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Research in Ceylon Floristics and Taxonomy — a survey

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Introduction

The richness of the Ceylon Flora and its significance to asiatic botany are well known. Fosberg (1969), the doyen of island floras, makes this relevant acknowledgement: "Scientifically the Ceylon Flora is one of the most important in the tropics. Ceylon is the type locality of a great many of the wide-spread plants of the tropics, and the original home of some of them. It is a complex flora, including the majority of the families of plants, and is of great phytogeographic importance." Comments such as Fosberg's are not without foundation. Phylogenetically, the Ceylon Flora exemplifies quite a few of the more primitive families, e.g. the Magnoliaceae, Ranunculaceae and Dilleniaceae. Besides, because of its former geological connections with the Indian mainland and the Malaysian Peninsula, the island bears a flora which shows close affinities with that of these asiatic regions. The most significant feature, perhaps, of this flora is its relatively high degree of endemism — 24% (Peeris, 1976) — which gives it a decided richness "probably greater than that of the Indian Peninsula of the same area." (Trimen, 1885). This feature, coupled with its species diversity of 0.12 (Good, 1969) relative to its surface area, imparts to the Ceylon Flora the distinctive mark of individuality and naturalness.

Such features of rare interest invariably offer the botanist a wide scope for research in the Ceylon Flora. The account that follows evaluates the consequent attempts made during a long historical period of botanical endeavour in the country.

Early attempts

Already during the Dutch occupation of the island Paul Hermann, a physician of the Dutch East India Company, began the first investigations into the Ceylon Flora. His collections, chiefly from the coastal regions, accumulated into a bound herbarium of 4 volumes and inspired Hermann to publish it (1717) as the *Museum Zeylanicum*. Many years later Hermann's herbarium reached Carl Linnaeus who used it (1747) as the basis of his *Flora Zeylanica*. The publication gave Ceylon the singular honour of having its first Flora written by the renowned Swedish botanist himself! A few of these plants described by Linnaeus in the *Flora Zeylanica* were later documented as types of his species listed (1753) in the *Species Plantarum*.

Such early attempts at the study of the Ceylon Flora were necessarily very circumscribed; and the vast range of its complexity had yet to be discovered.

Later attempts

These may be considered to have been confined to the early phase of British colonialism in the country. They were, therefore, entirely illustrative of British endeavour of the nineteenth century. At the time the natural environment (except where British plantations had taken over the land) was as yet largely undisturbed and the indigenous plants faced little danger of extinction or of restricted distribution. The setting, therefore, was ideal for original research and inspired dedicated work as exemplified by the efforts of the first band of botanists from England. These really set the pace of interested research and exposed to the scientific world the floristic wealth of the colony.

The colonial botanists first set about the task of exploration. The sampling collections from the field helped to build up the original herbarium on which future research was to be based. Pioneer collectors from Moon, Walker and Gardner to Thwaites and Trimen made tours into various parts of the country and deposited their collections in the herbarium at Peradeniya. These specimens formed the nucleus of the *C. P.* (Ceylon Plants) *Collections* which still form the better part of the National Herbarium. Unfortunately, such collections reveal one drawback. By modern standards they were not adequately documented.

Initially research by the early British botanists was slight and did not go beyond the preparation of a list of plants and of some isolated papers for publication. This was reflected in the work of Alexander Moon and George Gardner. Moon built up a fairly large herbarium at Peradeniya and his work could only produce (1824) *A catalogue of the indigenous and exotic plants in Ceylon*. Gardner, however, showed a more scientific bent of mind. His investigations brought out real, floristic data which he published (1845—47) as *Contributions towards a Flora of Ceylon*.

In successive years more tangible progress attended research by these pioneer botanists. There was, in fact, an increased tempo of taxonomic activity with the arrival of more qualified men like G. H. K. Thwaites. An academic training helped Thwaites to produce research of quality. He made extensive tours in the country and with his systematic acumen put order into the various C.P. collections. Aided by original observations in the field he closely studied the flora as represented in these collections. Finally he published (1858—64) this wide knowledge in his *Enumeration plantarum Zeylaniae*. For its time this was acknowledged

to be a comprehensive and modern flora of a tropical country. In this work, besides, Thwaites established his reputation as a taxonomist of merit by his creation of 37 endemic genera and about a double of the number of endemic species. He recognized in addition, a number of varieties naming them only by Greek symbols. Though some of these species have been transferred to more appropriate genera most of them are valid even today. Modern taxonomy has confirmed his taxonomic judgments by recognizing his varieties not only as valid new taxa but even as worthy of being raised to specific rank!

The more prolific taxonomic activity, however, of the nineteenth century coincided with the research of Henry Trimen, successor of Thwaites as director of the Peradeniya Gardens. Trimen augmented the collections of the Peradeniya Herbarium and identified much of this material. Consequent on his field observations and laboratory dissections he published a series of separate, well documented papers on the Flora of the country. One which especially showed the depth of his comprehension of the indigenous flora was (1885) *Remarks on the composition, affinities and origin of the Ceylon Flora*. In keeping with the floristic traditions of the nineteenth century Trimen finally produced (1893—1900) a national flora — *A Handbook to the Flora of Ceylon*.. The scientific world claimed this to be the finest production of its time of a tropical flora. On its part the voluminous publication (5 Parts) proved that Ceylon angiosperm taxonomy was in a progressive state of investigation.

Till recently, Trimen's opus magnum remained the standard reference on the plants of Ceylon. It transformed our early knowledge of the indigenous plants and might justly be called a magisterial work. Its 5 parts alone speak of a broad spectrum of knowledge representative of 192 families. At the end of the nineteenth century Trimen's Flora marked a significant progress in taxonomic research.

Such efforts of the latter half of the nineteth century went to make the great period of enlightenment in Ceylon systematics; and Thwaites and Trimen were its chief architects.

The beginning of the twentieth century set a further stage in Ceylon systematics. This began with the appointment of J. C. Willis as Director of the Peradeniya Gardens, after the demise of Trimen. Willis actually initiated a different emphasis in research in the indigenous flora as he realized that for this period the Ceylon Flora was sufficiently investigated into. However, he only reassessed (1911) the systematics and nomenclature in Trimen's Flora and then directed the major thrust of his research to studying some of the deeper aspects of this flora such as its endemism and biosystematics. He thus produced (1915) an original study of the Ceylon endemics. This was to prove useful later in developing his own theory (1922) on the distribution of indigenous plants.

During Willis' tenure of service research in Ceylon systematics led to the establishment of the first scientific journal. This was the *Annals of the Royal Botanic Gardens, Peradeniya*. Its first issue appeared in June 1901 under Willis' editorship and provided an outlet for better taxonomic work. Willis himself led the initiative by producing (1902) the first monograph of a plant group of Ceylon in which he added a new genus, *Farmeria*, to the long list of Ceylon endemics. The work is an example of a critical monographic study.

The foregoing period of research spanned an endeavour of remarkable achievement. It led to creating the nucleus of a valuable herbarium and had produced two major recognized works — Thwaites' *Enumeratio* and *Trimen's Flora*. These set the sound foundation for further systematic research in the country. Such remarkable achievement was made possible by the pioneer British botanists who well deserve a tribute of praise and gratitude.

Modern attempts

The modern period of Ceylon floristics may be said to have commenced about the first quarter of the twentieth century. Research in the first half of this period was animated largely by the efforts of two British botanists. The first of these was T. Petch, the first to occupy the new post of Systematic Botanist of the Peradeniya Gardens. Petch worked on a few minor taxa of the flowering plants. He did not accomplish much in this line as he turned his attention to the taxonomy of the indigenous fungi.

The more active research of this period, however, was continued by the other Britisher, A. G. H. Alston. He devoted his research to reassessing the status of several genera and species described in Trimen's Flora and worked out improved keys to suit the additional taxa not recorded by Trimen. Alston finally incorporated (1931) his findings in a *Supplement to Trimen's Handbook to the Flora of Ceylon* (*Part 6*). Withs his unrivalled knowledge of typification, Alston introduced 204 nomenclatural changes in his *Supplement*. Through field tours he discovered quite a few new species and recorded a number of naturalized ones previously not known in the flora of Ceylon. The *Supplement*, therefore, made Trimen's Flora a more comprehensive work and marked till recently the last major taxonomic enterprise in the flora of Ceylon.

The lone Ceylonese taxonomist of the period who produced some original research was E. J. Livera. He made notable revisions of a few taxa, though one, (1927) the *Aeginetiaceae* Liv. failed to be recognized by contemporary taxonomy. Livera, however, created a few, valid genera such as *Plaesianthera* (Acanthaceae) and *Petchia* (Apocynaceae), and generally manifested a penchant for original work.

From the 1930s activity in floristic and taxonomic research became a responsibility of the local

botanists; and the only centre where such activity was continued was the National Herbarium of the Department of Agriculture. Unfortunately, priority in agricultural research had already gained ground in this department and interest in the indigenous plants suffered as a result.

The years following the last war saw increasing international recognition of ecology dominating the field of botany. Research in local floristics and taxonomy, therefore, failed to enthuse further interest in the country. This was reflected in the meagre output of investigations into the local plants during this period notwithstanding the firm foundation laid by Trimen's Flora. For years the collections of the National Herbarium, for instance, continued to remain stagnant; and only sporadic work at Peradeniya by J. E. Senaratna produced occasional papers of notes and observations chiefly on naturalized species. Subsequent, however, on an interest in the economic importance of grasses Senaratna produced (1956) a commendable monograph, *The Grasses of Ceylon*, which despite certain shortcomings marked a significant milestone in Ceylonese effort in taxonomy.

What little interest that yet lingered at the Department of Agriculture died down in the sixties. Amidst an atmosphere of taxonomic indifference lone botanists in this field had to carry on as isolated individuals. In spite of this handicap, D. M. A. Jayaweera did some original research (1963) in the genus *Mussaenda* (Rubiaceae). He followed this with a gradual revision of the Orchidaceae of Ceylon as a side interest to his duties as superintendent of the Peradeniya Gardens. He completed the revision in manuscript form for publication in the *Revised Handbook to the Flora of Ceylon* (vol. 2, 1981).

About the same time L. H. Cramer undertook research in the Flora of the Galle District and completed (1968) this taxonomic study as a thesis for the Ph. D. degree.

It is unfortunate that from the time research in plant taxonomy became entirely a national responsibility the then University of Ceylon undertook no major share in this task. This was partly attributable to the rise of interest in ecology and to the lack of employment opportunities to graduates with any specialization in plant taxonomy. However, the sole university botanist who accomplished some research in this field was B. A. Abeywickrama. His main contribution (1959) was *A provisional check list of the flowering plants of Ceylon*. This was a revised nomenclature for his time of the Ceylon plants, based chiefly on Trimen's Flora and Alston's Supplement. It had, besides, the merit of having readjusted the out-dated status of quite a few genera and species held by Trimen or Alston.

Till the late sixties Trimen's Flora continued to be the main source of information on our indigenous plants. Except for the work of the Ceylonese botanists mentioned so far no other research in the indigenous plants, either of a monographic or revisionary nature, was produced. For thirty odd years, Ceylon taxonomy remained in somewhat of a backward state. By the late sixties, therefore, it became apparent that if the allied branches of botany had to progress in the country they needed the enlightening guidance of a revised Flora. But to undertake the needed task the country lacked the resources either of competent personnel or of finance.

It was in this context that in 1968 the University of Peradeniya requested the Smithsonian Institution of Washington to undertake the big task of revising Trimen's much out-dated Flora. The work got under way as the Flora of Ceylon Project and was a joint venture of the Smithsonian Institution, the University of Ceylon and the Department of Agriculture. Except for work of the four Ceylonese collaborators (two from the University of Ceylon) the revisionary research done was largely a combined effort of distinguished botanists from different countries abroad.

The *Revised Handbook to the Flora of Ceylon* represents somewhat of a new departure from Trimen's plan of presentation. According to modern standards, the nomenclature has been based on typification, the synonymy made more complete, while references to literature include citations to monographs when these were available. An improved feature of the revision is the citation of specimens which clarifies the basis of the author's concept of species. Additional information on ecology is also provided. All these improvements give the Revised Handbook the format of a modern, research Flora, a good example, perhaps, of van Steenis' (1957) concept of a "creative" regional Flora.

The general presentation of the Revised Handbook is good, though the standard of each revision varies according to the experience of the author. Variations in the style of writing indicate a certain freedom by the various authors within a set of prescribed guide-lines. There has been, therefore, no rigid editorial control as has been maintained for large Floras such as the *Flora Europea*.

The research accomplished in this work has been considerable, taking count of only the extensive tours and collections made over a period of eleven years (1968—1979). The final production, though still incomplete, has carried the progress of Sri Lanka Botany beyond limits not realized before, and will remain for many years to come the most advanced study of the native flora of the country.

The future prospect

The work of the Flora of Ceylon Project marks one of the glorious chapters in the history of botanical research in the country. The Revised Handbook itself (presently out in 3 volumes) does not seal the end of further research in Sri Lankan floristics and taxonomy. Additional headway remains to be made in this area if botanical science is to continue the search for more information on our plants.

Research on 83 families, for instance, yet remain to be done for the *Revised Handbook* including data, on large families such as the Acanthaceae and some major tribes of a few others such as the Rubiaceae and Leguminosae. And among the family treatments published or yet to be published one still has to clarify some difficult points in concepts in specific delimitation, given the complex range of variation in many of our tropical species. Critical analysis still remains to be done regarding the validity of the separation of such allied species as *Limnophila aquatica* (Roxb.) Alston and *L. indica* (L.) Druce, or of such allied genera as *Coleus* Lour. and *Plectranthus* L' Herit. The mature experience of van Steenis has led him to consider (1957) "specific delimitation as the basis of all taxonomy and the *conditio sine qua non* for the exactness of the status of all higher categories."

District Floras form an additional need in the botany of Ceylon, particularly in the context of new universities in different provinces of the country. Written up in the nature of Concise Floras these could provide much ecological information particularly with regard to the restricted distribution of the local endemics. They serve a useful guide to schools and universities; and their compilation could prove to be a practical means of harnessing undergraduate talent in learning the mechanics of flora writing. The only close approach to such a Flora is Alston's (1938) *The Kandy Flora* which circumscribes, however, only a limited area of Kandy and its environs. District Floras covering such vulnerable eco-systems as the Peak Wilderness, Horton Plains and Sinharaja Forest will broaden the basis for any future revision of the flora of Sri Lanka.

Ceylon floristics will continue to provide yet better opportunities for research if systematic studies are broadened to include serious monographic work. Such attempts should be a follow-up of the general floristic work done so far. The only monographs published so far have been very few — (Willis, 1902; Livera, 1924; Senaratna, 1956; Jayaweera, 1963; Cramer, 1978) If more such monographic work had been done in the past, this would have rendered the revision of the Ceylon Flora a less difficult task. Many genera in our flora, for instance, need to be reassessed through monographic studies. As sampling examples mention may be made of *Hedyotis* and *Oldenlandia* in the Rubiaceae, *Justicia* and *Strobilanthes* in the Acanthaceae, *Glochidion* in the Euphorbiaceae and *Dendrobium* in the Orchidaceae.

Much additional work, therefore, still attends the aftermath of the Flora of Ceylon Project. This could be attained through a new approach to the conduct of systematic botany. The basic climate for this has been well initiated by the recent work in the country of eminent taxonomists such as A. G. H. Kostermans, E. J. H. Corner, T. Koyama and N. Moldenke, collaborators of the recent flora project. Further, there are additional collections of a vast range of well-documented authentic material deposited in the National Herbarium, and, not the least, the volumes of a modern, research flora based on Trimen's Handbook.

Fortunate circumstances of the kind have brought about a cumulative influence on the Sri Lankan scene in floristics and taxonomy. Amidst this climate and the present trends of fundamental research in the country it is up to the universities to explore the yet untried aspects of Sri Lankan systematics. There is, in fact, in certain of the new universities an awareness of this need. The torch of interest has to be set ablaze so that in our future methodology an advance might be made towards the more modern aspects of taxonomy such as numerical taxonomy, biochemical systematics and micromolecular systematics. The universities might even envisage for the distant future the use of the SEM as a routine tool in their taxonomic laboratories.

Priority for more floristic research in the country is all the more imperative given the alarming rate of destruction of both known and unknown plant resources. Before long taxonomy might not have the requisite material for furthering research in the uncommon indigenous species and in those which are of doubtful status. This research should be enlarged to include population studies, reproductive biology and patterns of dispersal and distribution.

The pace of floristic and taxonomic research, therefore, has to be increased before further destruction of the natural environment could take place. The danger of extinction of species before appropriate investigations presents a constant threat to taxonomic research in Sri Lanka: and it is through continued activity in this field that systematic botany could provide both the vital information the country requires on our indigenous plants, and the necessary preconditions for resource and conservation action.

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Research carried out in the Department of Agricultural Chemistry, Peradeniya.

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Soil Science

A study on the effect of sulphur on growth of soyabean, on a cinnamon sand soil of the Western province, indicated that these soils are deficient in this element. The responses were very significant and an application of 135 kg sulphur/ha has produced the maximum dry matter yield.

Preliminary studies on the S mineralization of selected organic residues in soils indicate that mineralization and hence the release of available S, reaches a maximum around the third week of incorporation. Considerably high amounts of S were found to be released by the mineralization of salvinia, indicating the usefulness of salvinia as a possible source of S.

Encouraged by this preliminary study, a complete survey of the S status of all the organic residues was undertaken with a grant from the National Science Council of Sri Lanka. Organic residues commonly used by farmers in different parts of the country, and those that are potentially useful are collected, as far as possible, for each type of organic residue. Samples have been from three different areas of Sri Lanka. A total of 130 samples comprising 48 different organic residues were collected and are being analysed for their S and N contents. A study of S mineralization of the promising organic residues in some selected Great Soil Groups of Sri Lanka is envisaged. Preliminary laboratory studies will be extended to field evaluations.

Zinc deficiency in rice has become a serious problem in most rice producing countries, and the Government Department of Agriculture is intending to carry out a survey of the rice fields of Sri Lanka for their Zn contents. Greenhouse experiments were conducted to evaluate various chemical extractants for available Zn in rice soils. An experiment, with two improved rice varieties (Bg 400-1 and Bg 94-1) and 9 soils from 7 different districts of Sri Lanka, indicated that either 1N NH4OAC at pH 4.6 or 0.05N HCl could be used for Zn extraction from paddy soils.

A similar study for Cu indicated that EDTA was the most suitable extractant followed by NH_4OAC (pH 4.6).

The availability of Zn to plants is affected, among several other factors, by the adsorptive and retention capacity of a soil. No information is available regarding the absorptive capacity of Sri Lanka soils for micronutrients. An experiment was conducted to study the kinetics of Zn adsorption, and adsorption isotherms in four extensively cultivated soils of Sri Lanka, including a high organic matter soil. The effect of other micronutrients on the adsorption of Zn was also investigated. The Reddish Brown Earth (RBE) of dry zone showed very high adsorptive capacity for Zn and it was equivalent to that of the high organic matter 'patana' soils. Furthermore, the adsorption maxima and the bonding energy constants were extremely high for RBE soils and suggest an imminent Zn deficiency problem in these soils. The adsorption of Zn increased with increasing pH in all those soils and decreased with increasing concentrations of the ions such as P, Cu and Mn. An investigation of the adsorptive capacity of REB and some other soils under anaerobic conditions is anticipated as a follow-up work.

The high cost of chemical nitrogenous fertilizers emphasises need to search for alternate sources of nitrogen. A promising outlook is the use of *Azolla* with its *anabena* symbiont, in the rice fields as has been practised in Indochina and Central Asia.

Research is being carried out to study the decay pattern of *Azolla* in lowland rice soils and in upland soils. *Azolla* is used either in its fresh state or as the dried material. Preliminary results indicate that maximum decomposition occurs around the 6th week after incorporation under upland conditions, and fresh *azolla* decomposes more than dried *azolla*. Also it is seen that there is a greater accumulation of available N in low pH soils; than in high pH soils. This needs further clarification. The experiment with flooded soils is yet to be completed.

Food Science & Technology.

The Winged bean (*Psophocarpus tetragonolobus*) has recently been "rediscovered" as a potentially valuable and underutilized source of protein and oil, especially in developing countries. The alarming rate of chronic malnutrition (34.7 percent) among pre-school children, the increased consumption of wheat flour (30,000 metric tons per month) in Sri Lanka, coupled with disappearance of low cost wheat and price increases in the international market justifies the use of composite flour technology in the production of bread and fortification programme for bakery products. This will undoubtedly help to reduce the malnutrition problems and to conserve valuable foreign exchange spent on the importation of wheat.

Investigations are being carried out to find suitable soaking solutions for easy removal of seed hulls of the winged bean (WB) seeds and to establish an economically and technologically feasible method for the large scale preparation of winged bean full fat flour (WBFF). Preliminary studies indicate that soaking in 1 percent sodium bicarbonate or sodium carbonate solution overnight followed by boiling for 45 minutes, is a suitable method for easy removal of seed hulls. Even though certain amounts of nutrients are lost during soaking, anti-nutritional and flatulence factors are leached out. Studies are in progress to determine a suitable wet dehulling method utilizing the existing machinery that are used to make soya, full fat flour.

The feasibility of fortifying wheat flour with winged bean flour in bread making is another line of research that is being carried out. WBFF was substituted at various percent levels into wheat flour and the rhelogical properties studies on the Farinograph, Extensograph and Amylograph.

Incorporation of WBFF decreased dough strength properties, increased water adsorption and decreased dough stretching characteristics. Amylograms show that pasting temperature increased while peak viscosity decreased with increased levels of substitution. Straight dough method with a 2-1/2 hour fermentation period and variation in the recipe were used in baking studies. Quality factors by measurement of specific loaf volume and taste panel evaluation indicates that substitution up to 8 percent WBFF produced acceptable bread. Investigations are continuing along these lines to find the cost of WBFF substituted bread and increased protein availability in terms of amino acids in the substitution. Studies will be done to evaluate the quality of WB protein by animal feeding trials (PER, NPU, etc.)

A further line of investigation is on pshysaccharides of WB. The reported slow water imbibition rate and tenderization of WB seeds during soaking and cooking is closely correlated with the type and amount of pshysaccharides in the seeds. The study of polysaccharides is also important if WB flour of isolates are considered for use in extrusion or spin-processing of fabricated food. Thus characterization of the unique pshysaccharide composition of WB seeds and a study of their properties is being investigated.

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Research on Lightning in the Physics Department of the University of Colombo

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The Physics Department of the University of Colombo is at present engaged in a Research Programme on Lightning in collaboration with the Sri Lanka Meteorological Department and the University of Uppsala, Sweden.

As a start, relatively inexpensive devices called Lightning Flash Counters are being used to investigate the patterns of lightning that occur in the neighbourhood of Colombo. In particular, it is hoped to use these instruments to estimate the annual incidence of Cloud to ground lightning strokes in the Colombo area. This information would be valuable in estimating the risk from lightning strikes to a particular structure like a television antenna for example. It is hoped also to extract an important parameter of lightning through this research, namely the ratio of intra-cloud lightning flashes to cloud to ground flashes.

A lightning flash counter is triggered by the Electric field change that results from a lightning discharge. In the case of an intra-cloud discharge the effect in the tropics is essentially due to the discharge of an electrical dipole with its negative charge at an altitude of about 5km and its positive charge at a higher altitude of about 10km. Experimental evidence gathered over the years by various researchers suggest that in this type of discharge currents of the order of 120 Amperes flow between positive and negative charge concentrations in a cloud for about 250 milliseconds, neutralising about 30 coulomb of charge. There is evidence to show that superposed on this flow of current there are short bursts of current where the current rises to about 1400 Amperes for short periods of about 1 millisecond. If the electric field in the vertically downward direction is regarded as positive, an intra-cloud discharge causes a positive field change at the earth's surface at close distances within about 9km from the discharge measured horizontally, but it causes a negative field change beyond 9km. Also, due to the relatively low level of currents and rate of change of currents involved, the electric field change due to an intracloud discharge is dominantly electrostatic in nature. This is in contrast with a cloud to ground stroke where very much larger currents of a much more impulsive nature are involved which give rise to radiation field changes which are appreciable.

In a cloud to ground flash, at first a narrow column of negative charge lowers towards the ground from the cloud base and when the column comes to within about a 100 metres from the ground, narrow columns of positive charge rise from pointed earthed structures like trees, bushes, blades of grass, man-made structures like telegraph and electric lines, lightning conductors, television antenna, etc. If one of these upward travelling positive columns makes contact with the downcoming negative column from the cloud, the result is spectacular. The negative charge on the downcoming column from the cloud, which amounts to about 5 coulombs is discharged violently to Earth in a few micro-seconds, with the discharge current peaking at values of the order of 20,000 to 100,000 Amperes. The discharge is accompanied by a bright flash of lightning and a loud clap of thunder.

The electric field change caused by this type of discharge is positive at all distances from the discharge. The electrostatic field change is like a step voltage change. The magnitude of the change drops off as the cube of the distance from the discharge. Accompanying the electrostatic field change is a radiation field due to the very large rates of change of current involved. The radiation field drops off only as the first power of the distance. Thus beyond about 20km distance it is the radiation field change that dominates and this field change is appreciable at distances extending to about 60km.

The Lightning Flash Counters being used in the present investigation are two types called the VO3 counter and the VO4 counter designed by the Institute of High Voltage Research, University of Uppsala, Sweden and gifted to us. Both these counters use identical vertical antennae. In both counters, basically a voltage V_o (t) fed to the antenna gives a voltage V_o (t) through a filter circuit to the base of a 2N 914 transistor. If V_o (t) exceeds 0.58 volt at any time there is a count. After a count, there is a dead time of 1 sec before the counter is ready to register again. The antenna filter circuits are so designed that a sinusoidal signal at V_i (t) of fixed amplitude but variable frequency, gives a sinusoidal signal of maximum amplitude, V_o (max) say, at a frequency f_o, with the response dropping off on either side of f_o such that the

mplitude of V_o at a frequency mf_o is the same as the amplitude of V_o at a frequency f_o/m where m is a real positive number. In particular, the response drops to 10/17 of its maximum value when m = 5. For the VO3, f_o = 500Hz and for the VO4, it is 10kHz. The threshold of counting of the VO3 is for a sinusoidal input signal of frequency 500Hz and amplitude 15 Volt to the antenna and the threshold for the VO4 is for an input signal of frequency 10kHz but the same amplitude of 15 Volt.

When a VO3 and VO4 are operated together, a characteristic counting pattern is observed as a thunderstorm approaches from a distance. The VO4 starts counting first. As the storm approaches closer the VO3 begins to register in coincidence with the VO4. When the storm is close enough for thunder to be distinctly heard, that is within about 10km, the VO3 counting rate overtakes the VO4 counting rate rather dramatically. When the storm is within about 5km distance, the VO4 counting rate picks up and catches up with the VO3 rate. The pattern then repeats itself in reverse order as the storm recedes from the counters.

We have interpreted this counting pattern on the basis that the VO4 registers cloud to ground strokes through the radiation field at distances beyond about 20km. Within 20km the VO3 begins to register ground strokes through the electrostatic field change. When the storm approaches within 10km, because of the field reversal of the electrostatic field change caused by inter-cloud flashes, which was explained earlier, the VO3 starts registering intra-cloud flashes as well. When the storm is almost directly overhead the VO4 is also sensitive to the electrostatic field change caused by intracloud flashes and so its counting rate picks up and catches up with the VO3 rate.

Counting data from the two counters have been collected for a continuous period of almost two years. These counts are being correlated with visual and aural reports of thunderstorms sent in on an hourly basis 24 hours a day from meteorological substations and Physics A-level school teachers and students scattered all over the country. From the analysis of this data and on the basis of the interpretation of the counting pattern of the counters given earlier, it is possible to deduce the average number of intra-cloud flashes strong enough to trigger the counters per ground flash and the average number of cloud to ground flashes per year hitting the ground within a distance of roughly 10km from the counters. The analysis done so far indicates that there are at least 10 intracloud flashes per ground flash in the Colombo area and that annually there are about 2000 lightning hits to ground within a radius of about 10km in the Colombo area.

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Current Research in the Faculty of Medicine University of Colombo.

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The research projects being carried out in the different departments of the Colombo Medical Faculty are summarized in this article. A considerable amount of variation exists between the work carried out, although in every case the accent is on topics of local importance.

Several research projects are being carried out in the Department of Biochemistry on the constituents of the coconut, such as the biochemistry of the coconut and the extraction of proteins and enzymes from the coconut. Studies on medicinal plants reputed to be of value in the treatment of diabetic states, the enzymes released from heart muscle and the mode of action of cobra and viper venoms are also being carried out.

In the Department of Physiology studies on physiological functions in human beings and animals are being conducted. Abnormal bladder functions in patients with spinal cord disease, assessment of human nerve function using experimental techniques, the value of growth hormones in the treatment of dwarfism, visual defects in school children and the effect of tetanus toxin and herbal extracts on the transmission of nerve impulses are all research projects which are being carried out. In view of the emphasis laid on family planning methods, the long term effects of vasectomy (male sterilization method) are being studied. In the field of animal physiology, research into the toxic effects of chillies on animals and the spinal reflexes in cats and dogs are current projects. Acupuncture has been advocated for many ailments, and experiments are being conducted to assess the value of acupuncture in the treatment of bronchial asthma. An unusual and rare mental phenomenon in the nature of a human calculating machine is an interesting subject which is also being investigated.

Diseases caused by parasitic and microbial agents are of importance in Sri Lanka and the Parasitology and Microbiology departments are engaged in research on the incidence, mode of spread and control methods in malaria and filariasis. The malaria problem in the Killinochchi area is the special project which is on hand at present. This is linked with attempts to evolve a mode of in vitro culture of of the malarial parasite. The prevalence of eye and genital tract infection caused by micro-organisms, the causative agents in infection of the upper respiratory passages and bowel diseases in children, and the problems associated with German measles form an important part of the programme. Malignant disease of the female genital tract, its probable cause and methods of early detection and diagnostic procedures for viral diseases affecting the genital organs are also being studied.

Research being carried out in the Department of Pathology is centred mainly on malignant disease — the incidence of malignancy in different organs, early diagnosis, correlation of clinical features and laboratory findings — with a view to recognizing the pattern of malignant disease in Sri Lanka and thereby attempt to control it. Another aspect of maligancy that is being studied is the incidence of malignant tumours associated with pregnancy and the factors which predispose to their occurrence. Chronic liver diseases and kidney diseases are also being studied.

The Department of Forensic Medicine is engaged in conducting research into School Health Education in developing countries and Appropriate Technolgoy for Sri Lanka.

In the Department of Pharmacology most of the current research is directed towards the effect of drugs. Clinical trials of combination drug therapy in filariasis, mass treatment of worm infestation with a single dose of a drug followed by a combination of drugs, the effect of polpala on the kidney and its diuretic functions, studies on the concentration of anti-epileptic drugs in the blood of Sri Lankans and the cholesterol content of Sri Lanka fish are the projects receiving attention.

Research in the Department of Community Medicine is related to the health of the community and and occupational health hazards, nutritional problems and mortality rates in the newborn and infants. The projects vary from studies on pesticides and contamination of food with such substances to their effect on workers exposed to them and the incidence of disease among workers in particular occupations.

Nutrition studies on adults and infants in relation to changing socio-economic conditions, the problem of heart disease in the community, mortality rates in newborn children in Sri Lanka and field research in Management Studies are part of the research programme.

In the Department of Medicine, research studies are being conducted into the pattern of asthmatic disease in Sri Lanka, the clinical and pathological features of kidney disease as seen here and the incidence of the Australia antigen in such cases and the interesting "irritable bowel" syndrome. Studies to establish norms for blood protein levels in Sri Lankans is another study being carried out.

The Department of Paediatrics is studying the problems involved in the feeding of young children and perinatal mortality in Sri Lanka.

Psychiatric problems are assuming larger proportions in Sri Lanka and the research work in this field includes studies on the symptoms of depression in Sri Lankans, the incidence and causes related to attempted suicide among patients in the Colombo General Hospital, and behavioural problems in school children.

From the above account it will be evident that the current research in this Faculty is related to problems of topical interest and oriented to suit local needs and conditions in every instance.

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Research in the Department of Biological Sciences

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Research in the Biological Sciences was initiated in the Vidyodaya University of Sri Lanka (now the University of Sri Jayawardenapura) in 1968 when two graduate students were registered for M. Sc. degrees by research in the field of Fisheries; one, to study the Prawn Fishery at Bolgoda Lake, and the other to study the Biology of the Flying Fish off the coast of Trincomalee. Since then, the research activities of the Department have expanded to include, apart from fisheries biology, subject areas such as Genetics (Plant and Animal), Entomology (Insect Pests), Pollution, Soil Biology, Microbiology and Plant Pathology.

Apart from the M.Sc. (and Ph.D) research activities, from 1972, a research component has been added to the undergraduate biology courses as well. For the General Degree Course, the students have to carry out a 2-year unguided ecologically oriented research project, the results of which are presented as a dissertation and tested at the B.Sc. General Degree Examination. The Biology Special Students (one year course after the General Degree Course) have to carry out a 9-month guided laboratory oriented research project the results of which are presented as a dissertation and tested at the B.Sc. (Special) Examination. The B.Sc. (Gen) research projects given at the undergraduate level are many and varied, eg. seasonal variations in populations of insects, fishes, plants (weeds), etc, or migration pattern of butterflies, or fluctuations in the population of seaweeds and many more. The B.Sc. (Special) projects are more precise and have been the study of the uptake of N_2 fertilizer as foliar spray to soya beans, the biology of matapenaeid prawn at Bolgoda, or the study of the biology of anchovy, to name just a few.

At present, the following research projects are going on in the Department.

1. A study of the effect of radiation and chemical drugs on the induction of sterility of the mosquito vector of filariasis (*Culex quinquefasciatus*). This is in order to obtain data about recovery from genetic damage to male germinal cells from the treatment, which information is important if the sterile male technique is to be adopted for the control of the mosquito. These experiments also would enable us to obtain genetic strains which can also be used in control programmes of the mosquito.

2. A study of the biology of an insect parasite of the house cockroach (*Periplaneta americana*) which is found in the ootheca of the cockroach. The name of the oothecal parasite is *Evania appendigester*. Studies were made earlier on another hymenopteran insect pest of *P. americana*, namely, *Tetrastichus hagenowii*. It is possible to use both parasites in the control of the cockroach. Tentative comparison between the two parasites show that *T. hegenowii* is the better parasite for control of the cockroach.

3. A survey is being conducted of the recruitment of prawn fry into the Bolgoda Lake. Earlier studies on the Bolgoda Lake had given information with regard to various hydrochemical factors, now hydrobiological studies are being extended.

4. The biology of an insect pest of brinjals has just been started. The purpose is to study the biology of the pest in order to be better able to control it, either with the use of parasites of the pest or by chemical means.

5. A study is being made of the spontaneously arising mutant load in *Drosophila ananassae*, which is the local species of *Drosophila* found in Sri Lanka. By this means, we built up stocks of *Drosophila* flies for use in our practical classes as well.

6. Various research activities are carried out at the Rubber Research Institute by students registered for M.Sc. degrees in this Department. For instance, some work on tissue culture techniques to evolve easily cultivable rubber clones, as tissue culture clones have been carried out. Not much success has been achieved yet. Other work on the biology of the various fungal pathogens of rubber for which two M.Sc. theses have been presented and accepted have helped considerably to control diseases of rubber plant.

7. A member of the staff is making a survey of plant extracts for pesticidal properties, while at the same time he continues his studies on the foliar application of N_2 - Fertilizers on soya beans. He has to use isotopes as traces for these latter experiments.

8. Another member of the staff is attempting to recruit into artificial ponds, prawn fry at Bolgoda Lake using tidal fluctuations of water level. If this is proved successful then prawn farming can be started by the villagers with greater economy benefits than the present "Ja-kotu" trapping system. The ponds being sited at Bolgoda has led to some extraneous problems about squatters at the moment.

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Research investigations of the Department of Agronomy of Ruhuna University College.

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Studies on nitrogen

(i) **Nitrogen losses** — Nitrogen is extremely essential for plant growth. Deficiency of this element causes a reduction in growth and depresses yield. However, most of our agricultural soils do not contain this nutrient in sufficient amounts. Hence application of nitrogenous fertilizers become important. Large quantities of these materials are used in crop production. In rice alone, nearly 125,000 tons of N containing fertilizers are applied annually. Studies carried out by a number of institutions within and outside the country indicate that as much as 50-60% of N applied to rice soils could get lost.

Studies are being carried out in the Agronomy Department to determine how much N applied to rice soils get lost and also methods of reducing these N losses. In these studies, laboratory investigations, pot and field experiments are carried out.

(ii) **Nitrogen fixation** — Although N is applied as fertilizers or organic manures, a large fraction of the atmosphere (78%) constitutes nitrogen. If this N could be used by all crop plants, the need to apply nitrogenous fertilizers does not arise. However some bacteria and algae have the capacity to make use of atmospheric N. Plants which symbiotically associate with these bacteria and algae are in turn benefited by the N fixed. Studies are also being carried out on various aspects of this N fixation and utilization. Relationship between the nutrient uptake and N fixed by *Azolla*, pattern of nodule formation and types of bacteria that fix N in association with legumes such as ground nut, winged bean, etc., are also under investigation.

Studies on minor export crops

(i) Cinnamon — Minor export crops have become an important foreign exchange earner during the last few years. Cinnamon is one of these crops, cultivated widely in Matara District.

In the Dept. of Agronomy, studies are being carried out on weeds in the cinnamon crop and the best combination of NPK fertilizers for young and mature cinnamon.

(ii) Cardamom — This too is an important minor export crop cultivated in some parts of the district. Investigations on suitable fertilizer mixtures and times of application are carried out in Deniyaya.

Studies on irrigation — Irrigation is an important operation in the cultivation of any crop. While insufficient irrigation could cause crop failures or losses, excess irrigation also brings about a number of undesirable results. Yields may be reduced, soils could get leached.

Studies are being carried out to determine the most suitable methods of irrigation for maize and cotton under the soil and climatic conditions prevailing in Mapalana.

Physical parameters of soils — Properties of soils are important in any agricultural programme. Studies are being conducted on the more important physical properties of soils found in Mapalana. The variation in these properties in a catenary sequence is also under investigations.