillars were not bark but more caterpillars, and much to the native's amazement, nine of them were found lying closely packed side by side, and utterly indistinguishable from the bark except by the very closest inspection. These caterpillars fed at night only,[1] crawling up the trunk when the sun set and returning to the same resting place next day. The perfection of the concealment owes something to attitude. The claspers are spread out sideways, so that the body lies flat against the bark. The surface of the skin is roughened by numerous little excrescences, and the gap between the edge of the body and the bark is partly obliterated by fleshy lappets, and often by short, soft hairs.[2]

It is worth pointing out that a very large insect may be concealed in a way that c-nnot be believed, unless it is actually seen in its natural surroundings. It is well known that the caterpillar of the Privet Hawk Moth, with its lilac and white oblique stripes, is not so conspicuous

[1] A colony of *Eupterotidae* caterpillars (*Chrysopsyche varia*) was found on Bugalla Isle resting by day on a tree trunk. Wishing to obtain the perfect moth I took some of the caterpillars and kept them in a large circular glass topped box in which they rested quietly during the day. When evening came they formed the usual procession and attempted to climb upwards, which of course they could not do. The result was extremely absurd, for the caterpillars formed an endless chain, nose to tail one behind another, which ceaselessly promenaded around the circumference of the box in the endeavour to find a path upwards. Although there was plenty of food in the box they would not eat, since the proper preliminary of marching *up* the tree trunk had not been performed, and I had to put the caterpillars back on the tree and hope to secure the cocoons later. The limitations of instinct are here well shown.

[2] See diagram in *The Colours of Animals*, p. 30.

as would be expected among the leaves and varying lights on a bush,[1] but the following is a more remarkable example. On Kimmi Islet I was looking at a bush thinly covered with small leaves, and thought I saw a small brown "micro" moth sitting on one of the leaves. But gradually it became obvious that what I was looking at was not a small moth, but part of the ventral aspect of an enormous green Saturnid caterpillar, which was on the lower surface of a twig, its anterior segments being at an angle with the twig, as in the common attitude of many large caterpillars, such as those of our English hawk-moths. The closely folded brown legs on the first three segments had made the brown area which, against the green of the rest of the caterpillar, had been mistaken for a small moth sitting on a leaf. There was a whitish-green stripe running along the mid-ventral line of the caterpillar, which must have served to break up the otherwise uniform green area, and helped to render the huge form difficult to be seen. The curious point was that when the insect had once been visualized, I could not un-see it again, and found great difficulty in realizing how I had at first failed to discern it. Some of the natives were called up and asked if they saw anything on the bush, and their surprise was as great as mine when I pointed out the caterpillar. The moth was reared, and proved to be *Bunaea phaedusa.*

When procryptic colouring is dealt with, place must be found for mention of *Seasonal Variation.* Certain butterflies have been known for some years to have appearances differing greatly in the wet and dry seasons. So marked are the differences in the Nymphaline genus *Precis*, for example, that two forms of *P. sesamus*, one salmon-pink above, the other deep blue, with extreme difference of pattern and colour on the under surfaces, were thought to be distinct species until G. A. K. Marshall bred one from eggs laid by the other.[2]

[1] *The Colours of Animals*, p. 42.
[2] *Trans. Ent. Soc.*, 1902, part iii, p. 414 *et seq.*

Poulton, from careful study of this genus, concluded that " dry " forms are more procryptic, and that this is due to the operation of Natural Selection during the greater stress of the dry season, when insects are so scarce that insectivorous animals need to work harder to obtain food, and the risk to any particular insect is proportionately greater.[1] Now the climate of the islands of Lake Victoria has been shown to be more uniform than that of the mainland,[2] and it is very interesting and significant that in the case of the commonest *Precis* there (*P. archesia*), the *only* form met with was the " wet " one ; and of *P. sesamus*, the salmon-pink " wet " form was so much the commonest that the appearance of a " dry " one was quite a memorable event. During the campaign in German East Africa, I first became familiar with the phenomena of a typical dry season, and was soon impressed by the much greater procrypsis of the " dry " *Precis*, and also of such Pierines as *Teracolus*, *Belenois*, *Pinacopteryx*. When the grass is quite dead and dried up it becomes brown, tinted with pink or grey, and the dry season Pierines, when at rest, harmonize most admirably with their surroundings on account of the suffusion of the under surface with brown, grey or pinkish scales, so that they are often exceedingly difficult to detect after they have alighted. It is noteworthy that, just as in the case of the moth above mentioned, this especially procryptic colouring is only found where it is needed on the under surface, viz. on the whole of the hind wing, but only on the tip of the fore wing, which is not covered by the hind wing in the position of complete rest. The remainder of the under surface of the fore wing is as in the " wet " form.

The above examples of concealing colouration are all *pro*cryptic ; that is to say, they are species, found highly desirable by vertebrate enemies, which have acquired

[1] *Trans. Ent. Soc.*, 1902, part iii, pp. 424–443.
[2] See chart, Chapter iii.

colours, shape and habits concealing them from discovery by enemies.

The class of *anti*cryptic colouration has not so many examples. In it are to be found creatures whose concealment aids them, primarily, not to escape their enemies but to obtain their prey.

On many occasions I have seen a butterfly apparently caught by a flower which it had visited, and at first imagined that the proboscis had become entangled. On examining the flower it was found that the butterfly had been caught by a spider, which had lain in wait on a flower which it so closely resembled that, until one had had this experience several times, one still imagined it was part of the flower.

Two species, or possibly two forms of the same species, have been frequently met with that thus caught their prey, both of the "crab-spider" type. One was found on a yellow flower like a small sunflower, the other was on a milk-white flower of a small low-growing herb. In each case the spider was of precisely the same tint as the flower on which it caught its prey.

The curious and interesting *Mantidae* are often quoted as instances of anticrypsis. A species *Pseudocreobotra ocellata* was abundant on the islands, and, like the spider, varied in hue according to the colour of the flowers which it frequented in order to catch its prey. One form, green and yellow, was found on the small "sunflower," the other, green and mauve, sat among the spikes of purple flowers of an abundant aromatic labiate herb. Very young specimens found on the latter were of a uniform purple or mauve tint, and it was extremely difficult to see them.

In all these cases, however, the *pro*cryptic element cannot be definitely set aside, since birds are well known to eat spiders, and *Mantidae* are so universally cryptic that they must be supposed to be highly edible.[1]

[1] In 1916–17 I had a tame *Cercopithecus* monkey which, taken out to hunt for itself, would devour *Mantidae* with the utmost avidity.

But the following example is more probably anticryptic. On Nsadzi Isle there is a fine sandy beach frequented by Egyptian geese and wading birds, whose droppings attract little blue butterflies and Skippers, which settle on them to feed. I found one day, sitting on a patch of bird dropping and sucking the juices of a captured *Lycaenid* butterfly, a small flat bug, *Mononyx grandicollis,* of the group *Cryptocerata,* whose tints accorded admirably with those of the dropping on the wet sand.

Hitherto we have been considering examples of insects concealed by their resemblance to their surroundings. But a large number of species are extremely conspicuous, and many of them seem to court attention. I use these words deliberately, and as a result of several years' observation in the field. But a school has arisen in America following the teaching of the distinguished artist-naturalist Thayer,[1] which believes that all creatures are concealed by their resemblance to their surroundings, no matter how brilliant and startling their colouration appears to be in the cabinet. Many butterflies are supposed to be like the flowery part of their surroundings.[2] In some cases this is certainly true; the greenish-yellow Pierines of genus *Terias,* when feeding from yellow flowers among herbage, are very well in harmony with them, and quite well concealed. So also the under surfaces of the wings of other Pierines tone very well with flowers or grasses; our own orange-tip is a well known instance.

But these are all what a Darwinian calls procryptic, so that here there is no difference between him and the follower of Thayer. When the species which Poulton called *Aposematic* (i.e. with "warning" colouration) are considered, it is difficult to accept the doctrine that they really harmonize with their environment or with any part of it. Take for example the typical habitat on the islands

[1] See *Concealing Coloration in the Animal Kingdom.*
[2] *Loc. cit.,* pp. 228–229. New edition, 1918.

of a typically aposematic butterfly, *Acraea egina*. This brilliant black and scarlet species could be seen in great numbers on the open grass land near the well defined border of the dense forest which, as has been described, ends abruptly, presenting a dense wall of greenery among which one searches in vain for scarlet flowers or any patch of scarlet with which the *Acraea* could harmonize. Near the edge of the forest, but often as much as a hundred yards away, in the open grass land, flourish clumps of the plant *Erlangea tomentosa*, which bears fine heads of lavender coloured flowers. These are extraordinarily attractive to Acraeines, which crowd together on them, making a brilliant picture. Not only the black and scarlet *Acraea*, such as *egina*, *zetes*, *perenna* and the rarer *pharsalus*, together with smaller species similarly coloured, but black and white females of *Planema macarista*, *P. alcinöe* and *P. aganice*, the brown males of the two latter, and black, orange and white males of *P. macarista*, with both sexes of the similarly coloured *P. poggei*, all congregate in various proportions, and being freely exposed on the lavender heads of flower, make a very brilliant and conspicuous assembly which by no stretch of imagination could be considered to harmonize with the surroundings.

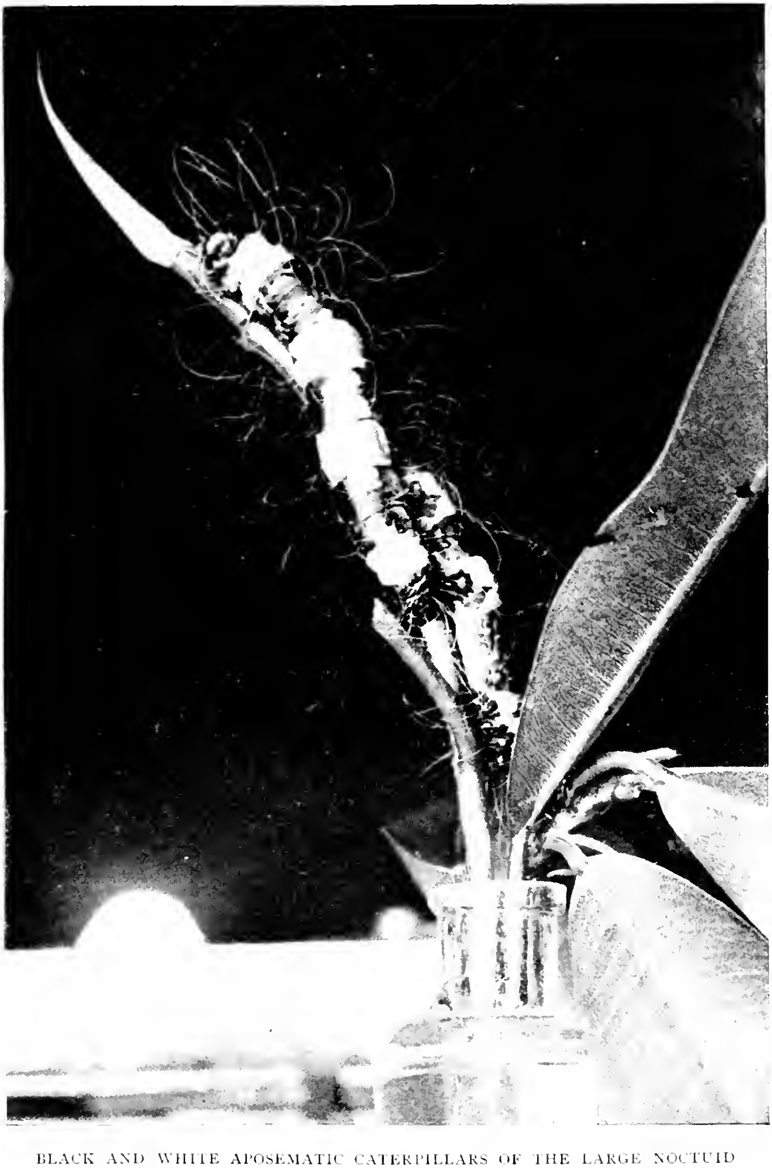
It is true that one tree with brilliant scarlet flowers, known to the Baganda as "Ekirikiti" (*Erythrina tomentosa*), is plentiful on the islands, but butterflies do not visit it, and it usually has no leaves at the time of its flowering, so that the isolated bunches of flowers high up in the air can hardly be considered to form a background against which scarlet butterflies would be invisible. Moreover, the tree usually stands by itself in open places.

It must, I think, be admitted that such insects as the above *are* conspicuous in their natural surroundings, and the explanation, first suggested by Bates, is that these are relatively distasteful species, to whose advantage it is that they should be as conspicuous as possible in order that their vertebrate enemies may readily recognize them as things to be avoided. The colours of such creatures are therefore known, in the terminology used by Poulton,[1] as "warning colours" or "*aposemes.*"

Obviously it will be to the advantage of such insects that their aposemes should be of simple type to aid recognition and memory on the part of the enemy. Hence one finds schemes such as black and yellow alternating rings in a wasp, or, in a butterfly, the wings of one colour except for strongly contrasted patches of another colour, especially at the apex of the fore wing. It is an interesting point that this apical or sub-apical patch of contrasting colour usually has its long axis at right angles to the long axis of the wing. Presumably the transverse direction makes the patch more conspicuous during the movements of the wing than if it were parallel to the long axis of the wing. This point is well shown in the illustrations of the various *Planema* (see Plates).

Before dealing with typically aposematic species, it may be said that quite a number of procryptic insects are furnished with an aposeme which they display if an inquiring enemy comes unpleasantly near. The caterpillars of *Lasiocampidae,* previously alluded to, show, if disturbed, a cleft across the second or third segments, or both, filled with brightly coloured fine sharp spines, which very readily become detached and penetrate one's skin, and would prove very unpleasant in the mouth of an enemy tasting such a caterpillar for the first time. The colour of the spines varies in different species. It may be orange, or pink, or steely blue-black, but is always such as to make the spines very conspicuous. When the caterpillar is quietly at rest and concealed by its procrypsis, the cleft is closed, but if the caterpillar is disturbed or touched it makes

[1] *The Colours of Animals,* pp. 336–337.



BLACK AND WHITE APOSEMATIC CATERPILLARS OF THE LARGE NOCTUID MOTH *AMBLYPRORA MAGNIFICA*.

To face p. 206.

the cleft gape widely open, so that the brightly coloured spines are fully displayed. This may be seen in England in the caterpillar of the "Lappet" moth.

In the case of these caterpillars it must be remembered that the presence of such an aposeme does not necessarily imply that the caterpillar is intrinsically *distasteful*, but that it possesses some unpleasant quality on account of which it had better be left alone. I have a certain amount of evidence that Hymenoptera, such as the stinging ants, bees and wasps, are not avoided so much on account of inedibility as on account of their powers of defence, which they advertise by their conspicuous scheme of colouring, or their habits.

So that the combination of procrypsis with an aposeme is not so inconsistent with the theory of natural selection as it might appear to be at first. Another interesting example of this combination is a fine large Noctuid moth, abundant on the islands (*Ophideres*). It was usually first seen on the wing after it had been disturbed from its resting place, when its orange hind wings bordered with black were very conspicuous. If it was followed up it was seen to settle head downwards on the bark of a tree, expose fully for a moment its orange hind wings, and then suddenly close the wings with a snap and become invisible owing to the mottled grey-green and brown tints of the fore wings closely resembling the surface of the bark. I am inclined to think that the conspicuous hind wings are aposematic, else why should the moth take such pains to display them for a moment, on alighting, before covering them with the procryptic fore wings? I suggest that the moth endeavours to dissuade a pursuing enemy by freely displaying its warning colours, and then settles and becomes invisible to any new enemy that had not seen it when on the wing.

On the other hand, it is possible that the colour of the hind wings is of the nature of *directive markings*,[1] which

[1] *Colours of Animals*, p. 204 *et seq.*

entice the enemy to seize an insect at some particular part which is especially brittle, and, being seized, breaks away, so that the insect escapes unharmed save for the wholly immaterial loss of some part of the wing. Such special directive marks often take the form of conspicuous eye-like spots at the angle of the hind wing or along its margin, or of tails, and every collector must have noticed how often in *Papilio, Charaxes, Satyrinae, Lycaenidae* such parts are missing, and a gap in the margin of the hind wing shows where the enemy has secured nothing but a mouthful of dry wing tissue. These gaps in the wing are just in the position where the wings are least likely to be damaged by contact with objects during flight. Moreover, it is just these pieces of the wing which break off when the butterfly is vigorously fluttering in the folds of a net ; the tails of *Papilionidae* are notorious in this respect.

On one minute islet that I visited there were numbers of black and white wagtails, and little Lycaenid butterflies were plentiful. It was noticed that a large proportion had a Λ-shaped piece missing from both hind wings symmetrically as if a wagtail had seized the butterfly by the hind wings when it was at rest, and the butterfly had escaped owing to that portion of the wing breaking away. After leaving the islands in 1915 I was fortunate enough to see this actually happen, and also to see numbers of *Lycaenidae* actually eaten by wagtails.[1] The question of directive markings has been here dealt with because it seems possible that certain instances of very simple, conspicuous patches of colour, which in the dead specimen look like aposemes, are possibly directive markings. I refer especially to the orange, crimson, or purple tips of the fore wings of the Pierine genus *Teracolus*. These lovely butterflies are conspicuous on the wing, but shy and wary. When one is fluttering in the net the

[1] *Vide* p. 238

orange tips very frequently are broken, which is an unusual occurrence with butterflies, the anterior part of the wing usually being the strongest (*cf. supra*). As has been said, the lower surfaces of these butterflies are decidedly procryptic, but it must be acknowledged that, as in our English "orange-tip," the bright colours of the *Teracolus* are more developed in the male, so that sexual selection may have been a factor in producing them (*vide infra*).

We must return to the subject of aposemes, having digressed somewhat.

Just as cryptic insects must behave in accordance with the resemblance to their surroundings, so aposematic species have a behaviour in keeping with their colouring. It would be of little use for a gaudy, distasteful insect to retreat timidly or endeavour to hide itself on approach of an enemy which, only partially seeing it, might grab at it and damage it fatally before the mistake was found out. Everything is to be gained by flaunting the banner in the face of the enemy, so that there can be no possibility of a mistake. Consequently, aposematic insects are of the boldest demeanour, and are the species most frequently seen by the casual observer. If endeavours are made to catch one, for instance a *Planema* butterfly, it merely flits out of reach, and returns to the same spot apparently unalarmed.

A large grasshopper (*Dictyophora laticincta*), of family *Acrididae*, was frequently met with on the islands fully exposed on pathways: a bloated creature with heavy body, whose wings are so atrophied that it cannot possibly fly. So sluggish is it that it scarcely troubles to move out of the way, or gives a feeble hop merely carrying it for a distance about equal to the length of its own body. In colour it is grey-black, and the short wings are scarlet, and there is some of the same colour along the sides of the fat abdomen. If persistently annoyed it will raise the wing covers to show the red wings underneath. Such an insect, *a priori*, *must* be distasteful, and proved to be so when offered to my young monkey, who would eat greedily until he was sick equally large, but procryptic, grasshoppers.

Since I offered this grasshopper to Wee Man he naturally thought it would be edible, and at once seized it, though he did not straightway bite it as he would have done had it been the ordinary procryptic species he was accustomed to eat. While he held it in his hand the grasshopper emitted copious bubbles of strongly smelling yellow froth from the thoracic spiracles, forcing it out by first distending and then strongly contracting the abdomen, so that a hissing sound was produced, audible several yards away. At the same time the wing covers were raised so as to display the bright red, black bordered wings.

Wee Man was obviously much interested in this very curious and, to him, novel phenomenon, and tasted the froth, but though he obviously did not like it, he persisted in trying to eat the insect, pulling it to pieces and tasting each. But none of it was actually eaten !

Many other insects, *none of which are procryptic*, emit strongly smelling, bright coloured fluid when roughly handled. This is well known to all who have collected Acraeine butterflies.

The following is quoted from my article in *Bedrock* [1] :

" A most typically aposematic Arctiid moth (*Rhodogastria leucoptera*) was found resting fully exposed on low herbage. Its wings were of a pure hard shining white, but not very thickly scaled, so that when they were brought together over the body of the moth, the abdomen, which was of a bright rose pink, was distinctly visible. The thorax was pure white, spotted with black. The legs were of the same bright rose as the abdomen. When the moth was disturbed it separated its wings and spread

[1] Vol. ii, 1913, "Notes on the Struggle for Existence in Tropical Africa."

out the legs so as to display the bright pink (a typical aposeme), and emitted from the thorax just behind the head a copious yellow froth, till a mass of yellow bubbles, with a very strong acrid odour and taste, projected on each side."

Equally remarkable is another specialized grasshopper, known to the Baganda as "Semukutu."[1] It is a large heavy insect of dull greenish-grey colour, and though not in any way aposematic in colouration, yet has all the characteristics of such an insect. It has no trace of wings or wing covers, and the thorax is set with spines around its margin. The abdomen is fat and bloated, and the sluggish insect makes no attempt to evade an approaching enemy. I could never induce a monkey to tackle one of them. When handled, a Semukutu ejects with some force from the sides of the thorax a yellow fluid of strongly acrid odour, which would prove extremely unpleasant in the mouth; and, indeed, the Baganda will not even handle the insect, for they say the fluid produces sores on the skin.[2] But I never found that it had any effect on my skin, and I have handled a great many Semukutu. This is an interesting case, for here we have an insect which has acquired the habits and attributes of an aposematic species, yet not the colouration. Indeed, a young specimen is rather procryptic, being mottled with green, but it has not then the power of exuding the acrid fluid. One might, however, suggest that the appearance of this stout, spiny, wingless grasshopper is so unlike that of others that it can be very easily recognized, and the need for aposematic *colours* may not have arisen.

The above observations on the monkey and grasshoppers have exemplified the deliberate use of an aposeme by an insect when hard pressed. This is again brought out very well by an experiment with fowls, the subject being

[1] *Enyaliopsis*, possibly *durandi*.

[2] See *Bulletin of the Entomological Research Committee*, vol. i, p. 227.

Phymateus viridipes, another large grasshopper of a hard green colour, with spiny thorax, and fully developed blue and crimson wings, so that when flying it is extremely conspicuous.

One of these was put on the ground some little distance away rom a group of fowls, one of which at once ran up to it. The grasshopper remained where it was, but, when the fowl came dangerously near, raised the wings and wing covers perpendicularly and opened out the former to show their bright red colouring. The fowl halted, looked at it, turned round and walked away, nor could it be induced to touch the insect. After a similar result had been obtained on another occasion, the grasshopper was killed and laid down near the fowls, the wings being of course hidden beneath the covers. A half-grown fowl at once ran up and pecked at it, and, being pursued by another, ran off with the grasshopper, put it down and pecked at it again, but certainly did not seem to relish it, finding it very tough. The fowl at length picked off the legs, but made no impression on the body.

Just as it was about to leave it, a second half-grown fowl rushed up, took it away and pecked vigorously at it, pulled off the head but did not eat it, and finally walked away and left it. These observations show, firstly, the value of the aposeme in warning off dangerous enemies, and secondly, the distastefulness of the owner.

It will have been noted that the fowl made no impression on the tough body of the grasshopper, and this brings out another point. Should an aposematic insect have the misfortune to be one of those that are tasted by an inexperienced young foe, it may quite possibly survive the tasting, and be able to propagate its kind if it is of sufficient toughness. Consequently one finds that aposematic species, in strong contrast to procryptic species, are endowed with astonishing powers of resisting injury, at any rate in the case of *Lepidoptera.* It is quite impossible to kill a Danaine or Acraeine butterfly by the mild pinch on the thorax sufficient for a non-aposematic Pierine or Satyrine, for their tissues are so elastic that but little impression is made on them. Further, such insects have remarkable powers of resistance to chemical poisons.[1] It takes a very long time to kill an *Acraea*, or a Burnet moth, in a cyanide bottle, and I have had *Planema* pupae all night in a killing bottle, which when taken out in the morning were unharmed, and showed their characteristic movements, although that very bottle was in daily use for other insects, which very quickly succumbed.

It has been pointed out above that a disagreeable taste or smell is not the only quality associated with aposemes, as in the case of the sting of a wasp. The well known irritating qualities of fine hairs from Arctiid, Lymantrid, or Lasiocampid caterpillars, or the spines of Apodid or Saturnid caterpillars are all found to be associated with typically aposematic colouration. In this case the aposeme has no bearing on the actual taste of the insect, but only refers to the presence of some irritant or penetrating hairs ; indeed, many such caterpillars, as in *Lymantridae*, become typically procryptic, and presumably edible moths. But the rule cannot be stated that when the aposeme is due to adventitious hairs, etc., the insect is not distasteful in itself, for many Arctiid caterpillars renowned for their hairiness, such as the "Woolly Bear," become typically aposematic moths, such as our English "Tiger-moth." It would, however, be very interesting to test the edibility of Lymantrid and Arctiid pupae removed from the hairy cocoon. On the other hand, when a caterpillar has aposemes that are, as it were, intrinsic, that is, not depending upon hairs or spines, it seems to be the rule hat

[1] It must be acknowledged, however, that certain very procryptic weevils, found on the ground which they closely resemble, have equal powers of resistance to chemical poisons, but they are exceptional in this respect among procryptic species.

its distasteful qualities are carried through all stages to the perfect insect. I do not know of a case of an aposematic larva of this type becoming a procryptic, and therefore edible, adult. A most typical instance is the Hypsid moth, *pactolicus*, which is equally conspicuous in all its stages. The caterpillar is ringed alternately with dead black and pure chinese white, the head being crimson. It feeds fully exposed on a yellow flowered vetch,[1] on which it is visible from far away. When full fed it stretches a few silk threads across and across to make an open hammock, in which it becomes an equally conspicuous chrysalis, fully exposing its light yellow colouring with black markings. The large adult moth is bright orange with steely blue-black blotches, and is one of the most conspicuous insects; it is of sluggish habit, and rests freely exposed on low herbage, or flies slowly and heavily. The moths of this family are sometimes copied by other less favoured insects, and there is little doubt that they are relatively distasteful.

On the other hand, cases of a procryptic caterpillar becoming an aposematic adult must, I think, be exceptional. I have not yet met with one on the islands.

A very interesting species is the typically aposematic genus *Aletis*. These moths are sometimes mimicked by butterflies (see p. 233). One species, *A. erici*, was found in abundance on Sanga Island in such numbers that the bushes had been completely stripped of their leaves (see p. 103). The caterpillar was tawny orange with black blotches, and was extremely conspicuous; since many grouped themselves together, hanging head downwards in clusters from the bare twigs, their attitudes accentuated the conspicuous colouring—they had the typical shape of all *Geometridae*. Inasmuch as the vast majority of Geometrid larvae are procryptic, the ancestral forms were probably so, and the *Aletis* has been transformed from a

[1] *Crotalaria striata.*

procryptic to an aposematic type, the larvae still retaining the characteristic shape and the attitude which follows from the absence of the first three pairs of claspers, but acquiring the habit, most unusual among Geometrid larvae, of grouping themselves so that the effect of the warning colours is accentuated—a habit not at all uncommon among aposematic insects.

The *Pentatomidae*, highly odoriferous *Hemiptera*, resplendent in green or blue and gold, commonly mass together. In 1917 I met with a very marked instance of this aggregation. An Acridian grasshopper,[1] conspicuously coloured green, orange and black, and of typically aposematic habits, was proved very definitely to be distasteful to a young monkey. When very young it is coal black, speckled with yellow, and on several occasions large numbers were found closely crowded together to form a black mass at the end of a spray of herbage, which attracted my attention, whereas a single individual from its small size would easily have escaped notice. Some of these black youngsters were given to a monkey, who would not even taste them, although hungry, as was proved by his subsequently eating other insects. Although the habit of collecting in a mass, whereby the conspicuousness of an individual is much exaggerated, is most commonly made use of for aposematic purposes, yet I have met with an instance where a full effect of procrypsis was only produced when a number of individuals collected together in a certain way. The effect produced was a likeness to a bird-dropping on a leaf, and could not so well have been produced by a single individual.

The species concerned is the Bombycid moth, *Trilocha obliquissima*, of which the type specimen, from Angola, was the only one in the British Museum collection. A company of very young caterpillars was found on Bugalla Island on a leaf of a Sapotaceous tree, *Chrysophyllum*.

[1] *Zonocerus elegans*.

The general colouration was a mottled stony grey. After the first moult the lighter parts of the markings became chalky white, and as the caterpillars always lay close together in a mass, and fed on the flat surface of the leaf from the upper parenchyma only, the resemblance to a bird dropping was very close. At the next moult the caterpillars became darker, and as they grew larger, after the third moult, were of a rich brown. They now had different habits, feeding from the edge of the leaf in the manner of all large caterpillars, and no longer massing together.

When full grown they were extraordinarily procryptic, being of the same rich brown as the leaf stalks, with greenish and purplish mottlings, the body being swollen here and there with numerous scale-like excrescences accurately resembling scales at the bases of the leaf stalks, and rugosities of the bark. The caudal horn, projecting forward over the back, also helped in this likeness. The caterpillars now rested along twigs and leaf stalks, and adopted a special attitude, which rendered them more procryptic.

An instance has been given of the use of an aposeme on certain occasions only. The following is a very remarkable instance of a structure useful at one stage of development being apparently made use of to protect a subsequent stage.

The larva of the Lasiocampid moth, *Chrysopsyche varia*, is quite conspicuous, being coloured a rich chestnut brown with large pale blue spots. When full grown it has in addition on the dorsum of each segment from 4–10 a dense patch of very short, closely set fine hairs of glistening white.

It has been already mentioned as showing peculiar limitations of instinct (p. 200). When full fed, it spins a firm brown cocoon of the type usual among *Lasiocampidae*. The point of interest is that at one end of the cocoon, opposite to the posterior extremity of the occupant, a weak spot, almost a hole, is left. When the caterpillar becomes a chrysalis the discarded brightly coloured larval skin is pushed out so that it *partly* projects through this hole. It is naturally to be expected that the adult moth would emerge through this hole, but it does not; it pushes its way out in the usual manner through the *other* end of the cocoon. Now if the object of the weak spot is to allow the discarded larval skin to be extruded so as not to take up space inside the cocoon, one would expect it to be got rid of completely, but this is not the case; it remains partly inside, partly outside,[1] its bright colours freely visible. Apparently the pupa makes use of the discarded aposematic skin to protect itself. I have not met with another case of this partial extrusion of the larval skin through an orifice especially provided.

Insects furnished with well marked aposemes are commonly said to be *protected* by the possession of sting, distastefulness, spines, hairs, irritant fluid, exceptional hardness, etc. It must be understood that this immunity from attacks by birds or mammals is not by any means claimed to be *absolute* at all times, but is entirely *relative*, depending upon the abundance of insect food generally, of that species in particular, and the state of hunger of the enemy, who, when food is difficult to obtain, will eat species which he would pass by when more edible insects could be easily found.[2] Also it must be remembered that certain creatures appear to be specialized for devouring prey which others pass over.

[1] In a certain number of cases the skin is completely extruded—evidently the habit, if it is of protective value, has not yet been carried to its fullest efficacy.

[2] See Poulton, E. B., *The Colours of Animals*, pp. 180, 181. Marshall, G. A. K., *The Bionomics of South African Insects. Trans. Ent. Soc. Lond.*, 1902, part iii. Swynnerton, C. F. M., *Proc. Ent. Soc. Lond.*, February 3, 1915; and in "Experiments and Observations bearing on the Explanation of Form and Colouring." *Journal Linn. Soc.*, 1919, *Zoology*, xxxiii.

Thus a Roller which was examined at Jinja was found to have devoured numbers of a bright green ball-rolling dung beetle, a member of a family whose habits render them nauseous to monkeys, and which emit a very foul smelling fluid when handled.

Bee-eaters (*Merops*) feed on bees and other stinging *Hymenoptera*,[1] cuckoos appear to feed largely on very hairy caterpillars. Now it is well known that every living thing produces very many more offspring than can possibly survive, and Wallace pointed out, in 1858,[2] that, of the offspring of one pair, on the average all but one must die or at least fail to produce young. So that any one who refuses to accept the explanation that aposematic colours and habits are produced by Natural Selection is quite justified in saying, " If you claim that these species escape being devoured by vertebrate enemies, the burden is laid on you of proving by what means they are prevented from overrunning the earth."

In order to answer this, all the restraining factors must be considered.

Firstly, there are the vertebrate enemies, birds and beasts, against which it is claimed aposematic insects are protected. Secondly, predaceous insects, such as dragon flies, carnivorous beetles and bugs, and Asilid flies, which eat or suck juices of other insects. Spiders are not here included, for they appear to be indiscriminate feeders on protected and unprotected alike. For the same reason fossorial *Hymenoptera*, which feed their young on other insects, are not here included. Thirdly, there are parasitic *Hymenoptera* and *Diptera*, which lay their eggs on other insects ; and fourthly, the micro-organisms of disease.

[1] See Reports of Sleeping Sickness Commission, vol. xiv, 1913, pp. 15, 16, and table extracted therefrom in Chap. viii, p. 172.

[2] " On the Tendency of Varieties to depart indefinitely from the Original Type." Essay reprinted in *Natural Selection and Tropical Nature*, 1895 edition, pp. 24–5.

Let the number of offspring of any two parents destroyed by each of these agencies be represented, in order as above, by V, P (with above described limitations), p and M: then if X be taken to represent the total number of offspring, X — 1 represents the number destroyed by all agencies together. So the equation can be written:

$$X - 1 = V + P + p + M.$$

And the number destroyed by any one agent alone

$$V = (X - 1) - (P + p + M).$$

It is obvious, therefore, that if, as is claimed, V is negligible for protected species, $P + p + M$ must be correspondingly greater, and there is some reason for thinking that this is actually the case, although much statistical evidence is required.[1] For instance, in the case of P, those who have paid attention to, or observed in the field, predaceous insects with their prey,[2] have probably had the same experience as myself, that the prey is very often among precisely those species which are believed to escape molestation by vertebrate enemies. Thus I found a company of spiny black and yellow larvae of *Acraea perenna*, of which many had already been sucked dry by a bug,[3] which was found in the act of sucking one. This one bug might very easily have destroyed *seriatim* the whole of the brood of these aposematic larvae. In the case of p we need especially comparative statistics showing the relative proportions of aposematic and cryptic species that are destroyed by parasites; the following bears on the subject. *Acraea zetes*, a typically aposematic scarlet and black butterfly, abounded on Bagalla Island, and its

[1] See *Trans. Ent. Soc. Lond.*, 1902, part iii, pp. 328–38.

[2] See collected data by Poulton, *Trans. Ent. Soc. Lond.*, 1906, part iii, pp. 323–409.

[3] *Damarius splendidulus.*

larvae, ringed alternately with orange and slate grey, with black spines and crimson head, could be found in numbers when full fed wandering over the grass land in search of suitable places for pupation. Judging by the situations in which the pupae were found, the larva chooses as conspicuous a site as possible, such as a tall grass stem fully exposed and unsheltered, quite out in the open. Numbers of these full fed larvae and of the equally conspicuous pupae were collected, and out of seventy, 77 per cent. were destroyed by parasitic *Diptera* (*Tachinidae*) and *Hymenoptera* (*Chalcididae*, *Braconidae*).

Lastly, in the case of M. The very peculiar and highly specialized legless caterpillars of the *Apodidae* are often brilliantly coloured, and furnished with intensely sharp strong spines set in clusters, often said to be "poisonous," so irritating are their qualities. The Baganda have a great dread of these stinging caterpillars, which they brought me with the utmost caution. I was very seldom able to rear them, for they seemed to be extraordinarily susceptible to some disease which very rapidly killed them. Possibly it was of the same nature as the "pébrine" which Pasteur investigated in silkworms.[1]

A very interesting special case of aposematic colouring is the development of "Terrifying" marks, and just as with the cases previously described, the colouration is associated with a special attitude, whose purpose is to make the specialized areas of colouring suggest something that frightens or discourages the enemy. In many cases the attitude is far more important than the colouring. I would refer the reader to Poulton's book,[2] and wish here merely to describe an example from my own experience. The large and handsome moths of the family *Saturnidae* very often, like our "Emperor moth" of the heather

[1] Comparative statistics of the number of caterpillars, procryptic and aposematic, destroyed by *p* and M would be exceedingly valuable.

[2] *The Colours of Animals*, p. 258 *et seq.*

moors, have large eye-like markings on the hind wings, which are concealed by the fore wings when the moth is at rest, but under certain circumstances are exposed. One of these, a comparatively dull coloured species, was offered to my pet monkeys on Bugalla Island. The following account is quoted from my article in *Bedrock*.[1]

"The moth was a large yellow species with well marked eye-like spots on the hind wings. When alarmed it bent the body ventrally into a strong curve, and held the wings in a very curious and unusual fashion—almost upright, with the upper surface directed forwards so that the eye-like markings were extremely conspicuous; indeed, the attitude was obviously intended to display those 'eyes.' The moth thus looked curiously weird and unmothlike, and the monkeys were afraid even to touch it. It was not merely the size of which they were afraid, because they caught and readily devoured large and protectively coloured moths (*Sphingomorpha*) often found about the house."

Finally, it must not be concluded that all bright colours in insects are aposematic. In the case of butterflies both surfaces of the wings must be considered; only the lower surface is displayed when the insect is at rest and likely to be caught unawares, for when on the wing a butterfly is alert and can escape by flight. Consequently a large number of species, the upper surfaces of whose wings are vividly coloured, are really procryptic if the lower surfaces be considered. I need only mention our English "Red Admiral," and the famous leaf butterflies of Asia and Africa (*Kallima*).

Darwin concluded that the colours of butterflies owed much to Sexual Selection, and those who have seen butterflies courting will probably agree that vision does enter into the question. I have seen a male *Papilio dardanus*

[1] "Notes on the Struggle for Existence in Tropical Africa," *Bedrock*, 1913, vol. ii, p. 366.

in headlong flight through the forest suddenly arrest its course and dally awhile with an *Amauris niavius*, and it was impossible to resist the conclusion that the swallow-tail had for a moment mistaken the *Amauris* for its own female of the form *hippocöon*, which closely resembles *Amauris*. Eltringham [1] has described an elaborate apparatus in male *Amauris* which I was fortunate enough to observe being actually used in courtship by *A. psyttalea*, on Bugalla Isle, in July 1912. A male was flying about after a female, which presently alighted on a dead flower spike of a common herb about two feet high. She sat almost at the top, vertical, with head upwards and wings outspread, and remained perfectly still while the male hovered a few inches above her head with a peculiar flutter causing him to rise and fall a little. Every now and then the flaps at the extremity of the body were widely everted at right angles to the body, and a large white brush-like structure was most energetically protruded and as rapidly withdrawn. I watched this for a minute or two, and then, to my surprise, for I had made no movement, the female suddenly flew away as if the performance had not appealed to her, and the male followed.[2]

The importance of the scent emitted by male butterflies was first recognized by Fritz Muller,[3] who described certain scales on the wings especially formed for producing scent.

A very curious and unusual occurrence was noted on Bugalla on October 25, 1912. A male of a small and abundant Syntomid moth (*Epitoxis albicincta*) was on a grass stem, and a male of the common butterfly *Acraea terpsichore* form *ventura*, in a state of great excitement, was endeavouring to effect union with the moth, passing

[1] *Trans. Ent. Soc. Lond.*, 1913, part ii, p. 399 *et seq.*; also 1915, part i, p. 152 *et seq.*

[2] For observations showing the relation of these anal tufts to the "brands" on the hind wing, see Lamborn, *Proc. Ent. Soc. Lond.*, 1911, p. xlvi; 1912, p. xxxiv; 1918, p. clxxii.

[3] *Jen. Zeit.*, vol. xi. p. 99; *Trans. Ent. Soc.*, 1878, p. 211.

the tip of its abdomen repeatedly over that of the moth. It was the more curious that there were numbers of freshly emerged *Acraea* females in the neighbourhood with which the male butterfly could have mated. Professor Poulton suggested that possibly it was a case of accidental likeness between the odours of two species very far removed from each other, which implies that the male seeks for the odour of the female as well as trying to charm her with his own.

White butterflies of the genus *Belenois* have often been observed courting. A male for a long time flutters round and pursues a female, who, perhaps wearied by his importunities, settles at last with wings expanded. The male alights behind her and commences vigorously to "paw" her hind wings with quick movements of his anterior legs, the action being as if he was trying to walk up a very slippery surface. Refusal on the part of the female seems to be indicated by a curious attitude. The wings are spread out flat, but not quite at right angles to the axis of the body, for the fore wings are directed slightly backwards. The abdomen is directed vertically upwards at right angles to the thorax.

In 1917 I witnessed the consummation of a courtship of a Pierine, the initial stages of which had not been observed. A male and female *Pinacopteryx simana* were fluttering in the air and the female suddenly settled, quite quietly, and sat with wings closed. The male stood over her with wings widely expanded so as completely to conceal her; the union was the act of a moment, and then they flew away, the female hanging passively with wings closed, the male carrying her.

Nymphalines such as *Precis* and *Byblia*, however, adopt different methods of courtship. The female, with wings closed over her back, faces the male, who endeavours to induce her to allow the union by butting against her closed wings with the anterior margin of his own, brought together over his back. It appears as if the male's endeavour is to approach from the flank or rear, and the female, unless willing, turns so as always to face him.

In the case of Acraeines little time seems to be wasted on persuasion. A male, in the air, makes for the female, who at once falls fluttering to the ground, where the two seem to struggle together. If the female is willing, union is almost immediate ; if not, the male soon flies away.

On August 2, 1918, in Portuguese East Africa, I saw a very good illustration of this. A fresh specimen of *Acraea natalica* was flitting aimlessly about, and I was awaiting an opportunity of catching it, when an old and very worn female came by. The male at once went to her, and she fell straight to the ground. I watched for several minutes. The male was very excited, and gripped the female with his legs round the roots of the wings, but she lay motionless on the ground adopting an attitude of passive resistance, the wings folded against her body and pressed closely, so as to prevent the male thrusting his abdomen down to meet hers, which he struggled to do. After a little he managed to pass his abdomen between her wings, but she made no response, and he suddenly gave up and flew away. I caught him, and then found the female still lying motionless on the ground, and secured her too.

In connection with the pairing of butterflies, the following is of interest to evolutionists.

During the nuptial flight it is known that in the case of some species the male carries the female, in other cases the positions are reversed, the one that is carried remaining absolutely passive with wings closed. In a discussion on Sexual Selection among insects in the *Descent of Man*,[1] Darwin remarks on some cases where the male is "less bright" than the female,[2] and points out that in the English *Pieris*, *Colias* and *Epinephele janira* the duller male is supported during the nuptial flight by the female, "so

[1] Chapter xi.

[2] The Lycaenid butterfly *Lachnocnema bibulus* has a dull brown male which is pursued in courtship by the brighter blue-marked female.

that the part which the two sexes play is reversed, as is their relative beauty," and Darwin goes on to say that it may be supposed that the female takes the more active part in the wooing. Since the middle of 1917 I have paid particular attention to this point, and a large number of pairs have been noted on the wing. In the Pierines,[1] in all cases save one, the male has carried the female as above described. So that it would appear that Darwin was misinformed regarding Pierines, unless our English species have different habits. My few observations of Nymphalines show that the female carries the male. This appears also to be the case with *Lycaenidae*. Acraeines show no definite rule. In the case of Satyrines the female seems to carry the male, and I have seen *Papilio dardanus* form *hippocöon* carrying the male.

We now come to the consideration of *Mimicry*, one of the most fascinating subjects for study that insects can provide, and one on which a large amount of work has been done in recent years, from the point of view of the Darwinian hypothesis, thanks to the influence of Professor Poulton, of the Hope Department at Oxford.

The study of mimicry was first taken up by Bates, who, on the Amazons, found that a large number of abundant butterflies were of the type previously alluded to as aposematic, but that others, although superficially resembling the former, belonged to groups anatomically very different from them.[2]

He put forward the explanation that these latter lived on the unsavoury reputations of their associates, or, in other words, were *Mimics* of more distasteful models. He found that whereas the models were abundant, easy to catch, and avoided by birds,[3] the mimics were less

[1] *Proc. Ent. Soc.*, 1918, p. clii. [2] *Loc. cit.*

[3] Bearing on this is the fact that Acræines and Danaines rarely show evidence of attacks by birds which is so common among *Lycaenidae*, unprotected Pierines or Nymphalines, Satyrines, etc., in which a Λ-shaped piece is symmetrically cut out from both hind wings, showing the nip of a bird's beak.

abundant, shy, and easily alarmed, and there was no evidence that they also were distasteful. On reflection it is quite obvious that a mimic must be less abundant than its model, for if, of a series of conspicuous insects met with some are edible and others distasteful, an enemy might find it worth while to catch every one he saw on the chance of it being edible. If, however, the proportion of edible to distasteful is very low, the chance of finding an edible specimen is too small to make it worth while catching large numbers that will not be eaten.

The mimic, as has been said, is easily alarmed, and it is not difficult to understand the reason. It has been pointed out above that aposematic species, which serve as models, are extremely resistant to harm, and even if caught and tasted do not of necessity suffer vital injury. Mimics, however, come from a stock which has in the past relied for safety upon concealment or rapidity of flight, and have not developed the toughness of their models; hence a nip by a bird's beak or the rough handling of a monkey may cause fatal damage.

So that one finds by experience that so long as mimics are not alarmed, they have a great resemblance in movement and habits to the aposematic species with which they are associated. If a mimic is frightened it takes to flight and dashes off at a great speed, whereas the model will merely move a little way, and often come back to the same spot, or may not even deign to move away at all.

Here again is well exemplified the action of natural selection in producing changes, not only in colouration and shape, but in the nervous system also, yet only so far as such changes are required. Thus in certain mimetic South American Pierines, a small part of the fore wing that is normally concealed by the hind wing retains the hue from which this group has derived the name of "Whites," while the visible areas of the wings are mimetic of a brightly coloured model.[1] Again, instincts are modified so long as the assumed attitudes and movements are needed to correspond with the false appearance of inedibility, but when these are no longer helpful, rather a danger, the recently acquired instinct of deceit is abandoned, and the more deeply seated instinct of flight comes into action.

Attitude is of very real importance in producing mimetic resemblance, and living specimens often appear mimetic when in the cabinet they do not. So that the ignorant remark, which may sometimes be seen in print, that mimicry is the product of the imagination of an "arm-chair philosopher" need not be seriously considered.

One day, on Damba Island, I was looking at a nest of the tree ant, *Æcophylla*, among the leaves of a bush. This species, by means of silk spun by a larva held for the purpose by an ant, fastens together leaves to make a more or less globular nest about the size of a cocoanut. Wishing to obtain a few specimens I proceeded to box them, when, to my great astonishment, one of them *jumped*, thus revealing itself to be no ant, but a mimetic spider,[2] which had been running about unperceived among the ants!

The wonderful thing about this case is the great anatomical difference between ant and spider, both internal and external. The model has head, thorax, and abdomen separated from each other by well marked constrictions, but the spider has head and thorax fused into a cephalo-thoracic mass, separated from the abdomen. The ant has three pairs of legs, the spider four; the ant has a pair of long mobile antennae, the spider none. Diagrammatically the difference is shown overleaf.

[1] Poulton, *Essays on Evolution*, p. 239.

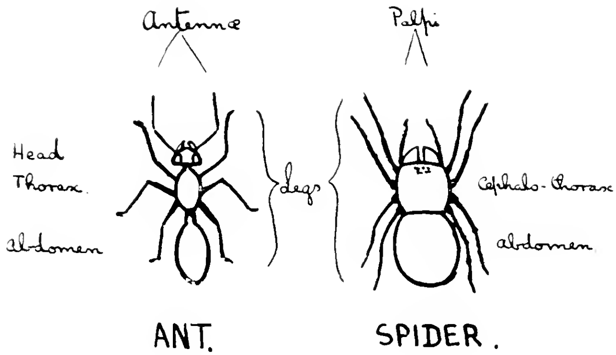
[2] *Myrmarachne fœnissex.* Another spider mimic of the same model is described and figured by Shelford in *A Naturalist in Borneo*, pp. 230–1.

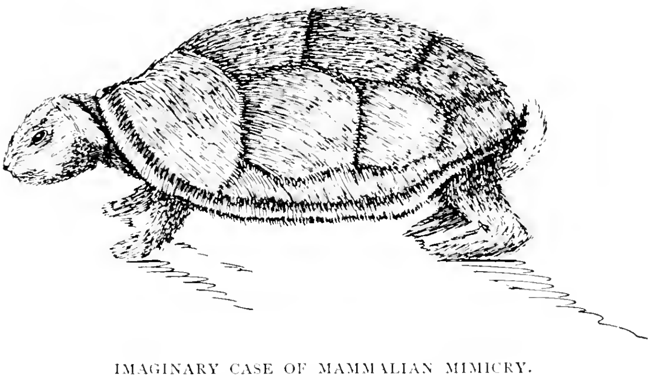
These differences are sufficiently obvious in the dead specimens, and the quick nervous movements of a live ant with waving antennae are as different as possible from those of a typical spider.

Nevertheless in this case the spider completely deceived me. How was it done? Firstly, the shape is unusual for a spider, the cephalo-thorax and abdomen being thin and prolonged, and a constriction in the cephalo-thorax of the spider represents the division between head and thorax of the ant. The spider did not use the first pair of legs for walking, but they were held up in the air and waved about to copy the movements of the antennae of the model. It is obvious that this functional modification necessitates a profound alteration in the neuromuscular system of the spider. It is worth noting, too, how in the last extremity the spider disclosed its true nature in its endeavours to escape by jumping, a habit common to the family to which it belongs (*Salticidae*), but suppressed by the new mimetic instinct until an emergency arose. This spider was not the only mimic of *Æcophylla*, for running among them, and almost as closely resembling them as did the spider, was a small bug of the family *Capsidae*,[1] which proved to be not only an undescribed species, but sufficiently distinct to be placed in a new genus.

It is of course easier for a bug than a spider to be brought to resemble an ant, since both are insects, and natural selection has the same basis to work upon. It might be supposed that the wings and wing covers of the mimic would prove a difficulty, since they lie over the abdomen, but in *Xenetomorpha* there is a constriction near the base of the wing covers which, seen from above, matches the constriction between thorax and abdomen of the ant. The bug lives among its models, probably sucking the juices from the stems of the leaves among which

[1] *Xenetomorpha carpenteri.*





IMAGINARY CASE OF MAMMALIAN MIMICRY.
Drawn by Dr. H. Eltringham.

To face p. 228.

the nest is made. The spider catches flies, and on one occasion was actually seen to run into the outer spaces of the nest with its prey. The wonderful nature of this mimicry of an ant by a spider may be brought out by an imaginary, but parallel, example for the benefit of those unaccustomed to deal with insects, and unfamiliar with the important differences between ant and spider. It is probable that tortoises are not eaten by those carnivorous animals which prey upon rabbits. Let us imagine a farmer in the country seeing what he thought was a tortoise, and idly watching it crawling about in the characteristic tortoise fashion. He goes up to it and frightens it, when, to his astonishment, it bounds away with the typical rabbit gait. He shoots it, and on examination finds all the essential features of a rabbit: it has rodent teeth, but the external ears are so small as to be unnoticeable. The main resemblance to a tortoise is produced by a matting together of the hair on the back to form a carapace-like structure,[1] and on the legs to look like scales, while the legs themselves are much reduced in length, but very thick.

A species which "assumes a virtue though it has it not" is a true mimic, and is said to be *Pseud-aposematic*, or to have false warning colours, for it appears in the guise of another more fortunate than itself in the possession of distasteful qualities. But when the mimetic association first described by Bates was more fully investigated, some of the members were found to be quite as abundant as the species which they resembled, and to belong to groups which could be claimed to be as well protected as the models. It was pointed out previously that a mimic must be *less* abundant than its model. Fritz Muller first pointed out how a distasteful and abundant species can gain by resembling another equally distasteful and

[1] Compare the so-called horn of a rhinoceros, which is structurally merely agglomerated hair.

abundant. In a brief preliminary statement in 1878[1] he says: "What advantage can it be to a creature protected by repellant odour to resemble another similarly protected species? If their foes avoid protected species by 'instinct,' none at all; but if, on the contrary, as appears so much more probable, the foes have to learn their unpalatability by experience, then the benefit is all the greater the less numerous the species. The advantage gained by two unpalatable species by their resemblance is in inverse ratio to the square of their numbers."

This quotation may be amplified a little. A certain number of lives of any species must be sacrificed in teaching inexperienced enemies what to avoid. But if the loss of insects of a certain definite aposematic pattern, instead of being borne by one species only, could be distributed over several resembling each other, the loss borne by each species would be only a small proportion of the total loss, while the lesson would be equally well learnt. Moreover, it will be of further advantage in that there will be fewer patterns to tax the enemy's memory.

So now we have to consider a second type of resemblance, characterized by the presence of Common Warning Colours, or, to use Poulton's term, *Syn-aposematic*. Although the term "Mimicry," first used by Bates, should refer to an edible species masquerading as inedible, it is loosely used to cover the likeness between two distasteful species, which is a matter of a different order. Properly speaking, Mimicry is *Pseud-* and not *Syn*-aposematic.

Instances of syn-aposematic resemblance may be seen in England, such as the yellow and black bands of different kinds of wasps, or the red and green of the Burnet moths. These insects being so closely related, it may with reason be argued that it is not surprising that Burnet moths of a single genus should have a close similarity.

[1] See *Proc. Ent. Soc. Lond.*, 1915, pp. xxii, xxiii.

As a better instance may be cited a number of *Hymenoptera* of different groups which I found on the islands, characterized by dark grey or dull black colouring with a segment of the antennae and the tip of the abdomen conspicuously white, and the transparent wings partly clouded to form a pattern. Several species of Fossorial and Parasitic *Hymenoptera* were collected that belonged to this syn-aposematic association ; in one case, a Scoliid, the white on the antennae was produced by white hairs, and was not, as in the other species, the colour of the integument. This is an interesting example of a point with which Professor Poulton has dealt at some length,[1] that natural selection has brought about the same effect in different ways on different subjects, according to the material offered for selection. Natural selection can *originate* nothing ; it can only work with and modify material offered to it by variation. This point can never be kept too much in prominence.

The best known syn-aposematic association centres round the undoubtedly distasteful and conspicuous Malacoderm beetles of the family *Lycidae*—such insects are very conveniently spoken of as "Lycoid." The Lycid aposeme is a general colouration of bright orange-brown, with the extremity of the abdomen and elytra black. The antennae and limbs are black or black and orange. The beetles are found collected in numbers [2] on flowering bushes, are of sluggish habit, slow, heavy flight, unafraid, and often exude a droplet of yellow fluid when handled, and have been proved to be distasteful to vertebrate enemies.[3] G. A. K. Marshall figured [4] a large number of Lycoid insects belonging to many orders of insects. In beetles and bugs (*Hemiptera*) the species are coloured

[1] See *Essays on Evolution*, pp. 264–6 ; also Punnett, *Mimicry in Butterflies*, pp. 40–2.

[2] *Proc. Ent. Soc. Lond.*, 1917, p. lvii.

[3] *Trans. Ent. Soc. Lond.*, 1902, Part III, pp. 347, 391.

[4] *Ibid.*

in the same way as in the *Lycidae*. In the clear winged *Hymenoptera* the wings are tinted with orange, and, at their tips, with black, so that when brought together over the body they produce the Lycoid effect. Lycoid beetles are numerous. I have met with them among the families *Cerambycidae, Chrysomelidae, Cetoniidae,* and their closer Malacoderm relations, *Lagriidae.* Of Hymenoptera, the fossorial *Sphegidae* and *Pompilidae,* true wasps, and parasitic *Braconidae,* all had Lycoid representatives on the islands ; also *Hemiptera.*

A small moth, of family *Lithosiidae,* abounded among long grass on Bugalla Isle, and as it rested with its wings superimposed upon its back, the resemblance to a Lycid was quite striking. This was less so in the case of a new species of Zygænid moth [1] which I was fortunate enough to find. The wings were laid along the side of the body in the usual Zygænid manner, so that the flat appearance of the model beetle was lacking. Many of these Lycoids could be found at the same time as the Lycid beetles on the flowers of *Haronga madagascariensis,* a tree or shrub very abundant on the islands, and known as the "Gamboge" tree.

The Lycid aposeme is not confined to Africa. Shelford [2] gives a long list of Lycoid insects met with in Borneo, some of which are syn-aposematic, while others are probably pseud-aposematic.

Mimicry, using the term in its widest sense, it to be found with every degree of relationship between the insects concerned. I have drawn up a table, from examples met on the islands, showing this graphically. At the top of the column of species will be found the pair in which model (uppermost) and mimic are as closely related as possible, being members of the same genus. At the bottom of the column model and mimic are as far apart as members of the Phylum *Arthropoda* can be. Between

[1] *Saliunca egeria.* [2] *A Naturalist in Borneo,* p. 241.

DEGREES OF RELATIONSHIP BETWEEN MODEL AND MIMIC

Examples of mimicry selected from—	PHYLUM.	CLASS.	ORDER.	SUB-ORDER.	FAMILY.	SUB-FAMILY.	GENUS.	SPECIES.
Species of same genus.							Acraea	egina perenna
Genera of same sub-family						Acraeinae	Planema Acraea	tellus jodutta
Sub-families of same family					Nymphalidae	Acraeinae Nymphalinae	Acraea Pseudacraea	zetes boisduvalli
Families of same sub-order.				Rhopalocera	Nymphalidae Papilionidae	Danainae Papilioninae	Melinda Papilio	petiverana leonidas
Sub-orders of same order.			Lepidoptera	Heterocera Rhopalocera	Geometridae Lycaenidae	Aletinae Lipteninae	Leptaletis Telipna	forbesi nyanzæ
Orders of same class.		Insecta	Hymenoptera Coleoptera	Aculeata Longicornia	Braconidae Cerambycidae	— Lamiidae	— Dirphya	Not identified Near pascoei
Classes of same Phylum.	Arthropoda	Insecta Arachnida	Hymenoptera Araneae	Aculeata —	Formicidae Salticidae	Camponotides Myrmarachneae	Œcophylla Myrmarachne	smaragdina fœnissex

Pairs of species mimetically associated; the model being uppermost of each pair.

The degree of relationship between members of a pair is closest at the top of the species column, least at the bottom.

these two is a series of pairs, model uppermost, showing every grade of relationship.

Mimicry, looked at from one point of view, is merely an example of resemblance to an especial part of the environment, and is strictly analogous to special procryptic resemblance. Both are forms of *Apatetic* colouration.[1] In one case the insect is like a leaf or twig which is of no interest to an insectivorous enemy ; in the other it resembles another species which the enemy rarely eats, knowing it to be distasteful. There seems no logical reason for supposing that the latter example is beyond the power of natural selection any more than the former, yet in spite of much recent work on these lines by the Hope Department, and also by naturalists in the field, it is held by some that the resemblances are fortuitous, or the result of causes which together or separately are not able to explain facts as are the Batesian and Mullerian theories, based on natural selection.

An objection is sometimes urged somewhat as follows. Since the potential numbers of patterns are limited, and the number of species large, it is quite possible that the same pattern may have been accidentally produced in two species without there being any meaning to be attached to the resemblance, except mere coincidence.

Dr. F. A. Dixey dealt with this argument at the meeting of the British Association at Birmingham in 1913.[2] He showed a number of examples of *Lepidoptera* from different continents with approximately the same colouration and pattern, and to these cases it would of course be absurd to ascribe a mimetic significance. But it is important to note that such coincidence has gone no further than to produce the crudest of patterns and contrasts, such as a light subapical bar on a dark fore wing, and the likeness even then is not so close as

[1] *Colours of Animals.* See classification at end.
[2] See Report, p. 518.

between species of *Planema* and their mimics, forms of *Pseudacraea*.

Coincidence has proved itself unable to produce such cases as those in South America described by Bates, where the colouration is a comparatively complicated mixture of red and yellow on a dark background. These cases, indeed, almost seem to be an exception to the rule stated above, that aposematic patterns are extremely simple.

The geographical variations of a mimetic species, according to the different species serving as models in the various subdivisions of its habitat, such as in the case of *Acraea alciope* [1] or *Pseudacraea eurytus* (see next chapter), with the transitional forms at the meeting points of two areas, are extremely difficult to explain, except by the theory of a causal connection between model and mimic.

One of the great difficulties felt by many to militate against acceptance of the theory of mimetic resemblance produced by natural selection is lack of definite evidence of a selective agent. It is claimed that it has not yet been proved that birds eat butterflies in sufficient numbers to produce selective action, and, moreover, that they have in certain cases been seen to devour just those species which are claimed to be exempt.[2] This latter point has been already dealt with. I think that few would claim, for instance, that the sting of a bee is of no protection to it because the Bee-eaters appear to be especially fond of them. A mimetist would account for such cases as the ashy wood swallow devouring Danaines in this way.

Regarding the general question, there is plenty of indirect evidence of attacks by birds upon butterflies. All collectors must have noted the Λ-shaped gaps in the hind wings, symmetrical on both sides, that could only have

[1] *Bedrock*, No. 1, April 1912, pp. 57–64.
[2] Punnett, *Bedrock*, vol. ii, July 1913, pp. 159–60.

been produced by a portion of the wings enclosed in a bird's bill breaking away, as I have previously described. As for *direct* evidence, G. A. K. Marshall first collected a number of records of attacks by birds actually witnessed,[1] but C. F. M. Swynnerton has recently produced such overwhelming evidence,[2] that there can no longer be any doubt about the matter. His many careful observations have shown that attacks on butterflies may very easily be overlooked unless an observer is *especially on the look out* for them.

For instance, the late F. C. Selous said : "I have never once seen a bird eat a butterfly in Africa." (*African Nature Notes and Reminiscences*, p. 9.) But I do not see that the negative evidence of a hunter, who did not pay so much attention to small life as to big game, weighs against the positive evidence brought forward by Swynnerton and others, who *have* paid special attention to birds and butterflies from this point of view.

In fact, Selous's statement only shows how much an observer may fail to see outside his particular sphere of interest !

It appears to me that observation of one class of life renders it difficult to observe another ; indeed, there are three definite fields, requiring radii of observation of different lengths. First, and nearest, are insects whose small size renders it necessary to look for them near at hand. I find that I instinctively keep my vision on objects within about ten yards' radius when I am out in the field, insects being my natural prey. Big game can hardly be expected to be seen within this area ! If it is desired to observe birds, the radius is longer, and one looks not on the ground or low herbage near at hand, but at bushes and trees at least twice as far away, and for mammals

[1] *Trans. Ent. Soc. Lond.*, 1902, Part III, pp. 353–71.

[2] *Proc. Ent. Soc. Lond.*, 1915, pp. xxxii–xliii ; *Journ. Linn. Soc.*, 1919 ; *Zoology*, vol. xxxiii.

the radius is much increased. I have often noticed that when out for insects I notice very little of the bird life, and if I want to see birds have to determine to ignore insects. How much the more is this necessary for mammals !

If an entomologist fails to observe distant game, equally so must the hunter, who is looking out for distant animals, be oblivious to much that goes on near at hand. The habitual gaze of such a practised hunter as Selous would be fixed beyond the shorter radius necessary to observe small birds and their prey. This seems a possible explanation of the failure of a great hunter to see what I have seen on several occasions in a fraction of the time that he spent in the field. I think, speaking from my own experience, that one is too apt only to notice such birds which, perched on conspicuous twigs or tree tops, look as if they were going to catch butterflies, such as Bee-eaters, Drongos, etc. At any rate, that has been my error on the islands, and I never *saw* a Bee-eater attack a butterfly, although I found several pairs of wings of *Terias* lying on the ground under a stem where *Melittophagus meridionalis* had just been sitting. Had I read Swynnerton's work before I collected butterflies, I should certainly have seen, as Swynnerton says, "a sudden sharp movement at the back of a flower head or the quick dash of a bird over the top of a pannicle on which butterflies and Hymenoptera may be feeding together ;" for birds often flew away at my approach to the flowering bushes of *Haronga*, on which great numbers of butterflies fed.

Since I left the islands I have seen a bush frequenting bird, probably *Campephaga nigra*, the black cuckoo-shrike, very quietly eating a Pierine butterfly (*Belenois*), but had I not heard the quick flutter of wings and the snap of a bill as it caught the butterfly, my attention would not have been drawn to this case.

In 1915, while on active service in German East Africa, I saw two wagtails at puddles eat eleven butterflies in five minutes, and on another occasion saw one eat eleven butterflies in three minutes, definitely selecting for its food *Lycaenidae*, *Belenois*, *Atella*, from among a crowd of butterflies assembled on the mud, and paying no attention to a number of the typically aposematic Danaine *Amauris echeria*, or the black and scarlet *Papilio ridleyanus*, mimetic of *Acraea egina*.[1]

Lastly, it may be said, when dwelling on this question whether birds do or do not by eating butterflies cause mimetic resemblances, is it not too often forgotten that butterflies are not the only mimics? No one will deny that spiders are eaten by birds, or flies, or beetles, or grasshoppers, yet numbers of mimetic members of all these groups are known, all explicable by the same theory as mimicry among butterflies, and all must stand or fall together.

Dr. W. H. Longley has suggested a modification of Thayer's views on concealment, supposing that all species have been forced to assume colour combinations which most effectually conceal them in their normal environment; and that in a few cases patterns have appeared which have been sufficiently alike to deceive enemies which discriminate in their choice of food.[2] This hypothesis thus evades the difficulty of understanding the gradual building up of a mimetic likeness while acknowledging that mimicry does exist and is of value to the mimic, and that different degrees of edibility exist, but it affords no explanation of the difference in behaviour between model and mimic. If both *Planema tellus* and *Pseudacraea eurytus* form *terra*, are equally well concealed, why should the former be so bold that it can be plucked

[1] *Proc. Ent. Soc.*, 1915, pp. lxix.–lxxv.

[2] "A Revised Working Hypothesis of Mimicry," *The American Naturalist*, vol. li, May 1917, p. 276.

from a flower by the fingers, while the utmost caution is necessary if one wishes to catch the mimic? Dr. Longley lays stress on the assertion that "colour and habit are associated variables," which hardly seems to be consistent with the great differences in habit between model and mimic of the same colour and pattern.[1]

Again, I would point out that it is difficult in the extreme to think of all larvae, for example, as concealed by likeness to their surroundings. On our common hawthorn bush, for instance, caterpillars of the gold tail moth, or of the "Figure of eight" moth (*Diloba caeruleocephala*) thrust themselves upon one's notice, and side by side on the same bush highly modified Geometrid larvae are only to be discovered by careful search, so similar are they to twigs. A large Hypsid larva (*pactolicus*) abounded on a papilionaceous plant growing on sandy shores of the islands of Lake Victoria. It was marked with alternate rings of dead black and purest chinese white, with red head and legs and long black or white hairs, and was visible clearly from as far away as a creature of that size could be visible. It developed into a gorgeous orange moth, with blue-black blotches on the fore wings and a black border to the hind wings, which was a brilliant and conspicuous object at rest or on the wing. It freely exposed itself, and was of sluggish habits and slow, heavy flight, as it would be expected to be on the Darwinian explanation. Yet Dr. Longley would have us believe that it is really concealed, and offers no consistent explanation of its habits.

The great attention that is nowadays being paid to the principles of heredity as expounded first by Mendel, and to the theory of "Mutations," has resulted in attempts to account for cases of mimetic likeness by sup-

[1] In the case of the *Lycidae* the larvae are carnivorous and live in the open; those of a very close *Longicorn* mimic live in dead wood. At the stages when the future similar colours of the adults are being prepared the habits of model and mimic are as dissimilar as possible.

posing that a mimic was produced suddenly in the likeness of some other species, by a large variation known as a mutation, and that the Mendelian principle perpetuated this unchanged, the pattern, etc., being due to presence or absence of certain "factors," or of factors inhibiting others.

If mimics are produced by mutations, it is remarkable that not only superficial aspect, but movements and habits should be produced that, quite fortuitously, are extraordinarily like those of some other species *in the same neighbourhood*, and it seems highly remarkable that such mutations should resemble species of the type described as aposematic. How is it that mutation does not produce new forms resembling *procryptic* species? Why should all the females of *P. dardanus* be modified by mutation to resemble different species of conspicuous, relatively distasteful butterflies of genera belonging to two different sub-families? Why has not a form of the excessively variable species *Pseudacraea eurytus* (see next chapter) been produced that deceptively resembles some procryptic species? This most wonderful genus has only two out of over a score of forms that are not close copies of some other butterfly, and yet the species resembled are all aposematic! It seems incredible that mutation can produce only pseud-aposematic variation. Where, then, are the other less conspicuous forms? No other conclusions seem possible than that they have been destroyed by enemies before they could establish themselves. If this be so, the argument that insectivorous enemies do not destroy butterflies in sufficient numbers to have a selective influence falls to the ground.

As a matter of fact, a few cases are known of such a variety differing very considerably from its parents to a degree that could be claimed as an instance of the sudden appearance of a mutation.[1] But they are ex-

[1] *Bedrock*, vol. i, pp. 63–4—an example of a rare large variation in *Acraea alciope*.

cessively rare compared with the numerous finely gradated forms that may be found connecting a mimetic form with a non-mimetic or transitional between two mimetic forms.

That birds do exercise discrimination and do destroy large numbers of butterflies there can no longer be doubt, thanks to Swynnerton. It seems difficult to avoid the conclusion that the conspicuous mimics are *preserved* by selection, and it is on the question how they arose that Darwinians and mutationists join issue.

The study of a mimic of wide distribution and changing form, such as *Acraea alciope*, *Pseudacraea eurytus*, *Charaxes etheocles*, shows by the transition stages that a mimic is not suddenly turned out complete. Evidence may be found in the publications of the Entomological Society [1] that the small, often quite small, variations on which a Darwinian depends, are heritable, whereas, according to the mutationist, such "fluctuations" are not handed down. On the other hand, the mutationist claims that his large variations are irrevocably fixed, and, when once formed, do not retrogress towards the parent form. Thus, for instance, the wonderful forms of *Pseudacraea eurytus*, mimicking different species of *Planema* according to the locality, should, if the model ceased to exert its influence, still continue to show the same great degree of resemblance without the occurrence of any intermediate variations. The next chapter, however, shows that this is not the case.

[1] Poulton, E. B., "Heredity in Six Families of P. *dardanus*, subsp. *cenea*." *Trans. Ent. Soc.*, 1908. Carpenter, G. D. Hale, "The Inheritance of Small Variations in the Pattern of *Papilio dardanus*." *Trans. Ent. Soc.*, 1914.

CHAPTER XI

PSEUDACRAEA EURYTUS

THE Nymphaline genus *Pseudacraea* is closely allied to the more widely spread *Limenitis*, but is confined to the Ethiopian regions, including Madagascar. The name is an excellent one; for out of a considerable number of species, although the number has been much reduced during recent years owing to the fusion of many "species" into one, only two are non-mimetic. The remainder resemble for the most part members of the Acraeine genus, *Planema*, a few mimic *Acraea* itself, one mimics the Danaine genus *Danaida* and others *Amauris*.

One of the most remarkable points in the resemblances is the fidelity with which a single polymorphic species mimics sundry species of models of very different appearances in different localities; and where a model is sexually dimorphic the sexes of the mimic faithfully copy the corresponding sex of the model. Yet in the very locality where this dimorphism of model and mimic exists other species of monomorphic models are closely copied by monomorphic forms of the same species of mimic.

The closeness of the resemblance is most remarkable, and is indicated by names such as *deceptor*, *simulator*, *imitator*, etc. Indeed, as Eltringham says in his *Mimicry in African Butterflies*, the deception caused Hewitson himself, a violent opponent of Bates's explanation of these resemblances, to comment upon the strange similarity between Acraeine and Nymphaline.

I have many times been deceived by these mimics in the forests on the islands, until long association and close familiarity enabled me to differentiate. But even then, after a pause of a few weeks during which they had not been seen, it was by no means easy to say at a glance whether a specimen seen suddenly in the forest was *Planema* or *Pseudacraea.* Certainly the mimics are not so bold as *Planema*, and if really alarmed will show it in their hasty flight, whereas the model is much more stoical, and may be easily picked off a flower with the fingers.

The flight of *Pseudacraea* is often of the "floating" nature, especially when several of these butterflies are flying rather high up, in the sun, and round about a tree. By this the mimic can be distinguished, but some species of *Pseudacraea*, e.g. *poggei*, do not show the "floating" flight to the same degree, and thus *poggei* bears an even closer resemblance to its model, *Danaida chrysippus*, whose flight is much more of the "flapping" type.

Professor Poulton has written as follows about this flight in a letter dated September 5, 1912: "I am very interested in the non-floating flight of the most distasteful butterflies. But I have seen a kind of floating flight in *D. plexippus* in America. Still this is not like our *Limenitis*, and this latter I suspect is like *Pseudacraea.* A floating flight for display, accompanied by alertness and activity when alarmed, seems to be characteristic of the second category of distasteful insects in Mullerian combinations; it is also true of the true *Heliconinae* in South America, mimics of the *Ithomiinae.*" Again, in another letter, written March 6, 1912, Professor Poulton said: "It is an extraordinarily interesting genus; its habits, I should think, are rather like those of our *Limenitis*, and the degree of distastefulness I should think about the same."

The genus *Pseudacraea*, therefore, is to be regarded as an example of the "transition from Warning to Mimetic colours" described by Poulton in the *Colours of Animals*, pp. 221–223, that is, these butterflies possess a certain degree of distastefulness compared to some others, but less than others which they resemble, and so benefit by the more unpleasant reputation of these latter. They are Syn-aposematic and not Pseud-aposematic: Mullerian and not Batesian mimics.

I have noticed a peculiar sheen on the wings, especially on the under surface, that has been found very useful in enabling me to distinguish the nature of a specimen seen sitting far out of reach on a leaf in the sun.

The forms with which we are concerned in this chapter frequent forest, and are not to be found outside. But flowering shrubs at the edge of a forest will often prove extremely attractive, so that Pseudacraeas will collect thereon in numbers, coming from the shady forest to the bright sun at the edge, when they may be found on the flower heads until shortly before sunset. On Bugalla Isle, in 1912–13, I had a favourite walk along the edge of the forest between 4·30–6 p.m., visiting the gamboge trees (*Haronga madagascariensis*), which, when in full bloom, supplied many fine Pseudacraeas, Planemas, and insects of many other kinds.

It is not proposed to mention here more than the forms of *eurytus* which occur in Uganda, together with the first known form, now known as *eurytus* itself, in West Africa, and the Eastern and South African forms. The valuable paper by Dr. Karl Jordan at the first International Congress of Entomology [1] and the beautifully illustrated book by Dr. H. Eltringham on *African Mimetic Butterflies*, will enable the reader to gain some idea of the most wonderful polymorphism of this species.

Dr. Jordan (*loc. cit.*) figures thirteen West African males "considered to belong at least to seven distinct species," but says that "as a result of my inves-

[1] Iere Congrès International d'Entomologie, Bruxelles, Août, 9110, pp. 385–404. Plates xxi.-xxiv.

PLATE II

1. *Planema aganice* form *montana* ♂, Ngamba Island, L. Victoria, 11 VII, 1914.

2. *Pseudacraea eurytus* form *rogersi* ♂ (the type specimen).
   Caught by Rev. St. A. Rogers near Mombasa, November, 1906.

3. *Pl. aganice* form *montana* ♀, Tavu Island, 1 VII, 1914.

4. *Ps. eurytus* form *rogersi* ♀ (the type specimen).
   Caught near Mombasa, 28 VII, 1906.

5. *Pl. aganice* form *nyasæ* ♂, 13 VI, 13.
   Caught by S. A. Neave on Mt. Mlanje, Nyasaland.

6. *Ps. eurytus* form *mlanjensis* ♂, 11 XII, 13.
   Caught by S. A. Neave on Mt. Mlanje, Nyasaland.

7. *Pl. aganice* form *nyasæ* ♀, 10 VI, 13.
   Caught by S. A. Neave on Mt. Mlanje, Nyasaland.

8. *Ps. eurytus* form *mlanjensis* ♀, 17 III, 13.
   Caught by S. A. Neave on Mt. Mlanje, Nyasaland.

9. *Pl. aganice* ♂, 13 IV, 1897.
   Caught by G. A. K. Marshall, Malvern, Natal.

10. *Ps. eurytus* form *imitator* ♂, 7 V, 1910.
    Bred by the late A. D. Millar, near Durban, Natal.

11. *Pl. aganice* ♀, 22 III, 1896.
    Caught by G. A. K. Marshall, Malvern, Natal.

12. *Ps. eurytus* form *imitator* ♀, 20 IV, 1910.
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6. *Ps. eurytus* form *mlanjensis* ♂, 11 xii, 13. Caught by S. A. Neave on Mt. Mlanje, Nyasaland.

7. *Pl. aganice* form *nyasae* ♀, 10 vi, 13. Caught by S. A. Neave on Mt. Mlanje, Nyasaland.

8. *Ps. eurytus* form *mlanjensis* ♀, 17 iii, 13. Caught by S. A. Neave on Mt. Mlanje, Nyasaland.

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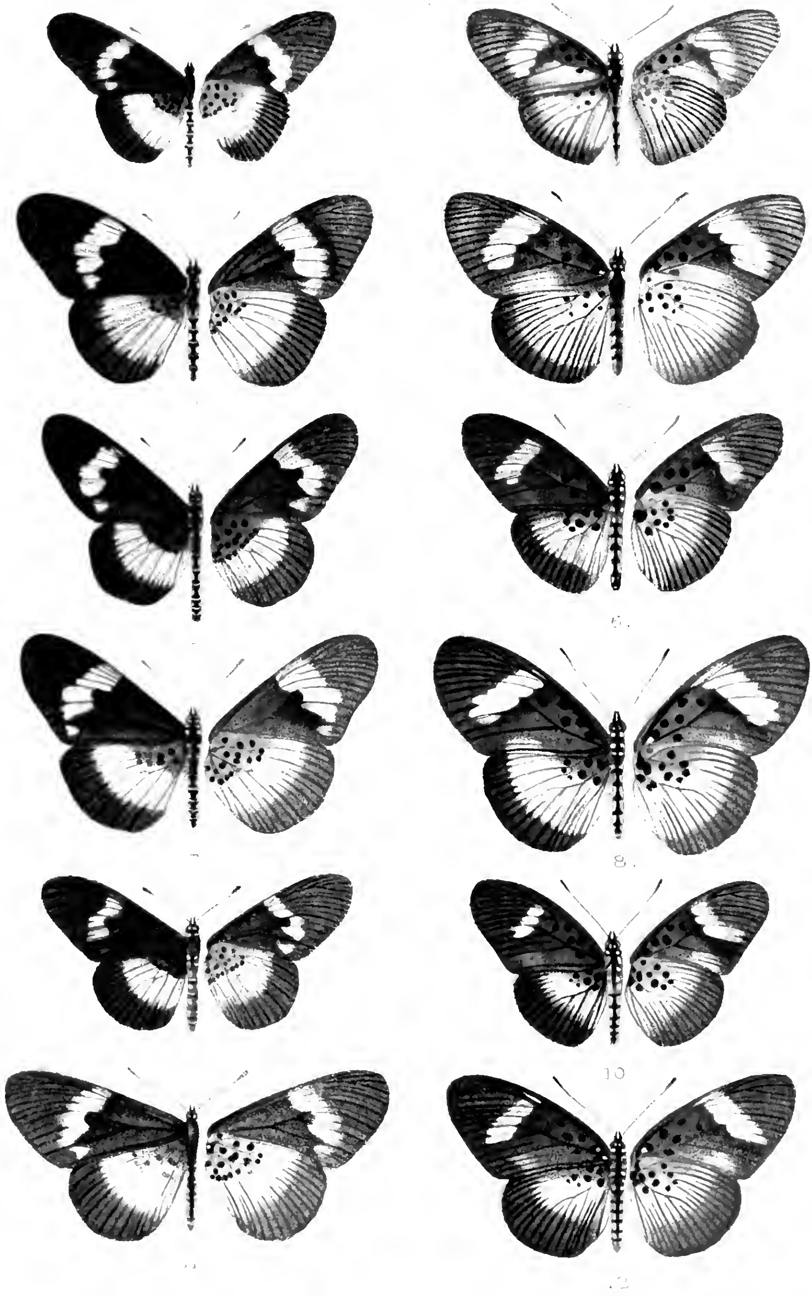
PLATE II.

Acraeine model. *... mimics*



... FORMS OF

tigations I must regard these insects as forms of only one single species, *Pseudacraea eurytus* (Linnæus, 1758)." Along with these forms of one species are figured thirteen *different species* of *Planema*, each a model for a form of *eurytus*; and on another plate "five white banded female specimens of *Pseudacraea eurytus*, together with the females of five species of *Planema*."

Pseudacraea eurytus[1] itself was named by Linnæus in 1758. It is sexually dimorphic. The male is tawny orange and blackish brown, the female black and white, with the white areas roughly corresponding to the pattern of the orange in the male, but being more contracted on the hind wing. It is a West African form, mimicking the West African dimorphic species *Planema epaea*. I have, however, taken on Bugalla Island a single female closely approximating to the typical *eurytus*; it is intermediate between two forms described below, namely *tirikensis* and *terra*, having the fore wing pattern of *terra*, but the black and white colour of *tirikensis*, while the pattern of the hind wing closely approximates to that of *eurytus* and thus differs from the pattern of *tirikensis*.

In 1919, in a small isolated patch of forest on the Kyagwe (mainland) north coast of the lake, I took a fine male which is not essentially different from the typical male *eurytus*.

All the Pseudacraeas mentioned in this chapter, except *kuenowi*, are now known to be forms of *eurytus*, using the name in its widest sense. It has a distribution throughout the tropical and subtropical forests of Africa, from west to east, and from northern Uganda to Pondoland, south of Natal. It is, however, very scarce in East Africa and Rhodesia.

The form *imitator* was described from Natal by Roland Trimen in 1873: it mimics *Planema aganice* and, like the model, is sexually dimorphic, although the difference in colour between male and female is not so marked as

[1] See the two coloured plates for illustrations of models and mimetic forms of this species.

in the first named form. Colonel Bowker, in a letter to Trimen, said it was "quite impossible to distinguish between this butterfly and *aganice* either when settled or on the wing." (Plate II, figs. 9–12.)

The male and female have the same pattern on a black ground, the pattern being cream coloured in the male, while in the female it may be either cream coloured or white. The female may thus resemble either the male or female of the model, which, so far as I am aware, does not occur among other forms of *eurytus,* in which, if the model is dimorphic, the male is copied by the male of the mimic and the female by the female. The white areas of the female differ quite noticeably in this form from the pattern of the female *eurytus*, there being only a trace of white, instead of a large, well defined area on the inner margin of the fore wing. This species possesses in a very high degree a most conspicuous aposeme on the underside of the base of the hind wing which, as in the model, must be of great value when the insect is at complete rest with the wings brought together over the back. This aposeme takes the form of a well defined patch of bright purplish or reddish brown, extending outwards from the base along the costal margin.

The form *imitator*, southern in distribution, is connected with the northern forms shortly to be described by forms found in Nyasaland quite plentifully, and others more rarely in East Africa.

Very recently has been discovered a single specimen of a most remarkably interesting form which extends our knowledge of the distribution of *Pseudacraea eurytus* south of Natal to West Pondoland. The specimen referred to is in the museum at Tring, and I am greatly indebted to Lord Rothschild and Dr. Karl Jordan for the loan of it that I might compare it with others. It was taken on April 16, 1915, by H. H. Swinny, at Port St. John's, and is of quite a distinct reddish orange tint, which renders it markedly different from any other form of *eurytus* yet known. It seems to combine the features of the western *eurytus* male with the *imitator* of Natal. The subapical orange area of the fore wing is small and narrow, as is the corresponding pale area of *imitator*, and the inner marginal area on the fore wing is like that of *eurytus*. The hind wings have a very large orange area with only a narrow black border, as in the western *eurytus*, but at the base they show the very large purplish brown aposeme extending along the costal margin to the tip as in *imitator*. This most interesting specimen is a male, and one awaits the discovery of its female with enthusiasm : probably it will be black and white. It presumably mimics a local form of *Planema aganice* which has yet to be discovered.

In 1904, S. A. Neave described four new Pseudacraeas from Uganda, which are now known to be all forms of *eurytus*, using the name in its wide sense. The form *hobleyi* was the first to be named, and the others make with it a group inhabiting Uganda, although some at least extend their range out to the West Coast. *Hobleyi* is a male form only, mimicking the male of *Planema macarista*.[1] On a ground of blackish brown it has a bright orange bar bent at an angle, crossing the fore wing, and a white bar crossing the middle of the hind wing. This latter bar, however, as in the model *macarista*, is often bordered with orange-brown and, in examples brought by Neave from Western Uganda, becomes wholly orange. This form appropriately mimics the local form of *Planema*, in which the white bar of *macarista* is replaced by orange. This is *Planema pseudeuryta*, very closely allied to *macarista*. The form *hobleyi* has a basal aposeme on the under surface of the hind wings, but this differs slightly from that of *imitator*, being more concentrated into a basal triangle, and of a more reddish and less

[1] Plate I, figs. 5, 6.

purplish brown. Needless to say, this aposematic triangle is a very marked feature in the model *macarista*.

The shape of the orange bar crossing the fore wing of *hobleyi* varies considerably, and in some cases bears a resemblance to the rather different shape of the bar in a very different *species* of *Pseudacraea*, namely, *Ps. kuenowi*, which has the same general scheme of colouring. It seems possible that these forms of *hobleyi* show the secondary resemblance of one species to another, both, however, mimicking the same model, which is found and has been described by Dr. Dixey and Professor Poulton in other combinations. It would be necessary, however, before accepting this for a fact, to ascertain whether the proportion of *hobleyi* with the bar like that of *kuenowi* is greater in the areas where both are found together than in areas where *kuenowi* does not occur.

Another form of *eurytus*, described at the same time by Neave as a different species, is a black and white female known as *tirikensis*. Later this was found to be the female of the male described as *hobleyi*, and the name *tirikensis* fell into abeyance. Now, however, that both are known to be not a distinct species but only forms of *eurytus*, the name *tirikensis* again holds good as a mimetic form name. This female form has a black ground; on the fore wing is a white bar bent at an angle, but the posterior end of this beyond the elbow is often so suffused with black as to reduce the bar to a large subapical area only. Such a pattern very closely resembles that of the female *Planema macarista*, also found in Uganda flying with the mimic. The hind wing is black and white, and shows well the umber triangle at the base on the under side as in the model. (Plate I. figs. 7, 8.)

This form is very variable, and graduates into others. Thus a form from Gaboon, copying the female *Planema excisa*, has the fore wings like those of *tirikensis*, but the hinder end of the white bar is tinted dull yellow, and the hind wings are pale yellowish, approaching those of such a form as *terra*, to be described below.

Another specimen in the Tring museum, from Fort Anderson, Nyasaland, although it might be termed a *tirikensis*, has a much larger area of white on the hind wing, whereby it approaches to the East African form *rogersi*, yet to be considered.

Dr. S. A. Neave has discovered on Mount Mlanje in Nyasaland a form of *Planema aganice* differing markedly from the more southern Natal form by the greater size of the pale areas on all wings in both male and female. It is copied closely by a corresponding form of *Pseudacraea* showing the same differences from the Natal form,[1] which is most interesting, for the shape and size of the subapical white bar on the fore wing in the female comes near to the form of *tirikensis* whose white transverse bar is suppressed at the posterior end, while on the hind wing the white area is as in the female form *rogersi* of East Africa. At the base of the hind wing beneath there is a large brown aposematic patch, which is exactly intermediate between the long narrow purplish brown patch of the southern *imitator* and the more triangular, umber-brown patch of *tirikensis*.

This new form in Nyasaland is thus beautifully transitional between the more northern and the eastern forms *tirikensis* and *rogersi* and the more southern *imitator*, and agrees as closely with its local model form of *Planema* as do other Pseudacraeas already mentioned.

At the time when *hobleyi* and *tirikensis* were looked on as male and female of a distinct species of *Pseudacraea*, a very interesting form was described by Poulton in his paper on the Wiggins collection [2] as a "female possessing the colour and to a large extent the pattern of the male." That is to say, it has an angular orange bar crossing the fore wing, but the direction and shape

[1] Plate II, figs. 5–8.

[2] 1ere Congrès International d'Entomologie, Bruxelles, Août, 1910.

of the bar is that of the white bar of the female form *tirikensis* in its most complete development: the colour, however, is not the rather deep orange of *macarista*, but the paler yellowish orange of the different species *Planema poggei*, of which both sexes are alike, and in which the direction of the orange fore wing bar is much more oblique than in the male *Planema macarista*.[1] The form of *Pseudacràea* now under discussion is thus brought to be a mimic of *poggei* rather than of the male *macarista* both in colour and direction of the bar across the fore wing, the obliquity being given to the bar because it is of the shape of that in the female form *tirikensis*, and not of the male *hobleyi*.

It is now incorrect to speak of a "female *hobleyi* with male colouring" with this difference in shade in the orange bar, and this form has been named *poggeoides* by Professor Poulton.[2] It is remarkably interesting from the point of view of geographical distribution. The models *Planema macarista* ♂, and *Pl. poggei* ♂ ♀, occur around Entebbe, but the former is there more abundant and *Pseudacraea eurytus* form *poggeoides* is very scarce, the females being almost all of the form *tirikensis* mimicking the black and white female *macarista*. But around Mount Elgon, in the north-east of Uganda, *Planema poggei* completely replaces *macarista*, which is not as yet known to occur east of the Nile, and the black and white female forms *tirikensis* are outnumbered by the form *poggeoides* with *orange* bar across the fore wing like the model.[3] Since the male of the mimic (*hobleyi*) has the bar on the fore wing orange, the change in proportion of the two model Planemas does not affect its appearance.

Thus, in the case of the female forms *poggeoides* and *tirikensis*, there is an exact parallel to the case of the

[1] Plate I. figs. 9, 10. [2] *Proc. Ent. Soc.*, 1912, p. cxvii. [3] *Ibid.*, pp. lxx.-lxxi.

male form *hobleyi* already discussed. In the centre of Uganda a few forms are found which, in the case of the male, become the predominant form to the west, in the case of the female become the predominant form to the east. In each case the alteration between the proportions of the forms coincides with the different proportions of the *Planema* models on the west and east sides of Uganda.

Another form that was described by Neave in 1904 from the collection made by C. A. Wiggins in the environs of Entebbe is known as *terra*. (Plate I, figs. 1, 2.)

This form is monomorphic, male and female alike showing a rich orange pattern on a brownish-black ground, mimicking to an extraordinary degree of perfection the abundant *Planema tellus eumelis*, which is also monomorphic, although its West African form has a black and white form of female as well. The pattern of the form *terra* is much like that of the male *eurytus*, save that the subapical and inner marginal orange areas on the fore wing are more extensive : the colour, however, is a much lighter orange. But forms of *terra* with contracted fore wing areas are quite common on the islands, and one such, mentioned previously, that was taken in 1919 on the Kyagwe coast in an isolated area of forest, had such dark brownish orange colour that it was practically indistinguishable from a typical male *eurytus* from the West Coast. In *terra* there is no basal aposematic umber-brown triangle on the under side of the hind wing, and this is absent from the model *Planema tellus* also. The form *terra* is found from Uganda to the West Coast.

I consider it to be the most perfect mimic of all the forms of *eurytus* that I have seen alive : in pattern and colouring it approximates so closely to the model *tellus* that I have been deceived by it over and over again.

On the islands many variations have been found, showing some very distinct patterns and transitions to other forms. A common variation is reduction in breadth of the black bar separating the orange areas on the fore wing, and when this is completely eliminated the form described by K. Grünberg [1] as a distinct species "*impleta*" is obtained. It would not require a great change to develop the male form of *rogersi* [2] from *impleta*.

Another form known as *obscura* was also described by Neave in 1904, and is one of the group from Uganda coming under the subhead of *hobleyi*. This is also a monomorphic form, male and female being alike, as are the models, the eastern form *paragea* of *Planema epaea*, a common West Coast Acraeine.[3] The model is rather rare, and the mimic *obscura* is also rare. It has pale creamy markings, easily derivable from those of *terra*, but much smaller, on a dark greyish brown background. The pattern of these creamy markings does not follow so exactly the pattern of the model as does that of *terra*, but the general effect is decidedly that of resemblance. As regards flight, there is much more difference between model and mimic in this case than with the other members of the *hobleyi* group, for *paragea* the model has rather a weak fluttering flight, and looks a feebler insect than the robust and powerful *Pseudacraea*. I have never mistaken *obscura* for its model. Both show a certain amount of reddish brown at the base of the under surface of the hind wing, but this is of a paler tint than the rich umber that makes the characteristic basal triangle of *hobleyi*, *tirikensis*, *poggeoides* and their models, and is not so sharply defined.

The form *obscura* seems to be the least fixed of the Uganda forms of *eurytus* comprising the *hobleyi* group; at any rate, on the islands it was quite difficult to obtain two that were closely alike and did not show transition to one of the other forms.

Lastly, there is the extremely rare and little known form from near Mombasa, British East Africa, described

[1] *Sitzungsber. d. Ges. Naturf. Freunde*, Nr. 4, 1910.
[2] Plate II, fig. 2. [3] Plate I, figs. 3, 4.

as *rogersi* after its captor, by Trimen in 1908.[1] The form is dimorphic, the male having the wings blackish brown and orange, but the orange is of a slightly more reddish tint than in other forms, and approaches the hue of the unique specimen previously mentioned from West Pondoland. There is an irregular area on the fore wing like that in some of the varieties of *terra* in which the black bar is broken through.

The black and white female has a pattern after the style of the typical female of the western *eurytus*, except that the white area on the hind wing is very much larger, and sharply outlined by a narrow black border. There is a certain amount of reddish suffusion on the under surface of the base of the hind wing.

This form, *rogersi*, is represented in collections by a single male and female at Oxford, the types. When I was recently looking through Lord Rothschild's magnificent collection of *Pseudacraea eurytus* at Tring, I found there were three females bearing labels "Mombasa" that appear to be of this form, but I do not know of any other males.

The only *Planema* of abundance in the locality from which this form is known is *Planema aganice*, in its eastern and northern form *montana*.[2] In this form the sexes are different and much more unlike than those of the southern *aganice* [3] which, be it remembered, served as model in Natal for the form of *Pseudacraea eurytus* known as *imitator*. In *aganice montana* the male, instead of having a creamy yellow pattern, has the same areas of a rich orange. In the form *rogersi* now under discussion, the pattern is not quite like that of *Planema aganice montana*, and is much nearer that of another species of East African *Planema*, viz. *adrasta*. This species has, in the male, a complete orange bar across the fore wing, and the female has the very large sharply marked white area on the hind wing. Specimens of

[1] Plate II, figs. 2, 4. [2] Plate II, figs. 1, 3. [3] Plate II, figs. 9, 11.

adrasta in the Tring museum come from Usambara, but it appears at present too rare to be claimed as a model for *rogersi*, although the latter resembles it much more closely than it does *montana*. In colouring, however, the male *rogersi* approaches closely enough to the male of its model, and the black and white female is a close mimic of the female *aganice montana*.

The following table shows at a glance the models and mimics hitherto dealt with, arranged in geographical order from the west to the east coast and then southwards, each type of colouring and pattern having a row to itself.

Species of *Planema*.	Forms of *Pseudacraea eurytus*.	Distribution (roughly)
1. *epaea* ♂	*eurytus* ♂	W. Africa
2. *epaea* ♀	*eurytus* ♀	W. Africa
3. *tellus eumelis* ♂ ♀	*terra* ♂ ♀	W. coast to Uganda
4. *macarista* ♂	*hobleyi* ♂	W. coast to Uganda
5. *macarista* ♀	*tirikensis* ♀	W. coast to Uganda
6. *macarista pseud-euryta* ♂	form of *hobleyi* ♂	W. border of Uganda
7. *epaea paragea* ♂ ♀	*obscura* ♂ ♀	Uganda
8. *poggei* ♂ ♀	*poggeoides* ♀	Uganda, especiallyto its E.
9. *aganice montana* ♂	*rogersi* ♂	Mombasa, E. coast
10. *aganice montana* ♀	*rogersi* ♀	Mombasa, E. coast
11. *aganice nyasæ* [1] ♂	*mlanjensis* ♂	Mt. Mlanje, Nyasaland
12. *aganice nyasæ* [1] ♀	*mlanjensis* ♀	Mt.Mlanje, Nyasaland
13. *aganice* ♂	*imitator* ♂	Natal
14. *aganice* ♀	*imitator* ♀	Natal
15. *aganice* ♂ (?)	form of *imitator* ♂	W. Pondoland

We have here fifteen forms of one species of *Pseudacräea* mimicking eight different species or subspecies of *Planema*.

Specific names were also given in the past to a large number of other forms of *Pseudacraea eurytus* on the west coast of Africa differing from the above, although easily derivable from them by transitional varieties known to exist, and these bear equally close mimetic

[1] The names *nyasæ* and *mlanjensis* have been chosen to distinguish these geographical races of model and mimic.

resemblance to different species of West African *Planema*. (See Dr. Jordan's paper, already cited.)

It will be interesting now to trace the development of our knowledge of this most fascinating polymorphic species.

Professor Poulton, in a letter to *Nature*, August 28, 1912, stated: "A little more than two years ago Dr. Karl Jordan informed me that he had been studying the male genital armature of the Pseudacraeas, and that he could not find any difference between the 'species' of a large group made up of Linne's *eurytus* and its numerous allies on the West Coast, of Neave's *hobleyi terra* and *obscura* in Uganda, of Trimen's *rogersi* of the Mombasa district and his *imitator* of Natal."

The provisional conclusion drawn from this fact was that these butterflies are conspecific, and this was brought before the first International Congress of Entomology at Brussels by Dr. Jordan in August 1910.

At the same congress Professor Poulton gave a statistical study of the large collection made near Entebbe in Uganda by Dr. C. A. Wiggins, and stated that in this were two specimens which tended to confirm Jordan's anatomical findings. One was "a male *Ps. terra* with a pattern approaching the male of *Ps. hobleyi*," the other "a female *Ps. hobleyi* bearing the mimetic colours of its own male" (this is the form now known as *poggeoides*). (Plate I, fig. 10.)

Quotations from letters that I received from Professor Poulton after work was commenced on the islands in 1911 will show how keenly interested he was in the problem, and how important he considered it.

I first met with *Pseudacraea eurytus* on Damba Island in 1911, towards the end of my stay there, and, not knowing anything about it, found this mimetic butterfly very puzzling. Not only was it difficult at first to distinguish the forms from their models, but they showed such variation that it was difficult to assign specimens to any particular form, for a single specimen often appeared to be transitional between *terra*, *hobleyi* and *obscura*. The model species of *Planema* were extremely scarce on Damba, and this point proved to be of great significance.

A letter from Professor Poulton, dated October 30, 1911, referring to the arrival at Oxford of the first consignment of these intermediate Pseudacraeas, said : "They looked most interesting, and perhaps here your island forms will be different and throw light on the polymorphism of this set of forms."

November 9, 1911.—"You have the Pseudacraeas abundantly evidently, and it is of the utmost importance to breed them from known parents. They tend to be far more intermediate than on the mainland. I suspect that selection of them is somewhat relaxed on the island, and they at once tend to mix. You have *terra* and *hobleyi* ♀ (I've not seen ♂ yet) and another form, *obscura*, and transitions of the most beautiful kind between *obscura* and *terra*, and between *obscura* and *hobleyi* ♀. I've only seen now among your specimens the models of *hobleyi* (*Planema macarista* ♂ and ♀ and *Pl. poggei*), but no models as yet of the other two (*terra* and *obscura*). Now if these models are rare or absent perhaps we have the cause of the varieties of *obscura* and *terra*, viz. a consequence of freedom from rigid selection. It is an exciting problem, and you are evidently in a most interesting locality."

November 12, 1911.—"This is the exciting thing; there is no doubt that the Pseudacraeas tend to lose their distinctness in the absence, or rarity, of their models. It is *most* interesting and entirely supports Dr. Jordan's views. I cannot tell you how pleased I am."

These specimens from Damba Island were exhibited at a meeting of the Entomological Society of London on December 6, 1911, by Professor Poulton, who said :

"I suggest that, in an area where these mimetic patterns are less strongly selected, there is a tendency, checked elsewhere, for them to run into each other, and also to move in the direction of the western *eurytus* forms, from which there can be little doubt that the mimetic Pseudacraeas of Uganda originally developed. It is to be hoped that Dr. Carpenter may be able to obtain the material by breeding, as well as by capture, by which this hypothesis will be confirmed or refuted." [1]

The following table gives at a glance the forms and varieties of *eurytus*, with their models, that were taken on Damba :

Models.	♂	♀
Planema poggei	2	1
,, *macarista* ..	1	1
,, *epaea paragea*.	♂ ♀ 4	
,, *tellus eumelis* .	♂ ♀ 7	
Models ..	16	

Mimetic forms of *eurytus*.	♂	♀
poggeoides	—	1
hobleyi	5	—
tirikensis	—	4
obscura	2	1
terra	6	9
Mimics	28	
Intermediates ..	10	
Total *eurytus* ..	38	

It is seen that the mimics are almost twice as numerous as the models, and there are in addition more than one-third again of forms intermediate between the mimics. The total number of Pseudacraeas is more than twice that of the Planemas. Concerning these specimens Professor Poulton wrote January 1, 1912 : "I am most interested to hear that you did not distinguish the Planemas and Pseudacraeas (I do not wonder at it) : it makes the results more conclusive. There must be, I conclude and argue in this little paper, something unfavourable to Planemas in the conditions of Damba Islands ; and in their absence or scarcity selection is damped down and

[1] *Proc. Ent. Soc.*, 1911, p. xciv.

the forms are beginning to run into each other and also to assume entirely different proportions from those of the mainland. It is most interesting and indeed exciting."

Early in 1912 I moved camp to the north-east corner of Bugalla Island, the largest of the Sesse archipelago in the north-west corner of the Lake. The north-west promontory of this island almost touches the mainland coastline at the port of Bukakata (see map).

It very soon became apparent that all the combinations which were of so great interest at Entebbe and on Damba Island were present here, and on March 16, 1912, Professor Poulton wrote :

"I am very glad that Sesse is turning out to be so interesting, and I quite think now that it will be even more interesting to compare these two groups of islands together rather than to get evidence from only one. You will realize the utmost importance of catching all the models and mimics you can secure on given days without any selection, so that we can estimate the proportions of models and mimics and see whether, as in Damba, the mimics are relatively far more abundant than on the mainland, and whether, as also in Damba, the intermediates are specially prevalent.

If the results in Damba are supported by a large collection on Sesse, I think the matter will really be established, and will constitute the strongest argument I know for the origin and maintenance of mimicry by natural selection ; for directly the models are reduced the mimics begin to run into each other. I think, in your case, when you are necessarily pressed with other work, that it would be best to concentrate attention on the most important problems, and those certainly are the proportions of models and mimics and the composition of the mimetic *Pseudacraea* group, and breeding the latter to prove that they are all one."

April 6, 1912.—"How splendid that the problem is more illuminated at Sesse than Damba. I never thought that I should get such evidence of the effect of a model on its mimic. . . . It is very important that the Wiggins *Pseudacraea* mimics come from *several* localities near Entebbe and yet *never* approach your island forms in being intermediate, or resemble their proportions to each other or to the models."

I began to try to obtain ova from captured females placed in a box in the forest, but although I knew the genus of tree on which they would probably oviposit (*Chrysophyllum*, *Sapotaceae*), it was some time before I discovered it in the forest. It may be said here that Miss Fountaine has published [1] beautifully coloured drawings of the early stages of the form *imitator*, which is the only representative in Natal.

But breeding this form has thrown no light on its genesis, or on the other forms. For, since there is only one *Planema* to act as a model, *imitator* appears to have become more fixed than the forms of *hobleyi* in Uganda, and varies very little.

Meanwhile, I had often seen the various forms in Uganda flirting with each other in the manner characteristic of male and female of the same species. The following letter to Professor Poulton is quoted from the *Proc. Ent. Soc.*, June 5, 1912, p. lxxxv : "I have already told you that I have seen male *hobleyi* flirting with female *terra* and *vice versa*, both hovering flutteringly in the air. Since then I have seen a male *obscura* paying court to a female *terra* in the same way. This makes the observations complete. . . . So far I have not succeeded in getting eggs, though I have kept four females full of ova : three have died without result, the fourth I have had for a week and it is still living, though it has hardly any wings left."

However, prolonged observation in the forests at

[1] *Trans. Ent. Soc.*, 1911, pp. 57–9.

length met with success, as told in a letter dated June 16th (and partially printed in the *Proc. Ent. Soc.*, 1912, p. cxv):

"I feel I can almost say, as did Charles Kingsley, 'At last!' To-day (Sunday) being a sunny morning after many wet mornings, I went butterflying. I saw a few freshly emerged Pseudacraeas, and, just as I was coming away, saw a beautiful *obscura*, whose very large pale areas indicated more than a touch of the female *hobleyi*. It was fluttering about from bush to bush, and was too shy to let me get near to catch it. At last it settled, and hung from the underside of a leaf, and I was able to see it had a fairly distinct basal triangle (indicating admixture with the form *hobleyi*). It remained motionless a few seconds, and though that attitude is exceptional for *Pseudacraea* (they always rest on the upper side of a leaf with wings usually expanded) it never struck me what was up. I tried to catch it, but it flew off before I got within striking distance. It then occurred to me to look at the leaf, and to my inexpressible joy and excitement, there was a freshly laid egg on the middle of the under surface, still moist with the secretion which fastened it to the leaf. So, if this egg produces a *terra* (and the chances are in favour of this, as *terra* is much the commonest here), you will have the proof you so ardently desire, seeing that the parent was a mixture of *hobleyi* and *obscura*! Anyhow, now that I know and have found the food plant, I may have better luck in getting a captive *Pseudacraea* to lay. There is just time for the egg, larva, and pupa to develop before the congress at Oxford is over, so that, should the offspring be *terra* or *hobleyi* I will let you know. As of course there will be no time to *write*, I will cable just the one word, either *terra* or *hobleyi*. If it is *obscura* I will not cable, but will, of course, write. I feel that it will be such a splendid opportunity for making this result known when you will be showing the Pseudacraeas with special intent to prove their conspecificity by the intermediate forms."

This egg, whose development is fully recorded elsewhere,[1] with descriptions of the larva at different stages (which I dubbed "Toby," feeling that he was important enough to deserve a name !) and of the pupa, eventually, on August 16th, became a butterfly of the form *terra*, somewhat transitional to *obscura*. Thus was obtained the first proof by breeding that the forms of *eurytus* known as *tirikensis*, *hobleyi*, *terra* and *obscura* are conspecific. The cable bearing the single word "*terra*," probably the first cable ever sent about a butterfly only, did not reach Oxford until after the conclusion of the Entomological Congress, but Professor Poulton announced the result in the letter to *Nature* (September 12, 1912, p. 36), which has been already partially quoted.

A letter that I received from him may be quoted here.

August 19, 1912.—"I must write at once now that the great cable has come to-day. I will send a letter to *Nature* next week, so that you may get the credit at once of this most important discovery. . . .

"It is splendid to have this great disturbing question settled at last. Your work is a splendid help towards confirming the Darwinian theory of mimicry. . . . I must now conclude, but cannot do so without again congratulating you on this great success. I have longed for this to be done for two or three years, and have tried my best to induce friends to do it. I even tried to persuade Millar to journey from Durban on purpose to do it ! It is a splendid thing to have accomplished ; quite side by side with Marshall's breeding of the seasonal forms of *Precis*.[2] . . .

"P.S.—After your cable I imitated your example and have just had a sleepless night ! But it's only

[1] *Trans. Ent. Soc.*, 1912, pp. 706–11.
[2] *Ibid.*, 1902, pp. 417–58.

natural, and to be expected after such exciting intelligence."

Again, on October 26, 1912, Professor Poulton wrote:

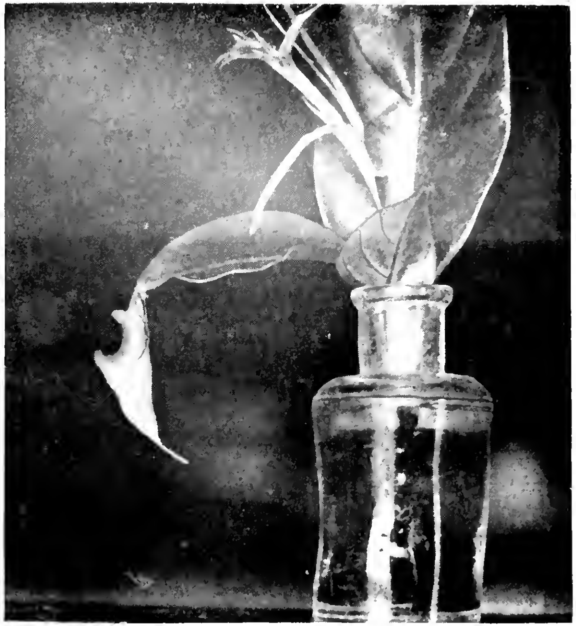
"I am glad that you are realizing the great importance of this material as a test for Natural Selection against Mutation. It seems almost too good to be true. . . ."

On November 22, 1912, he again wrote:

"I do not doubt that *imitator* in Natal is just as successful as *eurytus* on the West Coast. Probably nowhere in Africa are Pseudacraeas quite as successful as they are in Uganda. But on the West Coast they are very polymorphic, in Natal monomorphic, yet both about equally successful. I take it that any variety in Natal that might lead on to a new form is at once exterminated because there is only one *Planema* there, namely *aganice*, but on the West Coast there are many models, and any variety leading to one of them causes the variation to fall into the surviving percentage. If that model disappeared the form would then drop out. We get all this happening round Entebbe according as the models change or disappear" (e.g. the change in *hobleyi* from white banded to brown banded hind wing, and of the female from *tirikensis* to *poggeoides* in different proportions in different parts of Uganda). "Only to-day I saw the male *hobleyi* from Neave's Western Uganda series with a *brown* bar crossing the hind wing, and in the same lot was the *Planema*, a form of *macarista* with a similar male." (This form is known as *pseudeuryta*, and has been already alluded to.)

"I do not believe that any of these mimics depend for their *existence* on the model. The *pattern* depends for its existence on the model, but not the *species* which produces the pattern. That is to say, *Pseudacraea eurytus* is a species which could stand by itself, and indeed does so on certain islands where the protection afforded by *Planema* models is non-existent, but the form

"TOBY" AS A CATERPILLAR.
Note the web of silk spun for foothold on the slippery leaf.



"TOBY" AS A CHRYSALIS.

To face p. 272.

in which it appears is influenced by the varying proportions of these models. Reasons have already been given for regarding *eurytus* as a species at least partially protected."

On November 23, 1912, Professor Poulton writes again :

"The non-variation of *imitator* seems to me quite explicable by selection, for in its locality there is only one *Planema*. *Rogersi* may be looked upon as the connecting link between Uganda and Natal, and I have not the least doubt that there are plenty of Pseudacraeas in British East Africa and further south, but they are mistaken for *Planema* by collectors. . . . I have no doubt you are right about *hobleyi* being the most distinct form ; that it should keep its sexual dimorphism so clearly is further evidence of this, and I should suspect it does follow the Mendelian relationship to one or both of the others. It would be very interesting if this could be tested : the main reason against it is the very great abundance of intermediates. For this reason I should very much doubt a Mendelian relationship between *terra* and *obscura*."

Since "Toby" was reared I have been fortunate enough to obtain eggs from females kept in captivity. They were put with branches of the *Chrysophyllum* into a large wooden box whose sides and top had been partially replaced by mosquito net. The box was placed on tins standing in water in a large basin which stood on a fallen tree trunk in a small open place where gleams of sunshine could penetrate into the cage. I had no success unless the butterfly was kept in the forest, since the species seems to be easily killed by the less humid atmosphere outside the forest, and the greater heat. Several small families were reared from known mothers, and may be seen with the parents in the Hope collection at Oxford.

Family.	♀ Parent.	Offspring.
1	*obscura-tirikensis*	1. ♀ *terra-tirikensis*
		2. ♀ *obscura-tirikensis*
		3. ♀ *terra-tirikensis*
2	*obscura*	1. ♂ *obscura-terra*
3	*obscura-tirikensis*	1. ♀ *terra-tirikensis*
		2. ♀ *terra-obscura*
		3. ♀ *terra-tirikensis*
		4. ♀ *terra-obscura*
		5. ♂ *obscura-terra*
		6. ♀ *obscura-terra*
		7. ♂ *obscura-terra*
4	*tirikensis*	1. ♀ *tirikensis*
		2. ♂ *hobleyi-terra-obscura*
		3. ♀ *obscura-tirikensis*
5	*terra*	1. ♂ *terra-hobleyi*
6	*tirikensis*	1. ♀ *tirikensis*
		2. ♂ *hobleyi*
		3. ♀ *tirikensis*
		4. ♀ *tirikensis*
		5. ♀ *tirikensis*
		6. ♀ *tirikensis*
7	*tirikensis*	1. ♂ *obscura-terra*
		2. ♂ *obscura-terra*
		3. ♂ *hobleyi*
		4. ♀ *obscura*
		5. ♂ *obscura-terra*
		6. ♂ *obscura-terra*
		7. ♂ *hobleyi*
		8. ♀ *obscura*
8	*terra-tirikensis*	1. ♂ *terra-hobleyi*

It seems as if the forms *hobleyi* and *tirikensis* were predominant over the other two, for although *terra* and *obscura* tainted with *hobleyi* or *tirikensis* abound (as shown by the umbre triangle at the base of the hind wing), yet I have never seen a specimen that could be described as *hobleyi* tainted with *terra* or *obscura*. So far, *terra* or *obscura* untainted with *hobleyi* or *tirikensis* have not been bred from *tirikensis* parent, and one of the most abundant intermediate forms is *terra* with more or less

TABLE SHOWING HOW NUMBERS OF INTERMEDIATES VARY INVERSELY AS ABUNDANCE OF MODELS.

	1909. Entebbe (Mainland, C. A. Wiggins).	1911. Damba Isle.	1912–13. Bugalla Isle.	1914. Kome group of Isles.	1915. Kakindu (Mainland).	1918–19. Kome group of Isles.	1918–19. Sundry other Isles.
Planemas (serving as models)	252	16	129	440	102	39	3
Pseudacraeas (total number)	88	38	356	78	13	55	38
Pseudacraeas (intermediates)	2	10	156	3	0	22	14
The *percentage* of Planemas in the total captures	74·	29·	27·	85·	89·	41·	92·
The *percentage* of intermediate Pseudacraeas in the total number of Pseudacraeas	2·	21·	30·	4·	0·	29·	27·

of the basal umbre indicating influence by *hobleyi* or its female *tirikensis*. It would seem as if *hobleyi* and *tirikensis* are the strongest and most stable forms, influencing the other two.

These abundant forms of *Pseudacraea eurytus* that have been captured on the islands of Lake Victoria have a very important bearing on the explanation of mimicry by Natural Selection. As is abundantly evident from letters quoted, Professor Poulton believes that here is strong evidence of the efficacy of Natural Selection in at least keeping the mimics up to the mark. When models are scarce no one form of Pseudacraea has any particular survival value over another, and all kinds of non-mimetic transitional forms are preserved which, when the models are superabundant, are presumably destroyed by enemies so that they do not appear in collections.

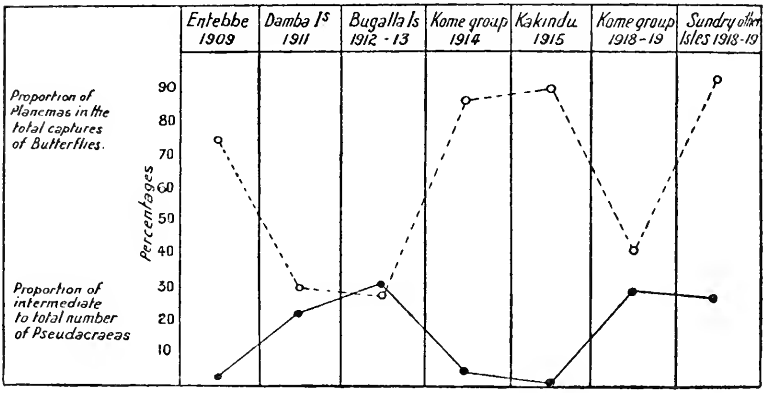
It would be of the very greatest interest at the present time to obtain offspring from the mimetic forms on the mainland and ascertain whether they will produce transitional offspring. Indeed, we *know* that they do produce a certain proportion of these, for two examples have been captured at Entebbe and have been alluded to before.

The table on p. 265 shows by comparison the difference between collections made without prejudice at localities where Planema outnumbers Pseudacraea, and where the latter are predominant.

The chart on p. 267 shows very graphically how the figures vary and the manner in which the numbers of Planemas and of intermediate Pseudacraeas vary inversely.

A most remarkable thing is the complete change in the proportion of *Planema* to *Pseudacraea* on Kome Island and its near neighbours to the west in the period between 1914 and the end of 1918 and commencement of 1919. When I was on Kome for several months in 1914, Planemas far outnumbered Pseudacraeas, which showed very little variation, as may be seen from the table.

But to my great astonishment, when I returned to the same islands after the war, the situation had been completely reversed, and the Pseudacraeas, which showed much variation, greatly outnumbered the Planemas (see table, p. 265). It must be supposed that the Planemas had been found at the summit of a wave of prosperity in 1914, but that their enemies (possibly parasites) had increased so greatly that they in turn reached the summit of a wave while the Planemas fell



into a trough. This would be analogous to what is known to happen in England in the case of the Hop Aphis and the Ladybirds which feed upon them, each in turn fluctuating in number.

It is most interesting to note how the Pseudacraeas changed in constancy, the intermediate forms having been apparently destroyed while the models exercised their protection to the mimetic forms in 1914, but having an equal chance of survival in 1918–19 when the protection of the models was in abeyance. Young birds in 1914 had a different lesson to learn from those of 1918–19; and also those that had learnt their lesson in 1914 must be supposed to have unlearnt it in 1918, when the models which they had known to be distasteful were no longer to be seen. If this be so, then it must be further supposed that birds need to refresh their memories at intervals during adult life.

These numerous and beautifully graded transitional forms of one species are quite consistent with the explanation of mimicry being produced and maintained by the continuous operation of Natural Selection upon small variations.

But at first sight they do not seem to be at all in conformity with the theory of the production of mimics by Mutations—that is, sudden large variations which appear complete all at once and never revert to the form of the parent. Indeed, the writings of such an exponent of the Mutation theory as Professor Punnett seem at first sight to support this argument, that the intermediates are a difficulty in the way of the Mutationist.

Thus, in the 5th edition of *Mendelism*, 1919, he discusses two forms of an interesting species of *Euralia*, a Nymphaline of which the form *wahlbergi* mimics *Amauris niavius dominicanus*, and the form *mima* mimics *Amauris echeria*. On p. 177 Professor Punnett says: "According to Mendelian views, on the other hand, the *dominicanus* pattern arose suddenly from the *echeria* pattern (or *vice versa*), and similarly *wahlbergi* arose suddenly from *mima*. . . . On the modern Darwinian view natural selection gradually shapes *mima* into the *wahlbergi* form owing to the presence of *dominicanus*; on the Mendelian view natural selection merely conserves the *wahlbergi* form when once it has arisen. Now this case of mimicry is one of especial interest, because we have experimental evidence that the relation between *mima* and *wahlbergi* is a simple Mendelian one, *mima* here being the dominant and *wahlbergi* the recessive form. The two have been proved to occur in families bred from the same female without the occurrence of any intermediates, and the fact that the two segregate cleanly is strong evidence in favour of the Mendelian view."

In the case of the theoretical origin of *wahlbergi* from *mima* the change in pattern is a large one, and it may well be asked what are the chances against the probability of the *dominicanus–wahlbergi* pattern arising suddenly, complete, in two cases, from the very different *echeria–mima* pattern, and in such a way that at one step the new pattern is the same in the two new butterflies and differs in the same way from the parent pattern!

Moreover, the possibility of the same large variation suddenly occurring in these different butterflies is rendered still more remote by the fact that while *mima* and *wahlbergi* are forms of one species, *echeria* and *dominicanus* are different species of one genus and by no means closely related within that genus. The two examples given are therefore not analogous.

Again, in *Bedrock*, vol. ii, Professor Punnett discusses the polymorphic forms of the mimetic oriental "swallowtail" butterfly *Papilio polytes*. He says: "Mr. J. C. F. Fryer has recently succeeded in carrying out an elaborate series of breeding experiments with this species and has shown that any form of female can produce any other form provided that she mates with an appropriate male, while in certain cases all three forms may appear in the same brood. Even in such a case all the three forms are sharply cut and clear, there being a complete absence of intermediates or transitional forms."

Incidentally it may be remarked in passing that had Mr. Fryer worked with the African *Papilio dardanus* there would not have been a complete absence of transitional forms.

At first sight the Mendelian argument seems to be that absence of intermediates is proof of origin by mutation.

It would seem therefore that abundance of intermediates as in the case of the Pseudacraeas is in favour of the Darwinian explanation. But the Mendelian claims their presence also to be explicable by the theory of mutations. Thus in the same article in *Bedrock* Professor Punnett discusses the various offspring of a cross between a "Silky hen" and a "Brown Leghorn" cock which show grades of transition, and says: "Even if a completely grading series" can be put together, it does not follow "that the various forms have arisen through the accumulation of minute variations." The series intergrading between the two extremes of the cock and hen "can be expressed in terms of two Mendelian factors. . . . Thus an appearance of continuity in variation may be brought about by the interaction of a small number of definite factors upon one another." And in *Mendelism*, p. 162, Professor Punnett says: "Neither the existence of such a continuous series of intermediates, nor the fact that some of them may breed true to the intermediate condition, is incompatible with the Mendelian principle of segregation."

In his book on *Mimicry in Butterflies*, he also says, on p. 129: "As the result of modern experimental breeding work it is recognized that an intermediate form between two definite varieties may be so because it is heterozygous for a factor for which one variety is homozygous and which is lacking in the other—because it has received from only one parent what the two typical varieties receive from both parents or from neither. Its germ cells, however, are such as are produced by the two typical forms, and the intermediate cannot be regarded as a stage in the evolution of one variety from the other. . . . It is quite possible that the new mimetic pattern appeared suddenly as a sport, and that the intermediates arose when the new form bred with that which was already in existence."

The extraordinarily varied forms of *P. dardanus*, subspecies *polytrophus*, on the high Kikuyu escarpment (6,500–9,000 feet) in British East Africa do not support the view that the mimetic patterns arose suddenly and the intermediate forms from them by interbreeding. Many of these transitional forms are abundant on the escarpment, but are very rarely found elsewhere; that is, they have a certain peculiar geographical distribution. "The Kikuyu escarpment is the only locality at present known where these transitional forms make up a large proportion of the females." [1]

Such a distribution is far more consistent with the interpretation that these are an ancestral set of forms, such as may have existed before the different named forms became as distinct as they are to-day, which have been left isolated on a mountain ridge.

One of the most varied of all these ancestral forms is *trimeni*, which is not considered to be an intermediate between two other forms of mimetic females, but to show how the female first began to depart from the ancestral type like the male. That is to say, *trimeni* is at one end of the long series of female forms, and cannot be supposed to be a stage between two others.

Thus it is seen that these intermediate forms are held by both Darwinian and Mendelian to support the respective hypotheses of evolution, but the latter has perforce to fine down his "large" variations or "sports" to such a small size that they appear to be of the kind which the Darwinian recognizes as "small" variations upon which Natural Selection can, and apparently does, work.

The Mutationist claims that if these differences are inherited according to Mendelian laws they must be of the nature of "large" variations; the Darwinian claims that they are the "small" variations which he

[1] Poulton, "Mimicry, Mutation and Mendelism," *Bedrock*, vol. ii, p. 49. A plate in this article shows some of these Kikuyu forms.

believes to be acted upon by Natural Selection, and adduces proof that they can be inherited !

One can quite appreciate the argument that the theoretical origin of *Euralia wahlbergi* from a form of such different appearance as *mima* would be an example of origin by " Mutation " or " Sport," but when it is necessary to fine down the " largeness " as in the intermediate fowls it becomes an apparent absurdity to allude to these differences as " large," that is, as " sports." It seems difficult to draw distinctions between the Mendelian's " Mutation," which is inherited by segregation of some very minutely differentiating " factor," and the Darwinian " small " variation, which can be inherited, but which the Mutationist calls a " fluctuation " and says is non-heritable, but if proved to be heritable claims as a " mutation " or " large variation."

If segregation comes down to produce such minute differences, the term " large variation, mutation or sport " seems to be worn rather thin !

On this matter the work done by T. H. Morgan upon the colour of the eye in the fruit fly *Drosophila* has a bearing. The eye is normally red, but in the investigations upon the inheritance of the eye colour it was found that there were seven gradations between white and red, and further, one of the grades has seven modifying factors, each of which alters its intensity and gives rise to a secondary grade. Professor Jennings remarks that " by means of these graded changes one could obtain, by the mutationist's own statement, the continuously graded results which selection actually gives. What more can the selectionist ask ? " [1]

A case strictly analogous to the case of *Ps. eurytus*, with its abundance of insular variations in the absence of the models, is noted by Professor Poulton in his presi-

[1] See a summary of Jennings' papers by Professor Poulton in the *Proceedings of the Entomological Society of London*, 1917, pp. lxxxv–lxxxix.

dential address to the Linnean Society in 1916. Dr. Lamborn bred *Papilio dardanus* on the west coast of Africa (South Nigeria), where the black and white form *hippocöon* is almost the only form known. This mimics the abundant *Amauris niavius.* Another form of *dardanus* female has been caught rarely all along the tropical west coast of Africa. This has a fore wing pattern approaching that of *hippocöon,* but with the bar between the subapical and inner marginal white areas very ill defined, and the hind wings are yellow instead of white. This rare form is known as *dionysus,* and *there is no model for it in Nigeria.*

Lamborn bred from a *hippocöon* parent nine female forms like it, but also eight *dionysus* which has never been bred before. Now these *dionysus* are in a position similar to the Pseudacraeas which, in the absence of control by the models on the islands, are producing large numbers of transitional varieties, for no two of them are alike, and they present a beautifully graded series, from a fore wing pattern approaching that of *hippocöon* to a pattern closely approaching that of the male. The nine *hippocöon* sisters, however, mimicking the abundant *Amauris,* present a very close resemblance to each other and to the *hippocoön* parent.

It is noteworthy that in the case of both *Papilio dardanus* and *Pseudacraea eurytus* the variation in the absence of models is best shown in the shape, size, and sharpness of outline of a dark bar separating the paler portions of the fore wing into two main areas.

We now come to discuss another point of great interest. If the collections of *Pseudacraea eurytus* from different islands in the lake, sometimes very close together, be compared, further evidence in favour of the maintenance of mimetic resemblance by Natural Selection is obtained.

Although the islets of Kimmi and Ngamba are so very close to each other and Kome (see map), yet the predominant form of *Pseudacraea* is not the same on each island.

At each locality the predominant *Pseudacraea* is that which mimics the species of *Planema* that is most numerous in that locality, and this is further borne out by the collection from Kakindu on the mainland to the west of the lake.

Combination.	Models and Mimics.	Kome, 1914.	Ngamba, 1914.	Kimmi, 1914.	Kakindu, 1915.
I	*Pl. macarista* ♂ *poggei* ♂ ♀ ..	56	23	15	10
	Ps. eurytus hobleyi ♂ ..	8	9	2	1
II	*Pl. macarista* ♀ .. .. *aganice montana* ♀ .. *alcinöe camerunica* ♀ ..	47	23	9	5
	Ps. eurytus tirikensis ♀ ..	8	7	2	—
III	*Pl. epaea paragea* ♂ ♀ ..	—	—	—	16
	Ps. eurytus obscura ♂ ♀ ..	2	2	—	—
IV	*Pl. tellus eumelis* ♂ ♀ ..	235	—	—	71
	Ps. eurytus terra ♂ ♀ ..	35	—	—	12

From the above table it is seen that while on Kome the model of type of colouring IV (*Planema tellus*) was most abundant, on Ngamba the species that predominated were of types I and II, and on each island the proportions of the forms of *Pseudacraea* are according to the prevailing type of models. At Kakindu, again, type IV predominated in the models, and all the Pseudacraeas save one were of type IV. The islands mentioned are so close together that it would be absurd to attempt to explain the differences in the *Pseudacraea* fauna by climatic conditions ; the factor that varies, however, is the proportion of species of *Planema*. The supposition is that on Ngamba a form of *Pseudacraea* that does not resemble male or female of *Planema macarista* has less chance of surviving birds' attacks than a form which is deceptively like *macarista* ; consequently the form *terra*, which is so common on Kome Isle only a few hundred yards away, is at a disadvantage on Ngamba.

This explanation, of course, presupposes that the species of birds which are presumed to exercise selection do not fly across from Ngamba to Kome or *vice versa* (see map). Now, although Bee-eaters may constantly be seen crossing open water in flocks, I do not think that I have ever seen such birds as Flycatchers, which abound on the islands and, in some cases at least, only in the forest which is the haunt of *Pseudacraeas*, crossing from one island to another. I have even noticed that the very characteristic songs and call notes of species such as the " Kunguvu " (*Tchitrea emini*) and a pretty little black and white *Platysteira* (? *jacksoni*) varied on different islands.

While on Bugalla in 1912–13, I became extremely familiar with the call of these abundant birds, and directly I visited the Kome group of isles in 1914 at once noted a difference—yet the difference was slight enough to make me feel certain that the species of bird was the same. This seems to show that at any rate on islands at this distance apart there is a tendency for geographical races to be perpetuated, but I have not been long enough among the islets of the Kome group to know if the song of the flycatchers of Ngamba differs from that of the same species on Kome. Yet, as has been shown in Chapter VI, many islands quite close together show distinct differences in their avian fauna.

CHAPTER XII

HYMENOPTERA

Ants.

The ant that most obtrusively calls for notice is the well known *Dorylus* or "Safari ant," known to the Baganda as "Ensanafu" and in Kiswahili called "Siafu."[1]

This totally blind reddish ant varies exceedingly in size, the largest individuals being half an inch long and several times larger than the smallest, but it is difficult to make out any difference in their functions.

They live entirely by hunting live prey, and owing to their incredible numbers must destroy very many of the creatures that are unable to escape them. They make temporary subterranean nests, which are easily discovered on account of the piles of loose earth that has been brought up from below grain by grain, and the numerous large irregular holes leading down to the burrows and chambers in which the queen lives and the young are reared. The queen is a curious looking creature, with abdomen much enlarged, as is the case with the well known queen termite, but in the latter the distension is very much greater.

Queen *Dorylus* are rare in museums, probably because of the courage that is required to dig one out of the nest among the hordes of ferociously biting workers; a native once brought me two, but I should have liked to see

[1] *Dorylus nigricans* and *glabratus*.

him getting them, from a safe distance! The adult male has been elsewhere alluded to in connection with signs of the weather. The worker *Dorylus* are often seen travelling swiftly in a column several ants wide, in a very orderly manner: hence the name Safari ant. They prefer a sheltered route among and under leaves or dense grass, but where they must cross an open smooth area such as a well trodden path, they sometimes make a tunnel for at least part of the way beneath the surface, or a deep furrow. At other times, however, they protect the travellers by forming a line on each side of the track, the ants standing high on their legs with mandibles wide agape as if seeking for something to bite. These guardians are so intertwined that they make a living wall which often bridges right across the ceaseless stream hurrying below. If interfered with, or disturbed by the tramp of a foot shaking the ground, they break loose and run about with menacing jaws, but do not go far, and if nothing is met within a yard of the column the guardians return and re-form the protective wall. These columns of hurrying ants fill one with amazement on account of the immense numbers of individuals.

The first one I saw was crossing a road close to my hut on the evening of July 18, 1910, and next morning the stream was still showing no signs of abating. It was about an inch wide, and 4–6 ants across. At noon the ants were still pouring across the road in the same direction, but by 5 p.m. those forming the protecting walls had moved, and by sunset they had all gone across: that is, for about twenty-four hours there had been a continual stream, for there is no reason to suppose that this column was exceptional, and had ceased to move when night fell.

This column was apparently changing camp, for nearly every ant carried a naked white pupa, although it is a curious fact that not a single larva was seen in the procession. Indeed, it may here be said that I have never seen *Dorylus* carrying its *larvae* on safari, only the pupae ; nor does one ever see a *queen* travelling. Is it possible that a column such as is above described is analogous to a swarm of bees, but that instead of taking a queen with them the members of the swarm carry pupae, from one of which a queen will emerge when they have excavated a new nest ? It is curious that where there are large and small ants there should not be some differentiation of function. Quite small individuals are seen struggling along carrying enormous pupae, while lusty fellows of the biggest size appear quite content whether they are carrying a small individual or one of their own bulk.

Although, on the whole, the column is an orderly one, occasionally considerable confusion is caused by individuals running back against the stream ; possibly they are "returning empty" ! If they are of very small size, they are often seen to be unable to make headway against the hurrying multitude, and unless they run quite at the edge are at length compelled to turn round and run with the rest. A very large individual, however, since it stands well above the small ones, can often run against the tide, for the small ones can run under it, between its legs.

But every column of Ensanafu that one sees is not engaged in changing camp ; most often they are either going out to hunt, or returning laden with spoils.

When they have reached the hunting ground the main column breaks up into minor streams, and the ants swarm over the ground, investigating every nook and cranny and climbing up bushes.

If one is in the forest when they are hunting, one often first becomes aware of it by hearing a peculiar pattering noise, caused by the countless ants which have run up branches to the extreme tip, and finding no prey there drop off and fall on to the leaves below.

VIEW TO THE WEST FROM BUGALLA CAMP.

To face p. 278.

Their activities are also revealed by the great disturbance they cause among the countless spiders and insects of all kinds that have previously been concealed among the dead leaves and ground cover. Before one sees the hunters themselves one meets spiders, harvest-spiders (*Phalangeridae*), caterpillars and especially cockroaches scurrying away in great excitement. As one draws nearer to the area being hunted over, one sees little masses of *Dorylus* ants busily engaged in cutting up some unfortunate insect that has failed to escape, and then, standing just outside the area and keeping careful watch around one's feet, one can see the hunters running about and going into every nook and cranny.

A cockroach takes fright and rushes out from under some dead leaves, only to be seized by one or more ants and overpowered by superior numbers. Sometimes, on a sandy shore, where they have a chance of running away, the cockroaches forfeit their lives by losing all presence of mind and running wildly hither and thither, often tumbling head over heels in their frantic endeavours to escape, and so falling all the easier prey.

Sometimes, however, certain spiders by moving cautiously first in one direction and then in another, and, as it were, feeling their way, manage to evade the awful fate of being eaten alive.

It is an unpleasant sight when a huge caterpillar is seen writhing and twisting in the endeavour to free itself from the numerous ants which have firmly fixed their sharp jaws in its skin and will not leave go.

Slugs of large size are cut up piecemeal, although some of the ants at least are overwhelmed and suffocated in the slime that is secreted more abundantly when the slug is attacked.

A certain snail that was common on Damba Isle was able, as related in another chapter, to keep the ants at a distance by surrounding itself with bubbles of foam into which the ants could not penetrate.

A medium sized Plant bug (*Hemiptera*) was once seen on a leaf of a bush over which *Dorylus* was swarming, and I was much interested to note that although ants would frequently seize hold of a limb or antenna of the bug they always let go again, and no harm was done to the bug. It is possible that its powerful odour may have been disagreeable to the ants.

One night a large army of Ensanafu raided my grass hut on Bugalla Isle; fortunately I was sleeping in a tent close by, and though a column ran through the tent they were only on the way to the hut, and I was not turned out. But a nestful of fledgling swallows in one corner of the hut was cut up and carried away piecemeal.

One day at Jinja I heard pitiful squeakings coming from some long grass, and found a baby striped rat being attacked and in danger of a horrible fate; needless to say he was freed, but very likely fell a victim subsequently.

During the campaign in German East Africa I was twice turned out of the little tent in which I was sleeping on the ground by an invasion of Ensanafu, and had to bolt, and then, after picking off those ants which had already attached themselves to various parts of my person, make a dash for boots, and by frequent painful visits gradually withdraw the bedding and shake down elsewhere outside, while the ants proceeded along the line to some one else's tent, to my secret gratification, for no one likes to be the only one who is turned out in the night!

On Damba Isle in July 1911, I saw a very interesting thing while watching the unfortunate denizens of the shady forest being turned out by *Dorylus*. Cockroaches were scurrying about in all directions, and hovering over them, and occasionally darting down upon them, was a small, thin bodied, long legged insect whose appearance suggested a Syrphid fly, though one seemed to have a short ovipositor, which would imply that it was an "Ichneumon" fly.

After watching for some time I suspected that the fly's object was to dart down and lay an egg upon a cockroach before it was cut up by the ants. Presumably the egg would thus be carried into the nest, where the larva would find food that it required, and possibly fragments of insects that had been brought in by the ants.

Bates, in his *Naturalist on the Amazons*, describes something similar in the case of *Stylogaster* and the *Eciton* ant, which has habits analogous to those of *Dorylus*.

In July 1914, I saw an interesting affair on Bulago Island. A small column of Ensanafu was hunting, and had discovered in a hollow, broken cane stem the nest of another ant, a large black species whose rotund abdomen is covered with golden pubescence. The rightful owners of the nest had found discretion the better part of valour, and were no longer attempting to resist the raiders, who had bitten through the stopper closing one end of the stem. Some, inside, brought up the grubs in the nest, which were at once seized by eager helpers outside, who usually fell to the ground with their burden in their excitement. It was a busy scene, and curiously reminded one of the unloading of a ship.

Another abundant ant is the giant *Paltothyreus tarsatus*, known to natives as "Waka," and to Europeans as "Stink ant," owing to the appalling smell of bad eggs emitted by it when roughly handled. About an inch long, coal black in colour, this species is often seen singly slowly wandering about searching for food. It seems to live on animal food—small insects or bits of dead ones which it meets with on its wanderings—but is not active in its movements. If handled it can inflict a severe sting.

The Waka nests underground, and in disused chambers in the base of old termite hills : one such nest that I dug out was perceptible to the nose from some yards away. When the nest was broken open the ants and termites running about of course met, and the termite invariably seized hold of the ant. But the ant seemed to be too hard for the termite to make any impression on it, and if unable to free itself by struggling turned its abdomen forwards and deliberately stung the termite, which at once let go and seemed more or less paralysed. One ant was tackled successively by two termites, and accounted for each in turn, but it was never the aggressor, and seemed reluctant to sting until other methods failed to release it from the termite's grip. I have found a winged male of this ant in the stomach of a Bee-eater.

Another large black ant that is often confused with *Paltothyreus* is *Megaponera fœtens*, though it is considerably smaller, has no odour, and is of very different habits. The name *fœtens* should apply to *Paltothyreus*, with which this ant, called " Enkolokoto " by the natives, must have been confused when the name was given to it.

I mention this ant because it is absent from the islands, nor have I met with it on the Uganda shores of the lake.

I first saw it when on active service on the southern frontier of Uganda in 1914 (Kagera river), and subsequently became very familiar with it in German East Africa. But the Kagera river, which forms the natural boundary to Uganda, also seems to act as a barrier to *Megaponera* in that part of the world, for though the ant is often seen on the south side of the river, it was apparently absent from the north side. I was informed by a missionary, however, that he knew it well further north in Uganda.

Megaponera feeds on termites, and marches out in orderly bands of a hundred or more, and when inter-

HOUSE ON BUGALLA, 1912-13.
Barbed wire lightning conductor over supports on roof.

INTERIOR OF BUGALLA HOUSE.

To face p. 282.

fered with produces a distinct stridulating or squeaking noise. These characteristics make it easy to recognize.

Probably it is absent from the lake area because its favourite prey is not found there. This is a species of dark coloured termite which does not build hills, but lives in burrows underground, from the open mouths of which they come out in daylight to cut the segments of grass blades, which they then drag down and presumably eat.

The remarkable ant *Œcophylla smaragdina* has already been alluded to on account of its being mimicked by a spider and a bug. It is not found by any means on all islands, but was common on the trees overhanging the "fly beach" on Damba. The nest is a globular shell formed by leaves attached together along their edges with silk spun, as H. N. Ridley first pointed out, by a larva held between the jaws of an ant for that especial purpose, and applied first to the edge of one leaf and then to another. It is an inoffensive species, its feeble mandibles being barely able to pierce one's skin, and being without a sting.

On Damba they fed largely on the thousands of small "E'sami" lake flies (*Chironomidae*) which settle on the leaves, but also from secretions of *Aphidae* on the stems of the leaves. The island specimens were of a shining light brown colour and form a distinct race, known as *longinoda*. Some that I saw in Portuguese East Africa in 1918 were more of a greyish brown tint.

Another ant that lives on leaves of trees is known to the Baganda as "Obusaji-saji," but unfortunately no specimens were obtained for identification.

It was very abundant on Bugalla and Damba, but does not occur on many islands. It is a small, very active long legged black species, which makes a frail nest of some friable brown material on the backs of leaves or between two leaves, which thus adhere together.

If one is so unfortunate as to disturb these when pushing between leafy branches, great numbers of the little ants rush out, and, getting a firm grip with their mandibles, inflict a sting which leaves a burning irritation for several hours. It is particularly unpleasant when they find their way down one's back or into one's hair!

The most noticeable wasps are species of the genus *Belonogaster*: large, dark, grey-brown insects with long pedicle to the abdomen, known as "E'numba" by the natives. Their nest is of papery substance, and formed of a single tier of cells supported from a slender stalk, with the open mouths downwards. It is attached to the under side of an overhanging rock, or to the eaves of a house, and in a favourite site numbers of nests are seen close together.

Natives are very much afraid of the sting of these wasps, which is certainly extremely painful, and do not like going near their nesting places. It must be acknowledged that there is reason for this, for sometimes a wasp will fly off the nest and viciously sting any one who it thinks has come too close, returning immediately to the nest. I noticed, however, that if one allows a nest to grow up in a position constantly approached or passed by, the wasps become accustomed to people, and are inoffensive as a general rule.

I allowed several nests to be built from the underside of the ridge of my tent, and the colonies grew to a large size without any sign of aggressiveness on the part of the wasps. But one day an officious individual, perhaps a freshly hatched and inexperienced one who had not been taught properly, flew off at me when I came into the tent and inflicted a vicious sting. This sealed the death-warrant, and all the nests were destroyed.

The grubs in their cells hang mouth downwards, the anterior end of the body protruding slightly. They are watched over by certain individuals who act as nurses, while others go out hunting for the smooth caterpillars wherewith to feed them.

A wasp having found a caterpillar pounces on it and stings it, and at once begins to pulp it with its large mandibles, beginning at one end and passing systematically along the whole body. Finally, the mangled remains are rolled up into a pellet about the size of a pea, with which the successful hunter flies back to the nest. In one case that was observed two wasps were on the nest when the hunter (A) returned with a mashed-up insect in her mandibles. This she gave to B, who appeared to mince it up further and then shared it with C, each going to one of the larger larvae in the cells and holding the mass to its mouth. The larvae could be seen eating it. A afterwards went round and fed the larvae with fluid regurgitated : this process was accompanied by a kind of violent shuddering motion. I could see the drop of fluid appearing between the wasp's mandibles, to be slowly sucked up by the larva.

Caterpillars are not the only prey of *Belonogaster*, for one frequently sees them capturing and pulping small brown *Acraea* butterflies, which is of interest when considering the enemies of protected insects. The *Belonogaster* itself may be considered a typical protected insect, but I have found it in the stomach of a Bee-eater (*Merops superciliosus*). This subject is discussed elsewhere.

Belonogaster has all the characteristics of a protected species, and serves as a model for a most interesting Neuropterous insect, *Mantispa*, which has been elsewhere described.

Although it is not considered too formidable by the Bee-eater, which seems to be specially adapted to feed on stinging insects, there are probably few other birds, and certainly no mammals, that would dare to catch it, so that its enemies must be mainly other insects.

There are often to be seen in empty cells of the nest the pupa cases of flies, one to a cell, probably *Tachinidae*, but I have not actually seen a fly depositing its egg on the wasp larva. These wasps belong to the *Diploptera*, or true wasps, whose wings are doubled up longitudinally when not in use, giving them a very narrow appearance.

In the group of wasp-like insects now to be discussed, known as the *Fossores*, the wings are not folded. While some of them, such as *Bembex*, have a certain resemblance to a true wasp, most of them are readily distinguished.

The group is remarkable from the habits whence the name *Fossores*, which means "diggers," is derived; they are also called "Sand wasps." The wasp *Belonogaster* has been described above as feeding its young on insects which it has first killed and pulped. It is obvious that meat of such kind must be troublesome to prepare, and must be supplied fresh at frequent intervals.

Some other wasps, which are of solitary habits (*Odynerus*, etc.), do not pulp the prey, but store them up whole in their burrow. But if one examines the store that has been laid up for the larva to feed upon, one finds that in the case of small geometrid caterpillars, some of them shrivel and dry up, and are not in very good condition to form food.

One family of fossors, the *Bembecidae*, has slightly improved upon this method. They feed their larvae almost entirely upon whole flies, which they do not kill, but sting so that they remain alive and juicy but cannot move, since the central nervous system has been paralysed; probably, therefore, they are insensitive as well. Regular supplies of these paralysed flies are taken down into the burrow by the mother *Bembex*.

A further step in the saving of trouble is exemplified by other fossors of the families *Sphegidae* and *Pompilidae*. These lay up in a burrow a store of paralysed insects sufficient to feed one grub for the whole period of its growth. Having stocked the burrow, the mother lays an egg, affixing it to one of the living but helpless prey, and having sealed up the burrow for good and all, she goes off to make another. Sometimes this process involves very heavy labour, for the inert grasshopper, caterpillar or spider has to be taken to the burrow. Usually it is too heavy to be carried in flight; sometimes it can be carried walking, but often it has to be dragged along the ground. In the latter case the fossor first finds and stings the prey, and then excavates the burrow in a suitable spot in the neighbourhood; but if she can carry her prey the burrow is excavated first and the prey carried back to it, gripped by the mandibles and carried between the legs. It is wonderful with what accuracy the mother will find her way over sticks, stones, bare patches of sand, or through thick grass, until the burrow is reached; sometimes she travels *backwards* with her load!

It is an obvious saving of this labour to find the prey first, and then excavate the burrow where it lies.

Another family, however, the *Scoliidae*, has economized labour even further. The larvae of these fossors feed upon the subterranean larvae of large Lamellicorn beetles. The mother burrows down to them and merely lays her egg upon them *in situ*, presumably stinging them first to render them inert, as is the custom in the *Fossores*.

Lastly, there are the peculiar *Mutillidae*, whose wingless females, as they run swiftly over the ground, look like brightly coloured ants. These are mainly parasitic upon other Hymenoptera, and do not burrow, but pierce through the walls of the nest and lay their egg upon the larva inside, just as the typically parasitic "Ichneumon" fly lays its egg upon a caterpillar. Thus one can trace all stages between the somewhat crude method of the *Belonogaster* wasp down to the labour saving parasitism of the *Mutilla* and the well known "Ichneumon" fly, parasites of caterpillars.

It may be remarked here that "parasite" hardly seems the correct term for an Ichneumon larva, whose activities necessarily result in the death of its host, which is devoured as completely as an antelope is by a lion. The only difference is that at first the young Ichneumon larva feeds only upon the juices of its prey, and the essential tissues are not devoured until the larva is full grown, when it has nothing to fear in the death of its unwilling host.

It does occasionally happen, however, if the disproportion in size is great between the host and the parasite, or if the number of parasites is very small, that the host is not killed. I once reared an Arctiid moth and a single parasitic Tachinid fly from the same caterpillar!

The habits of *Bembecidae* are, like those of other fossors, of absorbing interest. As has been pointed out, these feed their larvae on flies,[1] but they do not lay up one store for good and all as do the *Sphegidae* and *Pompilidae*. Perhaps the reason is that the flies, not being large-bodied, fleshy insects, might dry up before the *Bembex* larva had eaten them all. So the mother attends to her larva, bringing to it freshly stung flies at frequent intervals.

Since this necessitates constant work opening and closing the burrow, it is dug in localities where the soil is very loose and light, such as a sandy shore on the lake, and I have found thriving colonies of *Bembex* in such situations.

The first that I met with was on a dazzlingly white beach of fine sand on the south coast of Nsadzi Island, in March 1911, when I found numbers of *B. forcipata* flying about over the hot sand, and busily excavating their burrows, and spent many hours watching them,

[1] Occasionally on other insects. I have watched one catch a "Skipper" butterfly. See *Proc. Ent. Soc.*, 1917, p. xli.

for I soon saw that they were catching Tse-tse fly. A *Bembex* would alight on the sand at a spot which she evidently knew, although it was indistinguishable from the surrounding bare area, and commence to dig away the loose sand with her powerful toothed fore limbs, specially adapted for this work by a fringe of stiff hairs. So rapidly does she work that the sand is thrown behind her in a continuous stream, passing underneath her body and falling a couple of inches behind.

Without a pause she persists, and soon lays bare the mouth of a pre-existing tunnel, at the bottom of which lies her grub, hungrily devouring flies. As she works in the loose sand it constantly trickles down from above, but she removes it at such speed that it is thrown out faster than it falls, and presently the burrow is clear and she disappears from sight into it.

Sometimes she throws up behind her enough sand to block the entrance ; if she does this she usually remains below for some time, but what she does down there I know not.

Presently up she comes, and, if she is careful, turns away from the mouth of the burrow and throws enough sand back into it to block the entrance. The reason for this will be given later.

But quite often the careless worker flies away without closing the burrow, leaving the helpless grub at the mercy of any marauder that discovers the opening.

Now the busy mother has to seek food for her young, and she flies round and round me as I sit on the sand, apparently looking for a nice fat Tse-tse fly full of blood ! Naturally she finds none, and has to take the next best, but searches very carefully, coming within an inch of my face and under the brim of my hat. Sometimes a Tse-tse that has been sitting on my clothes takes alarm and darts away, but not quickly enough to escape its enemy, who pounces on it in a flash.

There is a shrill buzz, like a scream, from the fly as it is caught and stung, and then the *Bembex* is seen to be holding the fly closely to her abdomen between the thighs of her hind legs, and darts away to her burrow.

Sometimes the *Bembex* pounces on a fly as it sits on my clothes, and I am able actually to see her sting it.

Arriving at her burrow, *Bembex* alights at the exact spot, and without a moment's hesitation, still holding her prey between her legs, opens up the burrow and passes in.

Almost immediately she emerges again and repeats the chase. On March 13th I thus watched one worker for three and a quarter hours, during which she caught twenty-nine Tse-tse and two other flies. The last four Tse-tse had been caught and carried into the burrow in five minutes. After this she finally closed the burrow and flew away, and I, with great difficulty in the loose sand, found the chamber at the end of the burrow and took out all the flies that had been collected, and the legless white grub, full grown.

There were thirty-one Tse-tse flies and one other fly. About half a dozen of them were dried and some partially eaten. Twenty-one were males and ten females, eight of which were fat ones containing a larva ; this is a very high percentage of pregnant flies, for out of ninety-six female flies that had been caught by my boys that morning only 22 per cent. contained large larvae. So that the *Bembex* had definitely selected the fattest flies she could find in default of full fed individuals, which are heavier on the wing and easier to catch.

Another specimen was seen to catch six Tse-tse and several other flies in an hour ; if, after close examination, she found no suitable Tse-tse on me, she would fly away and return with other flies, though once she came with a Tse-tse caught elsewhere.

The burrow of another that was dug up, about eight inches deep, contained a nearly full grown larva and twenty freshly caught flies, one of which was as large as a "blue-bottle," but the rest were all about the size of the common house fly, and appeared to be of several species—three of one species, nine of another, one of another, two of another, one of another, and three of another.

It is a curious fact that the mother does not know when to cease provisioning the burrow, and gives herself much unnecessary labour. Thus, in the first case described above, the larva was full grown and commenced spinning its pear shaped cocoon at once. On another occasion I found that the *Bembex* had taken down flies to a larva that had already begun to spin its oval cocoon! This is formed of silk, with grains of sand attached on the outer side, and measures about an inch in length.

The mother *Bembex* appears to pass the night in the burrow underground, for quite often, if one visits the colony early in the morning, a *Bembex* will suddenly emerge from the ground at a spot where the soil has not yet been disturbed that morning; and also late in the evening they may be seen going down into the burrows and closing them behind them. The male spends an idle life basking on the hot sand or darting about in chase of the females, or sipping honey from neighbouring flower heads.

The *Bembex* is a most delightful insect to watch, as she works at such high pressure, and so efficiently and quietly.

She has her enemies, for wherever a colony is found there can be seen numbers of little brown insignificant flies, by name *Idia*, who await a chance to go down the burrow and deposit their own eggs on the flies laid up as store by the *Bembex* for her own offspring.

As was pointed out, the *Bembex* may close her burrow when she leaves it. The moment she has gone, up hurries one of the *Idia* flies and attempts to get through the barrier. Sitting almost upright on the end of the abdomen, the little fly throws the sand forwards with quick movements of its legs, as if trying to burrow backwards through the barrier. But I have never seen one accomplish more than making a slight dimple in the loose sand. But quite often the careless *Bembex* has gone away leaving the burrow open, and then the *Idia* has its chance. It hurries up with such eagerness to get down the burrow that it may be seen literally to tumble head over heels as it scrambles down. There is need for hurry, for how can it tell when the rightful owner will come back, and then it may meet with very rough treatment! But as a matter of fact I have never seen *Bembex* take any notice of the mean little intruder, though it may sometimes actually be met at the mouth of the hole by the returning huntress. Yet sometimes it does fall a victim to the sharp sting, for among flies dug up from a burrow I have found specimens of *Idia*.

Small pink dipterous larvae that are found in the burrows are probably *Idia*, though I was unsuccessful in rearing them. It is, of course, possible that they are not strictly enemies of *Bembex*, even in an indirect manner, by devouring the larva's food; they may merely feed on debris of legs and portions of bodies left by the more fastidious *Bembex* larva.

Every colony of *Bembex*, of those species that I have seen, has had these little brown flies in attendance. Some were sent to the British Museum, and I was informed that the species was a new one, and this habit had not previously been recorded for the genus.

The first *Bembex* that I ever saw at work was *B. capensis*, which I found at Jinja in 1910. One was seen going into the burrow carrying a full fed Tse-tse, whose shining red, bloated abdomen full of blood was quite

BACK OF HOUSE ON KOME ISLE, 1914.

FRONT OF KOME HOUSE.

To face p. 292.

unmistakable. Another burrow that was opened up was found to contain the remains of several small flies and of the Tabanid *Chrysops brucei*, besides two *Tabanus thoracinus*. The fact that *Bembecidae* prey upon *Tabanidae* is well known, but not, I think, that they prey upon *Glossina*, the Tse-tse fly.

In March 1912, I saw the following curious incident on Bugalla Isle, where I had found a colony of *Bembex ugandensis*. One was seen to come out of her burrow, and soon returned with a small fly, went down, quickly came out and flew away, leaving the burrow open.

There now appeared on the scene a medium sized fossor of quite a different type, with the black and orange "Lycoid" colouring. To my great surprise the stranger, after hunting about, found the burrow and went straight down! Then she came out again and stood waiting at the mouth on the heap of loose sand, but soon went in again and stood with her head blocking up the entrance.

The *Bembex* now came back carrying a fly of some kind, and attempted to go down the burrow, but on meeting the intruder flew off in a great fluster, dropping her prey. She soon came back, tried again, and again flew off, nonplussed. The third time she managed to get in, and I listened for the sound of an underground battle, but heard nothing.

However, in a few seconds the stranger came out, not at all hurriedly, and flew away, but soon came back and went in again while the *Bembex* was still there, then came out again and stood at the mouth. I then incautiously frightened it away by moving.

The *Bembex* now came out and flew away, and the intruder came back and stood inside the burrow again with its head at the entrance. After a while it flew away, but again came back and stood on the heap of loose sand outside the entrance, then buzzed round for a while and finally flew away.

I tried to dig up the contents of the burrow, but failed, and am at a loss to know what is the explanation of the intrusion. Unfortunately the Lycoid fossor was not caught for identification.

Another family of *Fossores* is the *Sphegidae*, which contains insects of very varied size and habits, although they all agree in storing up paralysed insects or spiders for their young. The species of prey chosen by Sphegids differ greatly; some choose spiders, many more grass-hoppers or crickets, and many others the smooth bodied caterpillars of Noctuid or Geometrid moths, but never hairy caterpillars such as those of *Arctiidae* or *Lymantridae*, though I have seen one species taking a pilose Lycaenid caterpillar into its burrow. If the species selected is of small size, a number must be collected, but very often a single individual furnishes all the food that a Sphegid larva requires.

Although they all belong to the natural group *Fossores*, the *Sphegidae* do not all dig in the ground.

A dead bough that contained a nest of a large Carpenter bee was also used by a large black Sphegid for its brood. A tunnel about half an inch in diameter had been excavated, and the mouth was stopped up by little pieces of wood and lichen. It penetrated perpendicularly into the wood for about an inch and then turned sharply to the right and ran longitudinally about four inches. At the end was a collection of the remains of some half-dozen small *Locustidae*, and a cocoon about an inch and a half long, formed of an outer silky and an inner papery layer. Inside the cocoon was the larva, and six small larvae, probably *Diptera*, which were presumably indirect parasites like *Idia*. Beyond the cocoon the passage was directed towards the centre of the bough, then turned to the left for two inches, and eventually opened to the exterior below the original opening. This second orifice was not stoppered. It is much to be regretted that the species was not identified, since this method of nesting is very unusual for a fossor.

Another very unusual nesting place was found to be used by a specimen of *Sphex* (*Isodonta*) *pelopaeiformis.* This was in the open end of the hollow stem of a broken reed. The Sphex was seen going there carrying a small piece of wood, and I found she had finished provisioning her nest and was stopping the hole at the end of the stem. There were two collections of stored up *Locustidae*, belonging to species of very different types ; all were young, and in some the wings had not begun to grow. There were nine in one chamber and six in the other, the two being separated by a partition partly of earth, partly of some soft brown substance of almost woolly texture whose origin was unknown. One Locustid of each collection had the Sphex's egg affixed to it on the under surface close behind the head. It is very interesting that this fossor, while abjuring the earth as a nesting place, still made use of it as material wherewith to form a partition between the two collections of prey.

Another Sphegid with nesting habits unusual among this group is the extremely common and widespread *Sceliphron spirifex,* familiar in every house ; it is even found in South Europe.

This rather elegant black and canary-yellow species, with long limbs and narrow pedicle to the abdomen, is classed as a " Mud wasp " by the annoyed housewife, from its habit of building a collection of earthen cells in any convenient nook, such as the fold of a curtain, the corners of open boxes, the back of a book, and suchlike places. Like most *Sphegidae,* this energetic worker emits a curious note when working—a quavering, high-pitched buzz rising and falling slightly that is presumably made by quick vibrations of the wings as they lie upon the back. There are few houses in which this sound cannot be heard coming from some obscure corner. The completed cell is about an inch and a half long, thick walled and smooth, with an internal calibre of an ordinary lead pencil. It is stuffed full of small paralysed spiders, on one of which the elongated egg has been deposited.

The *Sceliphron* obtains its building material from a spot where the earth is damp, such as the edge of the lake, and gathers up in her mandibles a pellet about the size of a sweet-pea seed. With this she at once flies back to the chosen spot, and plasters it on to one end of the commenced cell, smoothing it with her mandibles very deftly, singing the while her high-pitched working song.

No sooner has she used up the pellet than back she goes for another, until the cell is completed, save for the closing of one end, which is done when the stock of spiders has been brought.

On Kerenge Isle, where spiders were exceedingly abundant, *Sceliphron* was also plentiful, and my grass hut was a very favourite nesting place, so that the high-pitched song of the worker was heard all day long. While sitting writing one morning I timed the journeys of one individual, noting the moment when she reappeared with a fresh pellet of moist building material, which she applied without waste of time, flying away again immediately to bring another pellet.

The following are the times noted: 8·45, 8·48, 8·50½, 8·57½, 9·1, 9·6, 9·8½, 9·12½, 9·17, 9·23½, 9·27, 9·30, 9·33½, 9·36½, 9·39½, 9·41½, 9·44½, 9·47. After this she did not reappear for half an hour, and I went out.

The average time taken to fly from the nest to the lake shore, collect a mud pellet, bring it back, and build it on to the nest was 3·6 minutes, the shortest being two minutes, the longest seven.

Although the cells are often built singly, they may be aggregated, being built one alongside the other, so that a single mass the size of a small fist may be formed, comprising eight or ten cells, each stuffed with spiders.

It is quite extraordinary to think that all that material, weighing perhaps half a pound, has been brought by one insect.

The destruction of spiders wrought by one *Sceliphron* in providing for a future generation is also surprising.

On Kerenge Isle I counted the number taken from twenty-nine cells. In the following table a cell is indicated by a serial number, and all cells found attached together, i.e. built by one individual, are indicated by the same letter.

1A	6	11D	8	21G	7
2A	7	12E	12	22G	9
3A	8	13E	8	23H	11
4B, 5B	25	14F	8	24H	14
		15F	8	25K	12
6C	1	16F	5	26K	15
7C	7	17F	4	27K	11
8D	5	18F	6	28K	11
9D	12	19	12	29K	19
10D	14	20	5		

The average number of spiders in a cell was 9·3, the minimum one, the maximum nineteen. The variation in the amount of food stored up is considerable, even in cells constructed by one *Sceliphron*. Thus No. 6 had only a single spider, very little larger than one of the seven in cell No. 7. The spiders are usually of a number of different species, but the twelve in cell No. 19 appeared to be the same.

The destruction of spiders by *Sceliphron* must be considerable. Supposing that ten cells are completed during the lifetime of one individual, it will have accounted for about ninety spiders.

Sceliphron itself, however, is victimized by a large "Ichneumon" fly of the same black and canary-yellow hues presenting a remarkable likeness to its victim, especially when seen on the wing at a little distance. Two-winged flies (*Tachinidae*) can also be reared from

Sceliphron cells, but they are probably indirect parasites, their larvae feeding upon the spiders and not upon the *Sceliphron* larvae, which thus die of hunger.

A smaller species of *Sceliphron* makes cells somewhat similar to the mud nests built by *S. spirifex*, but they are placed upon grass stems and are of more delicate structure, being composed of some light friable material mixed with fibrous substance. These nests were common also on Kerenge Isle, and were filled with spiders.

The great majority of *Sphegidae*, however, are true fossors—that is, they excavate burrows into which the paralysed prey is put.

Since a Sphegid having once stocked the burrow pays no more attention to it, there is no need for it to work like *Bembex* in loose light soil; indeed, the firmer it is the better they seem to like it, and often may be seen working on the hard surface of a trodden pathway.

The methods of a Sphegid differ somewhat from those of a *Bembex*. The earth cannot be removed by mere scratching, but needs to be excavated by "tooth and nail."

An *Ammophila*, for instance, having found a suitable site, commences to scrape together a little of the loose soil on top, which she holds between her front feet and head and, having walked backwards a few inches, deposits it with a little buzz of satisfaction and returns for another armful. Presently the soil is found firmer, and she sets to work with her powerful mandibles to loosen it, sometimes bringing up portions in her jaws. The work proceeds with rapidity until the hole descends vertically to such a depth that she disappears from view.

She seems to be on springs, so full of life and energy is she; it is often extremely curious to note how rapidly she shoots out from the burrow backwards, drops her load, and plunges headlong down the hole again as if drawn by a piece of elastic attached to the bottom thereof.

Occasionally a piece of stone defies removal, and a prolonged and angry buzzing from beneath the surface attests her efforts to dislodge it with her mandibles, but presently she works it loose and comes up with it.

At last all is ready, and she proceeds to cover the mouth of the burrow before going off to seek the prey wherewith to fill it. Pieces of stone of small size are selected and wedged together so as to block the entrance, and with her back to it she scratches a little loose earth over the stones and, after a final careful examination, flies away.

Now you may see her quartering the ground for the caterpillar, grasshopper or other insect which she needs; wings flicking and antennae quivering, she runs about eagerly searching until—pounce!—she has found one and stung it, and it lies helpless on the ground, with limbs slightly twitching.

Picking it up by her mandibles, unless it is too large, she walks with it back to her hole, keeping a marvellously straight course over all kinds of obstacles, even climbing with it up perpendicular rock faces, until after much effort she arrives at the site of the burrow. This is quite indistinguishable from the surrounding soil, but she knows it, for did she not herself take pains to conceal it before she left it? The precious burden is put down, and the barricade that closes the burrow is removed. Down she goes head first, and presumably, after making sure that all is well, turns round in the chamber at the bottom, for almost immediately her head reappears and she seizes the prey and drags it down. After a very brief interval, during which the egg is laid, she reappears and at once sets to work to fill up the burrow. Standing with her head away from the open mouth, she vigorously scratches the loose earth backwards into it with sure aim. But to make a good job of it something more is required, so she picks up pieces of stone and puts them down the hole, and then proceeds to ram it all down in a most workmanlike manner.

Firmly gripping the lips of the hole with her middle and hind legs, she launches herself with great force against the loose earth, using the front of her broad head as a battering ram, and making the loud buzz wherewith a great effort is signalized. At length the burrow is filled up flush with the surface, and it only remains to conceal the fact that the spot is in any way different from the surrounding terrain. Small stones are scattered over the surface, a little loose dust is scratched about, and the energetic *Ammophila* flies off to refresh herself on a neighbouring flower head before commencing to excavate a fresh burrow elsewhere. Unlike the *Bembex*, she will never visit her burrow again; it has been adequately stocked with food once and for all.

The above is a general description of the methods adopted by the majority of *Sphegidae*, and we will turn now to another great family of fossors, the *Pompilidae*, which is broadly characterized by rather longer limbs, and by the fact that they hunt spiders only. In essentials they work in the same manner as the *Sphegidae*, but so far as I can remember they work quietly, and never make the excited buzzing so characteristic of *Sceliphron spirifex* and other *Sphegidae*.

But when it comes to the filling up of the stocked burrow there is an important difference in the manner of working, which I do not think has been sufficiently appreciated.

As described above, a Sphegid uses the front of her broad head as a battering ram wherewith to press down the loose earth; but *Pompilidae* invariably use the end of the abdomen.

Sometimes the insect stands in the mouth of the hole and quietly presses down the soil in the burrow, but one specimen that I saw threw her body into such quickly repeated movements that her outline became blurred, and she reminded one of the rapid oscillations of a pneumatic hammer.[1]

Perhaps *Pompilidae* do not use the front of the head because it is less broad and flat than in *Sphegidae,* and therefore does not form such an efficient rammer ; but the difference is extremely remarkable.

The *Pompilidae* are most typically aposematic insects. Many are of intense blue-black with shining bluish or greenish black wings, often set off by canary-yellow antennae. The sting inflicts a very painful wound, but they do not use it unless molested, and may be watched with perfect immunity so long as they are not roughly handled.

It is difficult to conceive a more conspicuous insect than one of these fine creatures as it sails through the air with its long legs hanging down. Yet according to some of the American naturalists these insects are concealed by resemblance to their surroundings.

In that case it is difficult to explain one of the most striking characteristics of these large *Pompilidae,* namely, the extraordinarily noisy flight, which is often a loud rattling or clicking noise audible before the insect is seen, and reminding one of a badly made piece of clockwork.

If a Pompilid is really concealed, what is the meaning of this noise which at once directs attention to it ?

If, on the other hand, these insects are really highly conspicuous, as I think, the loud noise is merely an adjunct to their aposematic colouration, and serves still further to advertise their owner's unpleasantness.

Many times have I seen my pet monkeys' attention caught by the noise of one of these formidable insects on the wing, and they would turn their heads to the direction from which it came, and watch the Pompilid when it came into sight with the most careful attention, being evidently anxious to avoid it when it drew near.

[1] *Batozonus fuliginosus.* See *Proc. Ent. Soc. Lond.,* 1917, p. lx.

This "aposematic noise" is entirely in keeping with, and explicable by the same means as, the conspicuous appearance of the insect, which is thus enabled to appeal to more senses than one. But if the Pompilid is concealed, then one explanation is required for its colour and another for its noisy flight, though it is difficult to imagine what explanation of the latter could be given. I have suggested elsewhere[1] that there is an analogous example among birds in the case of the large black and white "E'nga-nga" hornbill, whose wings make an extraordinary roaring noise as it beats them, or sails with them outspread through the air, often at the same time calling attention to itself by its loud raucous cry.

It has been mentioned in the case of the *Bembecidae* that they have enemies in certain flies, and the same holds good with *Sphegidae* and *Pompilidae*.

The golden moment for the enemies of these fossors is when they have arrived with their burden at the mouth of the burrow and leave it outside while they go down. The attendant fly can then dart down and deposit its own egg upon the prey while the fossor is busy, and that it does so is evidenced by the fact that on grasshoppers taken out of the burrows of the little *Sphex marginatus* I found dipterous larvae which became flies of a species unknown to the British Museum, but allied to the *Miltogramma* described by Fabre. It is rather interesting that whereas most fossors seem to take little notice of other insects while they are at work, *Sphex marginatus* is extremely suspicious of any intruders on its privacy, and charges fiercely with open mandibles at even the smallest ant that draws near to its burrow, much to the dismay of the quite inoffensive ant! If the trespasser does not at once withdraw, the *Sphex* makes threatening movements as if about to sting, turning the tip of her abdomen forwards between her legs.

[1] p. 168.

Another family of fossors, the *Scoliidae*, has been mentioned because they save themselves a great deal of labour by searching out the food for their larvae and laying an egg on it *in situ.*

They are interesting also from another point of view, because, of all *Hymenoptera*, they have the quietest flight ; even the largest specimens produce a barely audible hum, thus contrasting greatly with *Pompilidae.* They are usually rather solidly built, hairy insects, sometimes black, sometimes reddish or yellowish in colour.

Lastly, there are the *Mutillidae,* which will only be mentioned on account of their scarcity on the islands. It seems that forested country and a damp climate are not so suitable to them as the more open bush country with regular dry seasons such as occurs in much of ex-German East Africa, where I found *Mutillidae* far more abundant than on the islands. They are remarkable among *Hymenoptera* for the complete absence of wings in the females, which are often mistaken for ants as they run quickly over the ground. A species of *Methoca* was obtained which was not in the British Museum collection : the few African species that are known of this genus had previously only been obtained from south of the river Limpopo.

Regarding Bees I have little to say. The very handsome large "Carpenter bees" (*Xylocopidae*), which in the tropics take the place of our "Bumble bees" at home, are plentiful enough, and may often be seen visiting the large yellow flowers of ambatch trees. A particularly handsome large one is covered with bright golden brown hair ; this is the male of a species whose female is black and white. Their burrows in dead trees are commonly seen. The natives call them "Buvumira," which is quite descriptive of a large buzzing insect.

A smaller bee (*Crocisa meripes*) presents a great contrast to these furry fellows, as its integument is hairless, and brightly coloured sky blue and black.

I do not know where *Crocisa* nests, but it has a remarkable habit of passing the night in the open on a grass stem, its mandibles firmly clasped round the stem, and its legs tucked up against the body, so that the insect, supported only by the grasp of its mandibles, projects obliquely from the stem. They may often be found dead in this position.

Sometimes several will affix themselves thus, one below the other, and the stem may be picked and carried about without disturbing the bees. Another species (*Cœliaxis carinata*) has the same resting habit. The islands are singularly blest in the absence of minute, stingless, but very annoying bees (*Melipona*), commonly known as "Sweat bees," from their habit of settling on one's bare skin and licking up the perspiration. If they would only settle quickly one would not object so strongly, but they spend a long time dancing about in front of one's face under the brim of one's hat; when they do settle they cause an intolerable tickling.

Though they have lost their sting they are very possibly still protected, for if one is squashed by a blow it has an unpleasant acrid odour. I first made their acquaintance on active service, and soon learnt to give thanks that the islands did not support them!

Like the *Mutillidae* they seem to prefer more open, drier country; hence the thirst which leads them so eagerly to suck up moisture from one's skin.

FLY BOYS' CAMP ON KOME ISLE, 1914.

SERVANTS' HUTS ON KOME ISLE, 1914.

To face p. 304.

CHAPTER XIII

SUNDRY INSECTS

Coleoptera.

Beetles were not systematically collected on the islands, so that there is not so much to be said about them as about *Lepidoptera.*

The first interesting specimen that was met with on the lake shore was a new species of Coprid, which Mr. Arrow informed me was quite unlike anything in the British Museum. I was watching a column of the "Safari" ant (*Dorylus*) moving from one camp to another, carrying their pupae with them, and saw this flat, black, highly polished beetle running in the column among the ants, who took not the slightest notice of it. That it did not belong to them was improbable, for it took the greatest care to remain in the column, and these ferocious ants most strongly resent the presence of any stranger among them. It is interesting to find that these dread hunters have their familiars. Possibly the larva acts as a useful scavenger in their nests, as does the larva of the Rose beetle in nests of other ants.

While at Jinja in 1910, I watched with interest the behaviour of some large polished green Coprids engaged in making their balls from the recent droppings of some grazing animal.

When I first came up one had almost finished making its ball. When it was finished the beetle pressed the material together with its front legs and then very cleverly rotated it on one spot, lying almost underneath it, so as to get a firm coating of earth on it; it then trundled the ball away. Soon other beetles arrived on the wing, dropping quite near to their objective and eventually crawling to it, obviously guided by smell. If one happened to meet another when both were searching for the dropping, one always fell in and followed behind as if quite certain that the other must know the way! I watched No. 2 make its ball. The desired portion of the dropping was the outer part which had hardened somewhat. The beetle stays at one spot and reaches towards it with its powerful forelegs enough to make a ball about the size of a very large cherry. It frees it below by insinuating the sharp front margin of the head between the ball and the mass, and making powerful lifting movements of its head.

No. 2, after making the ball, did not for a long time push it away, but kept pressing it together and patting it, and finally gave it a very smooth coating of fine earth, and then sat resting on it.

Meanwhile others had arrived (ten altogether came while I watched), some smaller in size. One of them, No. 3, apparently desired a share in No. 2's ball, but was driven off, hurled away by jerks of the strong front legs. Eventually it joined with another small one, No. 4, and these two very quickly made a rather ill-constructed ball and trundled it off, No. 2 still patting at its own.

There were numerous fights between the workers, who sometimes got mixed and each took the other's ball.

These beetles are eaten by a species of Roller, one of which when shot was found to have several of them in its stomach. Presumably its powerful bill enables it to feed on such horny beetles, whose large size and hard coat of mail must deter smaller birds. Of the carnivorous ground beetles I saw little on the islands, but two species of *Cicindelidae* (Tiger beetles) were found, which were very acceptable to the British Museum. One, a pretty green species, not unlike the English *C. campestris*, but larger, was found abundantly running over termite hills on Nsadzi Island. The other was a mottled grey species, found, but very difficult to see, on a stretch of sand on Bugalla that had at one time obviously been the lake shore. The huge black *Carabidae*,[1] common in Africa, were never seen on the islands; though I do not assert that they were not there, it seems curious that they should never have been met with.

Carnivorous water beetles (*Dytiscidae*, *Gyrinidae*, etc.) were of course abundant in the weedy shallow waters. The readiness with which they take to the wing is well known; but it was quite amusing to note how, during a storm of rain, several *Gyrinidae* appeared in the trench which led away the rainfall from the roof and solemnly executed their well known whirligig manœuvres so long as the water lasted, and when the storm was over they vanished. Large *Dytiscidae* several times dropped on to a shiny patch of wet ground during heavy rains, evidently misled into thinking it was a pool.

The beautiful *Longicorn* beetles were often met with, and one very abundant green species of medium size [2] had a very rank aromatic odour, and my pet monkey would not eat it.

The most interesting Longicorns are the mimetic species, and a very fine one [3] was abundant on the flowering shrub *Haronga*, where it was associated with the large *Lycidae* which it so much resembled. Other Longicorns mimic the parasitic *Hymenoptera* of the family *Braconidae*, many of which are typically aposematic in appearance, and have a powerful, rank odour.

[1] Genus *Anthia*. [2] *Phrosyne brevicornis*.
[3] *Amphidesmus analis*.

A common colour scheme for large Braconids is orange and black, and on Bugalla a Longicorn[1] beautifully mimetic of these was found. Being long and narrow, the beetle has a shape which affords a good basis for the resemblance. The orange abdomen, however, does not show the narrow waist of the Hymenopterous model, to which the resemblance is produced by a portion of the side of the base of the abdomen being of a glistening white, contrasting strongly with the remainder, so that that part in a high light suggests that it has been, to use Professor Poulton's phrase, "painted out." The first specimen that I found was a male which when handled strongly curved the tip of the abdomen in such a way as to suggest it was about to sting, and actually protruded a flexible white viscus which it moved about like a sting. Of course *Braconidae* are not strictly stinging insects, yet when handled they will use the ovipositor as such. The Hymenopteroid appearance of the beetle with its false sting was so very striking that although reason told me it was a beetle, instinct was so strong that misgivings almost prevented me handling it, and I feel certain the very great majority of people would have dropped the beetle in a panic. On the wing the resemblance is much greater; both insects have a slow, steady flight, and the long antennae are extremely conspicuous. The wings of the beetle are transparent and invisible during flight, but the orange, black-tipped, wing covers reproduce the appearance of the similarly coloured wings of the Braconid. Several smaller species of Longicorns also very closely resemble smaller black and yellow Braconids, so that even after several years of field work one is still deceived and, catching an insect which one has thought to be a Braconid, finds a beetle in the net.[2]

[1] *Dirphya*, species near *princeps*.

[2] This happened to me repeatedly in 1917 in German East Africa. See Proc. Ent. Soc., 1918, pp. cxxxviii–cxlii.

Many Braconids are coral pink and black, and they also are mimicked by small Longicorns. On Bugalla I obtained model [1] and mimic [2] at the same spot and time, and also a small Capsid bug,[3] equally mimetic.

Fireflies are interesting beetles, but, having read much about the wonder of tropical fireflies, I was much disappointed on the islands ; only a few were seen at a time, belonging to a species looking much like the male of the English glow-worm, and I have seen a much better display in the spring on the Riviera.

Wood-boring beetles are a great nuisance in a house constructed of freshly cut boughs and stems of trees ; the rafters are soon penetrated in every direction by tunnels, from the open mouths of which a continuous stream of the finest sawdust falls and soon covers anything left lying for long in one place.

Quite the most remarkable beetle met with on the islands belongs to the aberrant family *Lymexylonidae*,[4] it several times appeared in my hut in the evening, flying with sonorous buzz, and the first time I saw it puzzled me not a little, for it was like no beetle I had ever seen or heard of at that time.

The very long, thin body was quite soft and flexible, and a very short pair of wing covers entirely failed to cover a long pair of wings with stout longitudinal rays so that they folded like the wings of a grasshopper, but then projected far behind the covers. The legs were long and thin, and the antennæ short, with broad flat segments.

Neuroptera.

Dragon flies are, of course, abundant on the lake shore, but I do not think they are any more noteworthy than

[1] Not yet identified.
[2] *Dirphya*, species near *pascoei*, *Lamiidae*.
[3] *Kolopeltis bergrothi*.
[4] *Atractocerus brevicornis*.

our beautiful English species. One fine, abundant species is blood red, and another is vividly coloured with cobalt blue and red, but there are many dull species. One of these,[1] the commonest of all, may be seen on the wing before sunrise and after sunset, and on one occasion on Kerenge Island I saw a host of them about sunrise, dancing up and down in the air just as Mayflies do in England.

The large species of Dragon flies often prey on the smaller, as well as on bees and other protected insects. I have seen *Cacergates* preying on *Glossina,* and since both large and small Dragon flies are favourite articles of food of the bee-eater *Merops superciliosus,* the bionomic relation of this bird to the Tse-tse fly is rather a complicated one!

A curious Neuropterous insect named *Bittacus* was attracted to light several times on the islands; it is a slender light brown species with narrow wings and very long slender legs. On the first occasion I thought it was a Tipulid, and did not take much notice until something about it made me look more closely, and I saw it was not a "Daddy longlegs," but had four wings.

If there was any reason for supposing the *Tipulidae* to be protected one might consider the *Bittacus* to mimic the fly; but there seems no reason for supposing that a resemblance to a "Daddy longlegs" would be of any benefit.

A remarkable genus of Neuroptera is named *Mantispa.* These insects resemble *Mantidae,* and have the fore limbs modified in the same manner for holding the prey, which they devour alive. Several of them very deceptively resemble Hymenopterous insects. On Kome, one day, I saw on a twig an insect that at first appeared to be one of the abundant, conspicuous and fiercely stinging wasps of the genus *Belonogaster.* It was munching at

[1] *Cacergates leucosticta.*

some insect it had caught precisely as the wasp chews up caterpillars into pulp, and when disturbed flew with it on to a neighbouring branch. But the thickness of the abdomen caught my attention, and disclosed the true nature of the insect. The question may well be asked, How was it that the broad wings of a Neuropterous insect did not attract attention, as differing from the narrow folded dark wings of the wasp ?

When the *Mantispa* was at rest the fore wings lay above the posterior wings and concealed them. Their greater part was absolutely transparent and hardly noticeable, but the appearance of the narrow wings of the wasps was produced by a darkening of a narrow strip along the anterior margin of the fore wings, which dark strip roughly resembled in shape the whole of the folded wings of the wasp.[1] The *Mantispa* at rest held its wings directed backwards as does the wasp, but not quite parallel to the body, so that they made a slightly greater angle with each other than did the wasp's wings.

In colour the *Mantispa* very closely resembled *Belonogaster*, and the resemblance, probably pseudaposematic or true mimicry, was extraordinary, and would not be believed if one had only seen the specimens in the cabinet.[2]

Orthoptera.

Mantidae.—One species, *Pseudocreobotra ocellata*, has already been alluded to as an instance of Anticryptic colouring ; other equally cryptic grass green species were particularly abundant on certain islands, an account of which was given in Chapter VI. Sometimes the curious egg clusters were very abundant ; the eggs are embedded in a substance somewhat resembling the crust

[1] See also *Trans. Ent. Soc. Lond.*, 1902, Part III, pp. 528–9.
[2] Cp. G. A. K. Marshall, *Trans. Ent. Soc.*, 1902, Part III, pp. 536–7.

of a *meringue*, covered by a substance resembling parchment in texture, but produced by the Mantis as foam at the time of oviposition. These egg masses vary much in shape, size and texture according to the species—some are pure white, spherical, and about the size of a bantam's egg; others, no larger than a hazel nut, have an amber coloured, almost transparent covering, with a ridge along one side looking like a seam where two halves meet. These are very conspicuous, and may be seen at the tips of twigs, etc.; but there are other very cryptic forms of egg masses, laid along a twig and closely adherent to it, with rough opaque brown surface. The freshly hatched Mantids may sometimes be found hanging from the egg clusters by slender threads, but I do not know for how long they remain thus. Very young specimens are often black, and look extremely ant-like as they run about.

Phasmidae.—Stick insects found on the islands are small and not remarkable: "grass insects" would be a better name, because they are found in long grass, the stems of which their slender wingless bodies resemble in size and colour. They frequently betray themselves by a curious swaying from side to side, for which it is difficult to account, for were they to remain quite still they would certainly be invisible.

Locustidae.—The most noticeable insect of this family was a slender active grasshopper known to the natives as "Ensĕnĕnĕ"; about two inches long, usually grass green but sometimes light brown. These grasshoppers used to appear suddenly in great numbers and could be heard faintly chirping in the grass. As one walked along they took to the wing in clouds, and their pearly wings flashing in the sun produced a curious resemblance to driven snowflakes. At these times the natives would go out and catch large numbers for eating, walking through the long grass and whistling through their teeth to make a sibilant noise. They were prepared for food by frying. My pet monkeys were also excessively fond of them, and would eat them for as long as they were offered, even until the overloaded stomach rejected them.

A ghoulish species of *Ephippigeridde* was a great nuisance in my hut on Damba, as it found its way into every box of food and quite replaced the kitchen cockroach as a pest. It has a rotund short body with immensely long limbs and antennae, and is offensively familiar! It would come on to the table while I was dining in the evening and stand with the filamentous antennae waving in the air, and was so quick that I could never catch it before it leapt away. As it was a great nuisance I was glad to find that the egg cases, like little portmanteaux, were attacked by a Chalcid parasite, which laid its own eggs inside the case. One such, when opened, was found packed with rows and rows of the minute white pupae of the parasite, white, with shining black eyes, looking for all the world like neatly arranged mummies. The male of this species has imperfect wings, and has not been heard to make a noise.

Another very large burrowing species during the rains sits at the mouth of its burrow making a continuous "shrilling" noise which, if at all close, is quite unbearable, as it seems to make one's whole head vibrate in sympathy.

Another Locustid worthy of notice, of the same section, is known to the natives as "Semukutu." It is disliked very much by them, for they say it bites and makes sore places, and often show sores which they say were caused by a Semukutu. When handled this insect ejects with some force from the side of the thorax a stream of clear, yellow fluid with an acrid smell, but though I have handled a large number in the endeavour to collect a quantity of the fluid I have never suffered in any way from it. No doubt it would be excessively unpleasant in the mouth or eyes of an enemy. The Semukutu is a large, fat, bloated creature destitute of any trace of wings, and with spiny thorax. Young specimens are often greenish, but the adult is dull brownish grey. It is a very sluggish insect, and freely exposes itself as it crawls heavily about.

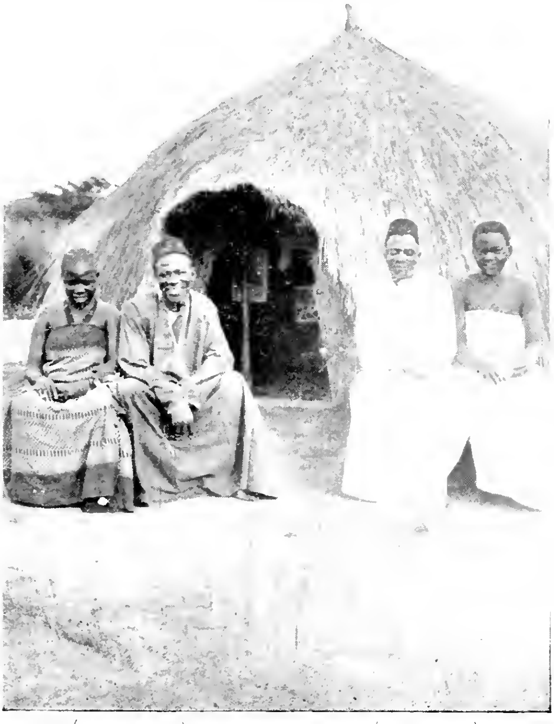
Acrididae.—Large and powerful grasshoppers of this family, species of *Cyrtacanthacris*, are known as "Amajansi" to the Baganda. Some of them are several inches long, and were apparently much esteemed as food by the monkeys. They were not noticeably abundant on all the small islands visited, but seemed to be so on Kerenge, where the beautiful bright blue kingfisher that feeds on them was much in evidence.

Blattidae.—Cockroaches of many species were common among dead leaves in the forest, but one saw little of them except when the "Safari ant" was out hunting. Then the unfortunate cockroaches, driven from their lairs, rushed hither and thither in frantic desperation, and in such a state of panic that they often tumbled head over heels, and the more easily fell a prey to the host of ants, which at once tore them to pieces. Some curious species may be found half buried in loose dry earth at the base of trees; absolutely wingless, they look much like huge woodlice.

DERMAPTERA.

The earwig family was not at all well represented on the islands, much to my surprise, for there seemed to be ideal conditions for them. I thought at the time that perhaps this was the rule in equatorial Africa, but later modified this view when on active service in German East Africa, where earwigs were found extraordinarily

COOK'S HUT (LEFT) AND KITCHEN ON BUGALLA.
Cook on right. The water boy on the left developed sleeping sickness.



HEAD BOY (A SWAHILI) AND SECOND BOY (MUGANDA) ON RIGHT.
Their wives had come out for a brief visit.

To face p. 314.

abundant in some parts of the country. So that the islands would appear to be unfavourable to them.

One large species was found on Damba under a stone at the very water's edge, so that the tiniest ripple must have surrounded it.

Diptera.

The most important fly on the islands, namely *Glossina palpalis*, has had a chapter to itself. Other biting flies (*Tabanidae*) were less common on the islands than on the mainland, but *T. variabilis* a small black and white species, and *Chrysops brucei* were occasionally seen, with one or two species of *Hœmatopota*.

Mosquitoes, of course, were to be reckoned with, and they were particularly abundant on Damba Island, perhaps because it was covered with low lying forest. But the Anophelines, carriers of malaria, were so scarce that the numbers of times one was seen could be counted on the fingers, so that the health of the party was excellent. The *Simuliidae*, or "Buffalo gnats," have been alluded to as particularly troublesome on certain islands when rain was threatening; they frequent rocky open shores, and when abundant render such spots unapproachable. The species found on the islands was not the same as the one I had previously met at Jinja, *S. damnosum*, called "Embwa" by the natives; the island *Simulium* is smaller and rather prettily coloured with golden pubescence. Both leave a severe burning and itching sensation, but whereas *S. damnosum* attacks particularly the lower extremities, the island species makes for one's head and neck, and especially the ears.

The parasitic *Tachinidae*, which lay their eggs on the surface of living insects, have been briefly alluded to as enemies of "protected" insects.

On one occasion a species was observed in the act of oviposition.

On the minute island Lula, several colonies of very hairy caterpillars, of the family *Eupterotidae*, were seen on trunks of trees. Near one colony was a large Tachinid fly, and the caterpillars, close together, seemed to be aware of her presence, for they moved uneasily; but the fly moved as they moved, sidling about in a very amusing manner so as always to face the caterpillars. She endeavoured to find one that was not moving, and then approached the head from in front. The long hairs of the caterpillar projected from all parts except the head, so as to form a *chevaux de frise*, but opposite the head there was a small gap in the barrier. The fly, having approached as close as she could, raised herself up on her anterior legs and protruded forwards, beneath herself, an enormous ovipositor whose tip projected in front of her head. The egg was laid in a very brief instant on or near the head of the caterpillar, but sometimes the fly was unable to reach its head, and then had to wait until the larva was near enough for her ovipositor to reach between the long hairs so as to deposit an egg on the flank of the larva.

It was a most interesting and instructive proceeding, illustrative of the adaptation of one enemy (the fly) to meet a condition in its victim probably directed against other enemies (birds). It was noted that the fly laid its eggs fortuitously on any larva that presented itself, so that one received many eggs but others none. This might quite well lead to some of the offspring of the fly receiving insufficient nourishment and being stunted in growth or failing to develop. One sometimes meets the opposite condition, when too few ova have been deposited, and the parasites have not damaged the vital parts of their host. I once reared a single Tachinid fly from an Arctiid larva which eventually produced a perfect moth!

Asilidae or Robber flies were often met with at the very margin of the forest where it abuts on open grass land; others in the forest, and others on the grass land. Robber flies seems a poor name for these powerful, hairy, predaceous flies, with long narrow bodies and strong legs. Hawk flies would be a better name, seeing how they pounce upon their prey; in some six years of work in the field I can only once remember seeing an Asilid pounce on its prey sitting.

Emphasis has already been laid upon the importance to the theory of mimicry of noting the prey of *Asilidae*. It is, I think, quite certain that the fly injects poison into the victim the moment it has been captured and the proboscis has been plunged into it. The prey seems to succumb at once before it can have been sucked dry, and if one actually witnesses the capture and at once catches both insects the prey is almost always found to be dead, or feebly moving its legs only. Only once have I met with an exception to this. An Asilid was seen to catch a bug, and I struck at it with the net. The fly escaped, but dropped the bug, which was found to be apparently unharmed.

Another family of Diptera, *Chironomidae* or "gnats," is worth mentioning here, owing to the abundance in which they appear over the lake during and shortly before the rainy season, resembling clouds of smoke from distant steamers. I have seen, on a calm day, a large area of water covered by the pupal skins of these flies, the pupae having come up from quite deep water, and the flies rising in a cloud from the surface, which was of a brown tint from the myriads of empty skins. When these flies, called "E'sami" by the natives, and looking more or less like mosquitoes without the sucking proboscis, have drifted in a cloud on to some land they find shelter from the wind on the lee side of trees and bushes, where they may be seen hovering in a cluster, the end of which, furthest from the tree, is strung out and torn by the wind.

On a very calm and damp clouded day the air is filled with the high piping of the Sami, hovering in myriads in the shelter of bushes, and a sudden noise will cause them all to rise suddenly upwards. It was very amusing to sing a scale, for one note appeared especially to upset the Sami, and when it was reached every member of the hovering cloud would simultaneously leap an inch or so upwards. The natives catch large numbers in baskets like strawberry baskets made of plaited grass through which a stick is passed; the whole is vigorously waved about in a cloud of Sami, the basket rotating around the stick, which passes across its diameter. The catch is compressed into a cake, but I do not know how it is prepared for food.

Sami have an odour of the lake which it is difficult to describe—a smell like weeds and fish from a muddy pool; it is a common saying at Entebbe that the arrival of clouds of these gnats produces an outbreak of nasal catarrh among the white inhabitants; possibly this is of the nature of "hay fever."

Spiders.

The most noticeable fact about spiders on the islands has been already recorded in the account of the tour in 1914, namely, the extraordinary abundance on certain islands of the huge *Nephila*, and the sheets of their webs. It was noteworthy that on some of the islands the spider was present in normal numbers only, as on Kibibi. Spiders, generally, are called "Nabubi" by the Baganda. A curious habit has been noticed in the case of a species, making the typical "orb web." Over part of the web it would spin a piece of very conspicuous, opaque, glistening white silk, which was visible from some distance away. The design in the same web would be changed from time to time, for sometimes there would be an opaque bar right across the diameter of the web, or at others a zig-zag between two of the radii only. The reason for this is obscure; I can only suggest that it is analogous to the trapper's artifice of putting an object across the track of some animal which, making a detour to avoid what it imagines to be a trap, falls into the real trap set at the side. An insect on the wing, supposedly, sees the conspicuous part of the web, takes care to fly past the side of it, and is caught in the inconspicuous part which it has not seen.

On an earlier page attention was directed to silver markings on insects; a spider found on Dwaji Isle in 1919 was notable. It was of fair size and spun its web among heads of dry grass; the colour of the cephalo-thorax and front part of the abdomen was pure silver, the rest of the abdomen was dark, but speckled with yellow and with a series of silver bands; the legs were banded alternately dark and speckled-yellow.

Of the smaller members of *Arachnida*, Ticks call for notice, but only on account of their great scarcity on the islands. This is presumably associated with the absence of cattle and all buck except the Situtunga; and if the islands could be again inhabited it should be possible to keep cattle there free from ticks and therefore from the diseases carried by them.

The *Varanus* often has numbers of ticks on it, but these are not of the species which feed on cattle; prettily decorated ticks [1] have also been found on the Horned Puff Adder. The islands are also singularly blest in the absence of Scorpions, which were not met with; possibly the climate is too continuously humid for them.

The great group of *Myriapoda* calls for passing notice, firstly because of the absence of the huge centipedes found in some parts of Africa, and secondly

[1] *Aponomma lœve.*

on account of the great abundance of giant *Millipedes* ("*E'gongolo*"). These fine creatures, with cylindrical bodies some six to eight inches long, as thick as one's finger, clothed in rings of polished black armour with reddish legs, are really extremely handsome. They may often be seen on the sandy beach feeding on decaying rubbish cast up by the waves, and are especially noticeable when rain is coming. They were not met with on certain of the smaller islets, which were yet of sufficient size to be expected to support them.

I think that they are occasionally devoured by the Enswa-swa, for rings of their armour may be seen in dried excrement believed to be of that reptile. But I am quite unaware what are the main checks on the increase of these millipedes; possibly the greatest loss is caused by enemies that devour the eggs, or parasites of the eggs. It is a curious fact that I cannot remember having seen a specimen less than half grown.

Crustacea.

Small crabs are one of the factors of the lacustrine fauna which suggest the sea, and they are abundant in shallow water. Superficially they much resemble crabs of a couple of inches in diameter that one finds in seaside pools. The natives call them "*Enjaba.*" One was found under a stone among damp debris about twenty yards away from the water, a young and lively specimen.

Crayfish were never met with, but shrimps, looking much like the common marine species, abounded in shallow weed grown waters.

The natives call them "Obuduli," and use them as bait for fish, but I do not think they eat them.

Fish lice, of two species, were met with on the "Mamba" and "Mălĕ" fish already described, and specimens sent to the British Museum proved to be of some value and interest.[1]

Woodlice, like other creatures such as earwigs, scorpions and centipedes, usually regarded as objectionable, were exceptionally scarce on the islands, and this was very surprising, for one would have expected a comparatively equable, damp climate to afford favourable conditions.

Molluscs.

The lake shore abounded with univalves and bivalves which had quite a marine appearance ; securely fastened to rocks was a species resembling the common oyster. Besides these were others very closely resembling our English genera of fresh-water snails and mussels.

A curious slug, that had very short tentacles and seemed to have no " mantle " at all, was found slowly crawling on wet sand, where also the large *Ampullaria* were occasionally thrown up by waves. Shells of these large molluscs may be found on the lake shore, apparently battered to pieces on a stone as our garden snails are by thrushes. I strongly suspect this to be the work of the " open-bill " stork.

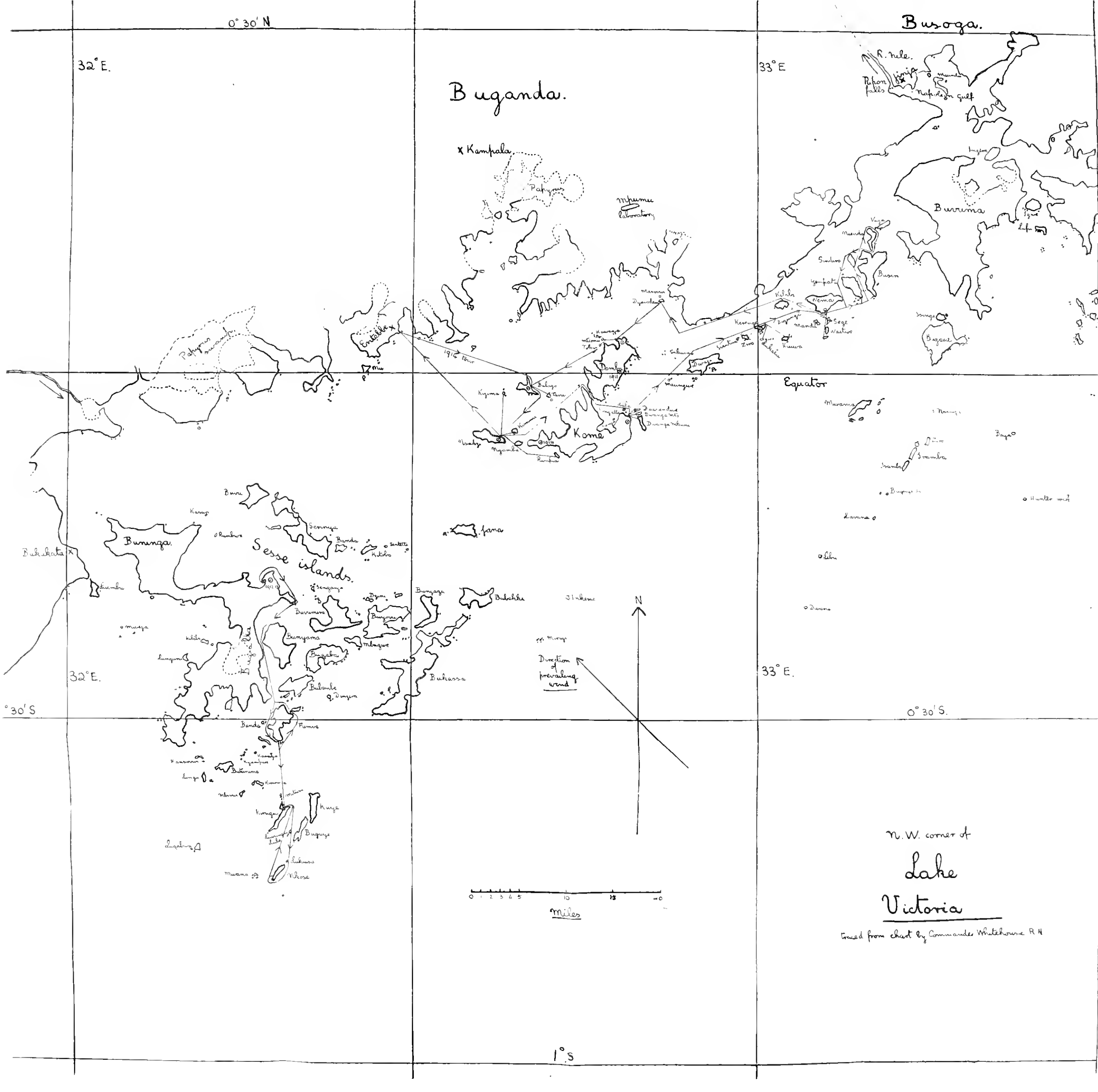
On Damba Island there was found quite commonly a snail of the type of our English *Vitrina*, but very much larger, with a thin fragile shell practically enveloped by extensions from the mantle. This was easily procured in numbers when the " Ensanafu " ant had been hunting, for its only means of escape was to crawl upwards. Should it happen to come to the top of a stem it was unable to descend again and face the ants, so defended itself by emitting bubbles to form a mass of foam completely surrounding itself, which the ants could not penetrate, and if they bit into it they could reach nothing solid. These white masses of foam, like " Cuckoo spit," were very con-

[1] *Dolops ranarum* and *Argulus africanus*.

spicuous in the forest after a raid by the Ensanafu. Specimens sent to England were found by Lieutenant-Colonel Godwin-Austen, F.R.S., to be a species hitherto undescribed. On Tavu Island, among dead leaves, I once found a minute snail like a *Vertigo*, but lost it again.

A very large snail (*Achatina*) with pointed shell of brown colour, the mouth tinted with purple, was common on Damba, and I once disturbed an Enswa-swa which had apparently been much interested in one that was laying its eggs in the ground. It is possible that the eggs were the attraction and not the snail ; they were a little larger than a pea, but not spherical, with a firm shell of canary-yellow colour.

The general name for a snail in Luganda seems to be " *E'sonko.*"



0° 30' N
Busoga.
32° E.
33° E
Buganda.
Kampala
R. Nile
Ripon falls
Napoleon gulf
Papyrus
Mpumu laboratory
Buvuma
Entebbe
1914 tour
Equator
Kome
Sesse islands.
Bukasa
Direction of prevailing wind
N
32° E.
33° E.
0° 30' S
0° 30' S.
0 1 2 3 4 5 10 15 20
Miles
1° S
N. W. corner of
Lake
Victoria
traced from chart by Commander Whitehouse R N

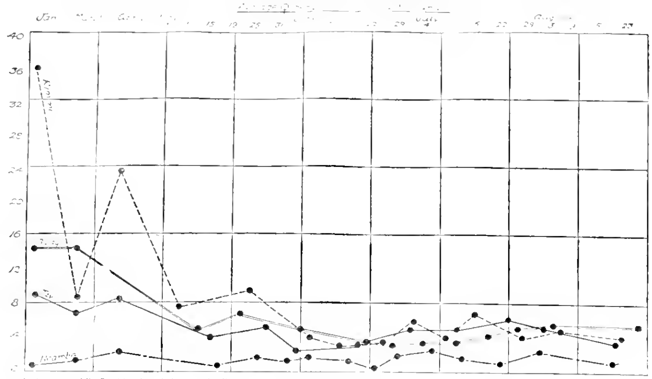


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CHART VI

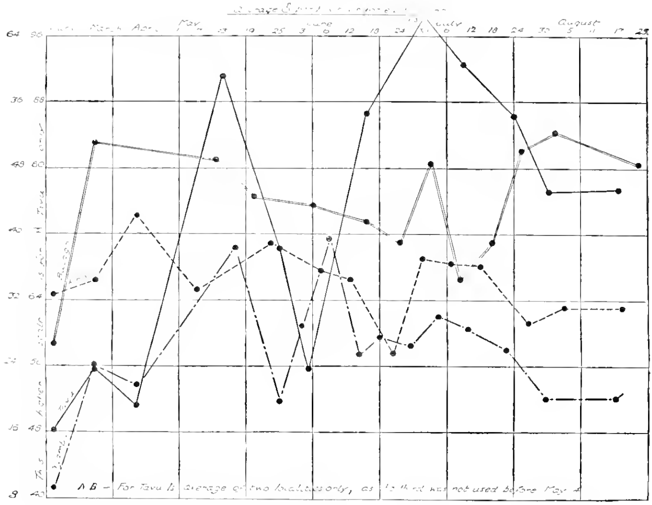

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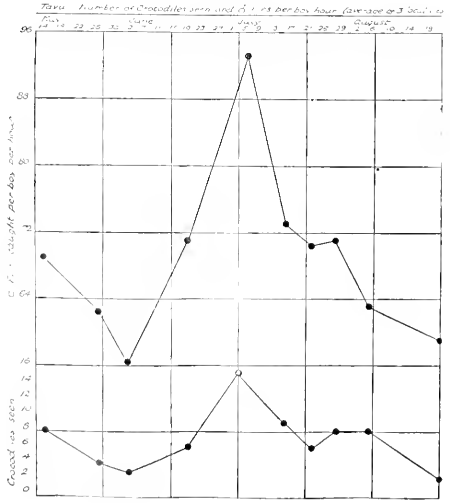
CHART VII



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