UNIVERSITY OF MADRAS

MAHARAJA OF TRAVANCORE CURZON LECTURES ON

AGRICULTURAL ZOOLOGY

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Mr. President, Ladies & Gentlemen,

I feel it my first duty this evening to express my thanks to the Madras University for the honour they have conferred on me by selecting me to deliver this year's lectures on agriculture under the Maharaja of Travancore Curzon foundation.

I certainly consider it a unique honor to be granted the previlege as an old graduate of the University of being associated with its many distinguished *alumni* who have left their mark as University lecturers; nor can I restrain my feelings of pride and pleasure at my being associated with the lectures endowed in memory of the famous viceroy Lord Curzon; for, little did I dream of such an association with this great personality, when in the spring of 1905, as a raw recruit in the newly started Agricultural Research Institute, Pusa, I had the previlege of witnessing Lord Curzon laying the foundation stone of the first Agricultural Research Institute in India.

I am particularly thankful to the University for graciously allowing me to deliver the lectures on the prescribed agricultural subject at this place (Coimbatore) where, in my opinion, subjects on agricultural topics are sure to command perhaps a better or at any rate an audience which can better evaluate the performance of the lecturer for obvious reasons. And this has given me an opportunity of coming into contact and renew acquaintance with the many officers and students of this institution with which I was intimately connected for over 25 years and from which I retired only a couple of years ago. The previlege therefore of allowing me to deliver the Curzon memorial lectures have enabled me to recall the days when I first entered the Agricultural Department and that of being allowed to deliver the same in this institution has helped to remind me of my connection with it until recently. I beg to be excused for this personal note. Coming to the subject prescribed for the lecture viz.: "Agricultural Zoology", I have again to thank the University authorities for giving due importance to a subject which has received scant attention from any of the Indian Universities; until about the middle of the last century biological (Botanical and Zoological) studies were persued more with the idea of discovering and elucidating scientific

phenomena than with the object of utilising the knowledge so gained towards the every day needs and practical affairs of humanity; in other words very little attention was paid to the applied aspects of biology as compared with the purely academic and intellectual sides of it. This has been the case with all the Indian Universities which have biological subjects included in their curricula of studies. To add to this, there have been existing in recent years among many scientists, especially among many men trained in or connected with the famous universities of the west some short-sided and unfortunate ideas regarding the applied aspects of the natural sciences. Many of them have been feeling that pure Botany or pure Zoology is of higher scientific status than applied Biology and that the Economic Zoologist or Botanist occupies a lower caste. At the International Conference of Botanists in London 1930 one of the leaders exclaimed thus. "At this conference let us have pure botany, real botany; we do not want all that applied stuff"; another said that "we discover facts and principles and you merely apply them to particular problems and nothing more". The late Dr. Barber one of our pioneer agricultural officers in Madras, under whom I had to serve for some time, has more than once taunted me with the remark that Economic Entomology is all a bundle of methods. In certain quarters there is often a three cornered fight between the research worker, the university professor and the applied biologist. The research worker is looked upon by some as an inoffensive but curious member of the social order moving in his own rut and knowing hardly anything of the outside world; the teacher is snubbed as an academic automaton whose place can be easily replaced by a gramaphone, and the applied biologist is regarded as a boorish plug of a farmer or mechanic with neither culture nor status. I have worked in all the three capacities and in my opinion all the arguments are but half truths. It is however gratifying to note that all this snobbery and mutual bickerings especially those between the pure scientist and the applied scientist are gradually disappearing and that they are beginning to realise that it is the proper balance between the two aspects that should be maintained. In the words of professor, Coulter "The physical needs of man great as they may be, must never obscure the intellectual needs of man, especially as the trained intellect is the speediest agent in meeting physical needs. On the other hand the intellectual needs of man, noble as they may be must never lose sight of the fact that the speediest results are obtained by the enormous increase of experimental work under the pressure of physical necessity." The rapid strides of civilisation, the general growing rivalry among the more advanced nations in the exploitation of the rich tropical regions, the frequent wars in that connection and the consequent economic needs of human communities all over the world—all these are compelling man to look for the applied aspects of the different sciences for his future needs. Nor has it to be

forgotten that it is on the foundation of agriculture that all human activities and thoughts depend in the last resort and that agriculture is mainly applied biology. Above all the late war and the events that have followed have demonstrated with great force the absolute dependence of all phases of industrial life upon the single industry agriculture, which, with its associated activities forms the one primal all essential requsite in the successful prosecution ofany enterprise, be it war or peace. The realisation of these stern facts has within recent years given a stimulus to the advance of the applied science. Applied chemistry, applied physics, and economic biology have nowadays begun to loom large in scientific circles and experts in responsible quarters have begun to feel that the motto of applied science and pure sciences should be the same viz. " A practice based on the science and a science that illuminates and extends practice ". It may also be concluded generally that all science is practically one though for conveniences it is divided into different aspects that pure science is often immensely practical that applied science is often very pure, and that between the two there is no dividing line, both being essential for the intellectual and material needs of man. My idea in giving experience to the above remarks was just to indicate the past and present status of applied sciences especially, of applied zoology in India and elsewhere.

Let us now pause for a while and see what the terms applied zoology, Agricultural zoology etc.—terms which are of comparitively recent origin—connote, and comprise in their relation to the science of zoology. As we all know, Zoology is the science of animals—the unravelling of the problem of the origin and nature of animal life—a problem whose complete solution will be the crowning achivement of humanity; and this has been attacked in many ways from the days of Aristotle. Until about the middle of last century however zoological studies were mainly devoted to the following lines.

Different aspects of zoological study. 1. *Morphology.* The study of the form and the structure of bodies of animals. This includes Anatomy, Histology, Cytology and Embryology.

2. *Physiology.* The study of the fuctions of the different parts of an animal separately and in relation to the organism as a whole. This deals with the process of feeding, waste repair, etc : studies on the physics and chemistry of protoplasm may also be included here.

3. *Evolution.* Study of the process which has brought about the great variety and wealth of animals and their distribution and space. Includes Zoogeography, Palaetonomy and Genetics.

4. *Taxonomy.* Classification of animals (Systematic Zoology).

5. *Ecology.* Study of the relations of animals to their environments both living and nonliving, and the various adjustments.

Though investigtions on these lines have been fairly comprehensive and exhaustive, have formed the foundations for all aspects of

zoological studies in the future and have produced remarkable results in the past, aspects of zoological studies regarding animals in their relation to man—in other words—the economic or applied aspects of the science began to receive serious attention only within the past two hundred years or so. Of course, from the very early days when half civilised man gave up his hunting and predatory habits for a settled life and began to grow crops and tend cattle, the various forms of life associated with these early activities also became his life long companions for weal or woe; gradually during ages of civilization as man began to clear wild jungle and grow crops in large areas for his food, clothing and other material needs, his relation with different forms of life became more and more pronounced. But excepting perhaps some of the higher animals like cattle and domestic animals the rest of the animal world interfering with man hardly ever received our serious attentions till recently.

What is economic or applied zoology and what is its scope? It is the study of such animals which are, in brief the friends and foes of man; in other words it is the subject of animals' and human welfare. Human welfare may be briefly brought under three main headings—Health, Wealth, Social and intellectual welfare. Applied or economic zoology therefore is the study of the relations of animals to man, and the utilisation of such knowledge in his endeavours to satisfy the above aims.

Table I.

Important Group of animals.

Animal Kingdom divided into Phyla.	Phylum.	*Protozoa.* One celled animals.
	do.	*Porifera.* Sponge.
	do.	*Coelenterata.* Jelly-fish, corals etc.
	do.	*Echinodermata.* Starfish, Sea urchins etc.
	do.	*Plathyhelminthes.* Flukes, tapeworms etc.
	do.	*Nemathelminthes.* Round worms, worms etc.
	do.	*Annulata.* Earthworms, leeches etc.
	do.	*Mollusca.* Snails, oysters, slugs etc.
	do.	*Arthropoda.* Insects, Crustacea, myriapoda, arachnida etc.
	do.	*Chordata.* Higher animals. (Vertebrata). Lower animals. (Invertebrata).

Table II.

Applied or Economic Zoology (groups).	1. Mammalogy. (Higher animals)	Agricultural Zoology.
	2. Orinthology. (Birds)	
	3. Entomology. (Insects)	
	4. Helminthology. (Worms)	
	5. Protozoology. (Protozoa)	
	6. Carcinology. (Crabs prawns etc.)	
	7. Malacology. (Mollusca)	
	8. Ichthyology. (Fishes)	
	9. Herpetology. (Reptiles)	
	10. Hydrozoology. (Corals etc.)	
	11. Poriferology. (Sponges)	

The two tables might give us some idea of (1) the main subdivisions of the Animal Kingdom and (2) of those groups which possess some economic importance. Of the 11 divisions shown, which in my opinion, play a good part in economic zoology, those from 1 to 7 can be conveniently grouped as animal communities which have something to do with agriculture. If however we employ the term farming or farmer in the wider senses that they are at present used, there is hardly any group of animals which cannot be brought under the above category, for, we hear of ostrich farms, snake farms, coral farming etc. Thus practically Agricultural zoology comprises almost the whole of the field of economic zoology.

Economic Zoology in India. Zoological work in India has been persued in different parts of India from very old times and numerous valuble works have been published till now on Indian animals. Most of these latter, though extremely useful to modern workers in numerous ways were generally of a descriptive, systematic or faunistic nature. From about the middle of the 18th century numerous zoological workers came into prominence. Such were Dr. Koenig of the Tranquebar mission—who wrote about white ants—Drs. Kerr and Anderson of the E. I. Co., who wrote on the lac insects and Dr. Buchanan the famous traveller who wrote on the silk worms. By about the second half of the last century considerable facilities and encouragement were afforded for the study of natural history subjects by the starting of institutions like the Asiatic Society of Bengal, The Bombay Natural History Society and the Indian Museum. The publications issued by these bodies ever since their birth, have included numerous valuable papers on the natural history of India. The real incentive however, for intensive investigations on agricultural zoology came from the interest shown by the Government of India in agricultural matters and the creation of the Imperial Department of Agriculture in India in 1901 and the appointment of the Imperial Entomologist to the Government in 1903. The first Imperial Entomologist was the late Professor Maxwell Lefroy who died under tragic circumstances in the cause of science and under whom I had the previlege of getting my ABC in Agricultural zoology. Our previous knowledge of agricultural or economic zoology was very scanty. Chief among those which devoted some attention to animals of economic importance was the periodical known as the "Indian museum notes" from 1890—1902 which confined its activities chiefly to Economic Entomology. "The pests and Blights of Tea" by Watt and Mann was another. The Fauna of British India volumes on various animal groups published by Government during these years have been of very great service to Zoologists, though they were purely systematic and faunistic. The first really important work on Agricultural Zoology in India was issued in 1906 viz. Prof. Lefroy's "Indian Insect pests". Mr. Stebting of the forest

department published his "Manual of Forest Zoology in India" in 1908 and the next important work on applied Zoology was Fletcher's book "Some South Indian Insects" published in 1914. Since that year considerable work has been done on the various aspects of applied Zoology in different parts of India, especially on Agricultural Entomology. A some what detailed account of this history may be found in my paper published in 1926 on the "Rise and Progress of Entomology in India".

I shall now proceed to give you as briefly as possible some account of the different aspects of Agricultural Zoology with special reference to South India with the help of some lantern slides, I had prepared in this connection. The subject can be dealt with in one or more ways; one method is to dwell on the work of the Economic Zoologists on the different animal groups having relations to agriculture, in their natural order, another way is to treat the economic aspects of animals under different categories such as animals concerned with plants, food, clothing, diseases store-products, livestock etc. I am taking up the former method with slight modifications and shall rapidly refer to each of the important economic groups of animals, indicating their relations to human welfare, especially in relation to South Indian Agriculture. Anything like doing full justice to a large and growing subject of this nature is far beyond the possibilities of even half of a dozen lectures; as such, my idea is to place before you in these two lectures a brief and succinct survey of the more important aspects of the subjects which might perhaps create in some of you at least, some interest on an important subject like this which affects human interest to a very great extent. I may tell you at the outset that among animal groups, which I just pointed out to you as economically important, there is one division viz. insects which is far more important from an agricultural point of view than many others and which has received very great attention at the hands of Economic Zoologists. I hope to deal with this subject of Agricultural Entomology which deserves some special attention after I finish with all the other groups. Starting from the lower ranks of the animal kingdom we have the protozoa or unicellular organisms. It will be seen that in no group of animals has work of such remarkable nature and magnitude been done in such a comparatively short period of time as in this group, and the branch of protozoology having advanced by leaps and bounds, has almost outbeaten many other branches of biological study, in its economic importance. The wonderful researches in the ætiology of malaria, yellow fever, and sleeping sickness, the study of their causative organisms and their life histories in different hosts—these alone of the many other discoveries with the protozoa will be sufficient to indicate some of the outstanding triumphs of modern biological investigations.

Pathogenic.

Protozoa (Agricultural).

Malaria	*Plasmodium spp.*	In man and cattle
Pebrine	*Nosema bombycis*	In silk worms
Cattle Disease	*Trypanasoma spp.*	In horses and cattle
Yellow fever	*Leptospira icteroides*	In man.

There is possibly no greater source of loss to the tropical farmer than that occasioned by the inroads of insidious malaria. It has been shown more than once by competent authorities that in many fertile areas of the world, the progress of agriculture has been greatly retarded by this one factor. The actual loss in money, lost time, employers liability and depleted energy due to active and latent malaria are almost beyond powers of computation. Any one knowing of anything of our hill plantations can testify to the troubles and loss caused to coffee and tea planters during certain seasons in the year when whole gangs of coolies are down with malaria, completely upsetting the work in the estate. Other studies worth noting are the researches in connection with the protozoan organisms causing Pebrine in silk-worms, Kala Azaar in man, Surra in horses and Texas fever in cattle. Though most of the investigations are relating to veterinary and medical branches the application of such knowledge in the alleviation of pain and the treatment of some of the deadly diseases to which man and beasts are subject to, has gone a great way in helping agricultural progress. According to Dr. Balfour of the London Tropical School of medicine the deaths due to malaria may be put down roughly at 2 million people every year. Malaria, yellow fever and kala azaar are considered as rural diseases and levy a heavy tax on the human and cattle strength of many countries which depend for their prosperity mainly on agricultural progress. Pebrine affecting silkworms is the earliest known of protozoan maladies, and this disease was on the point of completely ruining the silk industry of France when Louis Pasteur the farmer bacteriologist saved the same by his studies of the pebrine organism (*Nosema bombycis*) and suggested his method of microscopic selection of seeds. Further recent studies on pebrine by Hutchinson in Pusa have considerably helped the silk rearer in India in combating this dire disease of silkworms found in South India Bengal and other provinces. The investigation on the protozoan pathogenic organisms connected with the various protozoan cattle diseases in India are being carried out by experts at the Imperial Veterinary Institute, at Mukteswar.

Before leaving the protozoa it may be interesting to make a passing reference to the recent researches in soil protozoa and their effect on field crops. The biology of the soil fauna and especially, the microbiology—a knowledge of the activities of soil protozoa is a branch of zoology which has not as yet progressed sufficiently in India to enable us to know its economic value. It is believed that some of these

protozoa in combination with bacteria produce certain beneficial and injurious effects on the soils. Russel and Hutchinson have propounded a theory to the effect that many soil protozoa are injurious to the growth of plants and that a partial sterilisation of the soil yeilds better crops; this new theory is likely to lead into interesting avenues of investigations.

Leaving unicellular animals we come to the lowest of multicellular forms, the group porifera including the sponges. It is probably not known to many that sponges are of animal origin and that they have some economic importance. The bath sponge of commerce used for toilet and other purposes is the fibrous skeleton (called spongin) of a colony of minute sponge organisms; this skeleton is rough when dry and smooth when wet. The studies on these creatures have shown that they can be artificially cultivated from cuttings of the live colonies in shallow water and at present sponge farming on a large scale is carried on in parts of the Florida and the Mediterranian Coasts. Of course not having direct agricultural relations we need not dilate on these creatures.

Worms. From sponges we go to the next higher group the Worms, which constitute a very important division of animals both from the purely scientific and the economic points of view. This branch of zoology which is known as Helminthology has received considerable attention from very early times, and latterly the economic importance of these creatures to both higher animals and man has received special attention both from medical men and agriculturalists. From an economic point of view Helminthology can be studied in three important directions viz. in relation to man and livestock in relation to Agriculture and in connection with what is known as Biological control of pests.

The relation of worms to man and livestock consists in many worms living as internal parasites in higher animals and seriously affecting their health. In this respect worms form a very important group to constitute the subject of Animal Parasitology. The most important of these parasitic worms are what are known as tape worms, flat worms and round worms, and the well known representatives are the liver fluke (*Fasciola spp*), the tape worms of sheep, ox, pig and man (*Taenia spp*), the human pin worm (*Enterobius*) the filariasis worm (*Filaria*), the guinea worm (*Dracunculus*) and the notorious hook worm (*Ancylostoma*). According to Cameron "the liver fluke costs Great Britain at least a million pounds yearly and about 10 % of all sheep die yearly from worms. It is well known that numerous diseases and bodily troubles are caused by many of these helminth parasites to cattle and farmers and great loss is caused by their passing their lives in two or more hosts. It may be emphasised that as in the case of malaria, the trouble caused by the hook worm parasite in the different areas of the world is something very serious and noteworthy causing

considerable reduction in industrial efficiency in tropical farms, plantations and factories. The humanitarian work that the health board of the Rockfeller foundation is doing in the direction of alleviation of diseases, especially in relation to malaria and hook worm trouble in various parts of the world is one which cannot be sufficiently admired and appreciated by the world at large. The representatives of the foundation have been and are still doing work on malaria and hookworm in Ceylon and South India. To quote from their report for 1925 "An intensive study of the results of hookworm, treatment of coolies on a tea estate in Ceylon showed that treatment was followed by a rise in the number of red corpuscles in the blood and of the haemoglobin index and by a reduction in the number of coolies at the dispensary and in the hospital and also in the number of working days lost." Speaking of helminths affecting livestock many are the ailments caused to milch and work cattle, horses, sheep and other farm animals, the common ones being liver rot, gastritis, intestinal troubles, lung troubles etc. The Imperial Bureau of Agricultural Parasitology in England and the Animal husbandry wing of the Imperial Council of Agricultural Research in India are now dealing with this aspect of Helminthology seriously affecting livestock which forms the back bone of agriculture and it is hoped very substantial results will follow.

As regards the direct relation of Helminths to agriculture we have the Eel worms which play a very important part. These are minute round worms living as plant parasites and occuring in thousands in the soil with great diversity in form and habits. Though many of these soil forms are harmless some of them cause very serious disease on plants. It may be surprising that the larvae of some of them (*Angiullulina sp.*) revive when moistened after remaining in a dessicated state for seven years, and that some (*Hoterodera sp*) can lie dormant in the soil for a period of ten years or more. Three genera of this group form the most important of these plant pests (*Aplenchoides spp.*) attacking chrysanthemums, strawberries, currants. etc. and causing leaf blotches, galls, bud rot etc. This is not recorded in India as far as I know.

Anguillulina (Tylenchus) a species of this genus—*A. angusta* is known to cause the Ufra disease of paddy in Bengal; other species are known to cause cockle in wheat and galls in rye and grasses and diseases in potato, clover etc.

The third genus is Heterodera including the most notorious of these plant eel worms. The root knot eel worm (*H. marioni C.*) is the best known of these, causing galls in root and stems, of many plants. According to Goodey more than 850 plants as hosts of this creature have been recorded and numerous workers have carried out substantial investigations on this group all over the world. In South India many of our common garden plants, vegetables and crops like

pepper, betelvine, tea, pulses, etc. have been found subject to the attacks of this eel worm. Mr. P. N. Krishna Iyer of this Institute has recently studied the subject and has published some very good papers on this eel worm. The Imperial Bureau of Agricultural Parasitology, London, is also engaged on intensive studies in this direction. One other aspect of nematode activities in connection with agriculture is the discovery that some genera of these parasites are acting as natural agents in pest control; some of these nematodes have been found infesting pests like locusts, leaf and bark beetles, leaf hoppers etc. Well known genera of worms in this direction are Mermis, Gordins and Monnonchus. Though sufficient work has not been done in this direction, the subject offers a new and excellent line of pest control with the help of worm parasites as natural enemies, especially in the control of insect pests of crops. Before we leave the group of worms reference may be made to two other subdivisions belonging to this great group viz., the *Earthworms* and the *Leeches*. It is common knowledge that earthworms and their earthern casts are very familiar objects in our garden and fields and that they are useful to the soil in various ways though unfortunately they sometimes get mixed up as doubtful agents of mechanical mischief in company with eel worms as in the case of the trouble in the betel-vine gardens near Coimbatore. It is found that earthworms make some of the manures more assimilable by the soil, ventilate the latter and bring up large quantities of earth which has passed through their gut. Darwin's studies on earthworms is perhaps well known to most of you and according to him "the level of an acre of soil in England is raised by earthworm casts by one tenth of an inch each year." In some of our ever green and moist forest areas and foot hills, very long earthworms are found measuring upto a foot and a half or more in length. Our commonest genus in South India is *pheretima*. Flat worms (Turbellaria) like *Bipalium* and centepedes (Lithofires etc.) are found to be the special enemies of these earthworms. Leeches, which are well known from very ancient times as having medicinal properties, also play their part in relation to agriculture. Those who have visited any of the hill estates, in the Nilgiris, Anamalais, Coorg or Travancore might have experienced the trouble caused to men by leeches in the coffee, rubber and cardamom plantations. Hardly anyone entering any of these moist plantations in the forest valley escapes from the attentions of those blood suckers. Their work is so cleverly done that their attack is hardly ever felt or noted until long after the creatures have sucked sufficient blood from the host. Coolies working in such plantations suffer a good deal though they occasionally resort to various devices and local drugs to check the trouble. The common hill leeches in S. India belong to the genus *Haemadispa*.

I may also just touch one other fact in connection with the economic aspect of worms, though it is not of any direct agricultural

importance viz. the relation of some larvae of marine worms in pearl formation. Pearls inside oysters are now believed to be caused among other ways by the deposition of nacreous matter around the larvae of parasitic worms attacking oysters; and in Japan after Prof. Mitsukuru's studies they have started production of pearl by artificial introduction of foreign particles inside the bodies of oysters.

Mollusca. Regarding the group of mollusca or (shelled animals) the study of which forms the science of *Malacology* we have not much to note from a purely agricultural point of view. Most of these are aquatic animals and include the oysters, the proverbial slow moving snails and slugs, cuttle fish etc. Many of these are used for food but some of them are occasionally noted as pests of crops. These latter include land snails or breathing forms (*pulmonata*) which are occasionally found attacking aloes, hedge plants and even some cultivated crops like vegetables and flowering plants. The common ones I have found in S. India belong to the genera *Xesta*, *Rhacis* and *Ariophanta*. During the summer months hundreds of these are found attached to hedge plants apparently hibernating. In parts of the Tanjore and Godavari Deltas occasional trouble is also caused by some molluscar forms, to growing paddy. These have to be further investigated for correct information as to the real damage done if any. Snails are a delicacy in France—in restaurants snail dish " Escargot " is sold. Snaileries (farms) also exist around Paris. Slugs are, as you all know fleshy, slow moving creatures, which leave a trail of shining slime behind, often met with in our gardens. Though in some other countries they are noted to cause damage to plants such as rubber, tobacco, sweet potato etc. we have not yet noted any slugs with real pest propensities. *Limax* and *Parmarion* are the well known genera of these slugs. It will be interesting to note that the larvae of glow worms (*Lampyrids*) are very effective enemies of these land mollusca. Before leaving this group, I might invite your attention to the close relations existing between the liver fluke (*Fasiola*) mentioned under worms and snails (*Limnoea spp*) and to the fact that the former passes part of its early life in the body of the latter as an intermediate host.

We will now come to the consideration of the economics of the higher or vertebrate groups of animals, especially in their relations to agriculture. There is hardly any necessity here to dwell on the well known mutual relations of man and many higher animals like cattle, horses, sheep, dogs, poultry etc. which have become his life long companions from very ancient days—such subjects are generally treated under separate branches like Animal husbandry, Stock raising, Sheep breeding, Poultry farming, Pig rearing etc. etc. I shall therefore refer only to those higher animals which are known to be harmful or beneficial to agricultural interests in different ways, about the economics of which our knowledge has been very scanty till lately.

The studies on fishes (Ichthyology) especially those relating to the recognition of edible and poisonous forms, their breeding, spawning and migrating habits and the methods of artificial propagation (Pisciculture) preservation and canning—have all within the last few decades progressed so much as to create various famous and flourishing fisheries all over the world. In India we have fisheries departments under most provincial governments to attend to this important aspect of applied zoology. From the farmers' point of view the discoveries of fish, feeding on malarial mosquito larvae are of great importance. In South India species of *Heplochilus*, *Marcrones* and *Barbus* have been noted as such and trials are being made in different places to introduce such useful forms in malaria ridden areas. It may be interesting to note that among fishes one creature, an eel, a snake like fish (*Opichthys boro*) known in tamil as the "Anaikuthu pampu" is now and then found doing some appreciable harm to paddy fields and salt pans along the coastal areas of the Bay of Bengal from Ganjam down to Negapatam. The damage it really causes (known in telugu as 'Ramasuli') is not like that caused by other animals any direct harm to the growing plants; the injury done is indirect caused by numbers of this eel burrowing into and making wide passage across field and irrigation bunds and connecting the paddy fields containing fresh water on one side and the salt water channels or coastal tidal streams near the sea on the other. This causes the salt water of the estuaries to enter the paddy fields and affect the growth of the plant which, due to the ill effects of the salt water, wither and often die. The damage done to salt pans by this same creature, often in company with crabs, consists in causing the brine collected in the pans for salt to pass away through the openings made and thus leaving the pans empty before the salt has crystallised out. A short account of the creature will be found in a paper of mine published in the Bombay Natural History Society Journal in 1932.

Another point in connection with the economics of fish is the manufacture of fish oil soap from sardines for insecticidal purposes. It is perhaps not well known that while shoals of sardine are caught during certain years these disappear for a long time like locust plagues. This is an important industry along the Malabar Coast and our cheap contact insecticide for crop pests of different kinds is got from the factories in that tract.

Some of us would naturally doubt as to whether such creatures as frogs and toads have any mission or economic importance in this world. As a typical animal for experimental purposes and dissection in science institutions the frog has been found very handy and it is practically the 'martyr' for zoological studies. It is perhaps not widely known among us that the frog is used as an article of food in many western countries, and I had occasions to find them being sold alive for food purposes in the markets of California. Regular frog

farming is carried on in different places and there is said to exist in Ontario a farm in operation for the past 30 years, producing every year 7000 living frogs, in addition to 500 lbs. of dressed frogs' legs which is regarded as a special delicacy; zoologists are employed by these farms to investigate into the life history, breeding season and habits of different frogs so as to keep the industry flourishing. All of us are familiar with the tadpole stage of the frog and it has been found by frog farmers that the tadpole does not change into the tailless frog unless the edge of the natural or artificial pond has a sloping side, and in its absence remains as a tadpole for months together! Another interesting and important problem, with which these frog farmers who have to keep thousands of frogs alive all through the year, is said to be that of feeding them; for, the frog does not eat anything that is not moving though the tadpole in the water eats anything. I have referred to these apparently unimportant facts just to give examples of how small points in zoological studies often become important economic problems. Toads and frogs are very useful as insect destroyers as is found by their presence in numbers near lights especially around electric lights in the streets which attract numerous small insects. Kirkland in his account of his observations on the American toad says that the toad's food is made of about 88% insects and 16% of these are cut worms, and counting these cut worms alone he has estimated the annual saving to the farmer by each toad as 20 dollars or nearly Rs 60. During a pest of army worms he found in toad's stomach 55 worms; so that, as an insect destroyer the toad has few superiors. The common toad of our plains is a Bufo and of our frogs *Rana*. It will be interesting as has been done to some extent in the case of insectivorus birds, to study the nature of the insect food of frogs and toads so as to properly appraise the help they render in checking insect pests.

Coming to the higher group Reptiles, the study of which is known as Herpetology it is found that many of them such as lizards, blood suckers, chameleons etc. are decidedly beneficial in that they are all mostly insectivorus. The amusing and clever work of the wall lizards (*Geckos*) around our lights during nights shows their insectivorus habits. The clever manner in which the green chameleon catches its animal prey is also pretty well known, how it suddenly throws out its long tongue and gulps the prey with the help of its secretion. Though snakes and crocodiles are known to us as dangerous forms to be taken care of in the fields and lakes, some of them are responsible for doing some indirect good, since some of them feed on rats and mice. It will be a very useful thing if the cultivator especially in snake ridden areas near the hills and forests gets some ideas as to the features of harmless and poisonous snakes so as to avoid risks and danger from these creatures. The cobra, the viper, the krait and the ecis are the really dangerous forms, one is likely to meet with in different parts of

South India. The Russel's viper is a common form found in Coimbatore and during the early days of this college, hundreds of these have been killed from prickly pear bushes and field bunds. It will also be helpful if the cultivator knows something about the habits of crocodiles, since in some parts of Malabar and Travancore domestic animals cattle etc. and even he himself often run the risk of being attacked by these in the rivers and tanks. The turtles and tortoises belong to this same group but are not known to play any important part in relation to agriculture, though some of them are edible creatures.

The study of the next higher group of birds (Orinthology) offers us a very wide field of economic possibilities. It is one of the most important of animal groups which affect the farmer and the layman in various ways. Many birds are used as food as we all know such as fowls, duck turkeys, snipe etc. From the layman and farmers' point of view birds are generally classified into useful and injurious forms. Among the latter well known forms are the two species of crow, the Indian house crow and the jungle crow, *Corvus splendens* and *Corvus macrorhynchus*; these two are very troublesome and annoying near houses and on ripe cholam and other cereal crops, they are also insectivorus and do some good when they occasionally feed on crop pests like catterpillars, white grubs etc. It is a common sight to find the crow following the harrow in fields devouring soil insects such as white grubs, cut worm, etc. Of the other birds which may be classed as pests in South India we may note among the well known ones the house sparrow, (*Passer*) Bee eaters, (*Merops*), the green barbet (*Thereicery*), the parrots (*Palaeornis*) the weaver birds (*Ploceus*) the pigeon (*Columba*) the dove (*Turtur*) and the munias (*Munia*). There are also number of extremely useful and beneficial birds which help the farmer in not only destroying insect pests but also acting as flower pollinators in many cases. Among these the well known ones are the larks (*Alanda*) the drong (*Dicrurus*) the mynah (*Acridotheres*) sunbird (*Arachnechthra*) wood peckers (*Brachypternus*) the roller (*Coracias*) the shirks (*Lanius*) the tailor bird (*Orthotomus*) the paradise fly catcher (*Terpasiphone*), the night jar (*Caprimulgus*) the cattle egret (*Bubulcus*) the spotted owlet (*Athene*) the bulbul (*Malpastes*) the seven sisters (*Crateropus*) the tree pie (*Dendrocitta*) the common heron (*Ardea*) etc.

There are again some birds which are of doubtful value as they do not stick to one particular kind of diet; such are the oriole (*Oriolus*) the crow pheasant (*Centropus*) the partridge (*Francolinus*) etc. The birds of prey including the kites, falcons and vultures are also beneficial to a certain extent in that they are sometimes scavengers and offal feeders; but often some of them are dangerous to poultry and small domestic animals. The brahmini kite (*Haliastur*) is a highly insectivorus bird and feeds on also crabs in paddy areas. On the whole birds do a considerable amount of good work in helping the

farmer to get rid of insect and other vermin affecting his crops. A good deal of work has yet to be done however in verifying correctly the food habits of Indian birds, classifying them correctly as friends or foes of the farmer, and then utilising to the best of our ability the good work done by the former and devising ways and means to control the latter.

Though not directly connected with agriculture, a passing note may be made of birds like the egret and the ostrich which are reared for their feathers and plumes which often fetch fabulous prices. The African ostrich, the largest of living birds (*Struthio*) sometimes reaching 8′ in length is reared in ostrich farms in South Africa chiefly for its plumage. Its flesh is not eaten but the egg is relished and is said to contain as much food as two dozen hen's eggs. In North India similarly there are farms for rearing the Egret (the cream white wading bird,) for similar purpose. In India we have also the peacock (*Pavocristalus*) which is not only noted for its valuable feathers, but is regarded as a sacred bird as well.

We now come to the consideration of the higher group of animals the Mammals including man himself and some of his oldest companions the cow, the sheep, horse, cat, dog etc. As I have already told you the economic importance of these higher animals is studied under special branches called Animal Husbandry, Stock rearing etc. Let us see which of the other mammals have become friends or foes of the farmer. Unlike the lower animals the higher animals generally frequent only jungle and grassy areas and enter cultivated fields only occasionally but the harm they sometimes cause is very serious. Some of the commonest of these higher animals which often give a good deal of trouble to the farmer and fruit grower in South India are the jackals, wild pigs, the monkeys, squirrels, and rats. The jackal (*Canis aureus*) causes appreciable damage to coffee berries and sugarcane and frequents hills and plains, forests and open country. It is probably known to some of you that coffee seeds collected from the excreta of jackals in the coffee estates is said to be of the best quality, since the animals eat only the well ripened berries. Nor is the nocturnal howl of the jackals during certain seasons unfamiliar to most of us, even in this college. Sugarcane and root crops also suffer from jackal attack. The depredations caused by monkeys in certain districts is well known and often found very serious. The commonest and the cleverest of the monkey pests we have in South India is the macaque (*Maccacus silenus*). It is found in the plains and the lower hills and is the one led by showmen and street beggars and the one infesting sacred shrines like Tirupathi, Palni etc. According to Jerdon "this is the most inquisitive and mischievous of its tribe and its powers of mimicry unsurpassed". It is easily bred in confinement and docile when young. It has capacious cheek pouches and feeds on insects, roots, nuts, fruits,

cereals, and sometimes even crabs. I am experiencing great trouble from this creature in my small farm in South Malabar. These monkeys generally appear in gangs of 10 to 15 of all ages led by one or two hefty males which previously reconnoitre the area and lead the gang. The creatures destroy much more of the crop than actually use as food. The halo of sacredness attached to this creature as the 'Hanuman' or his kinsman and the consequent fear of becoming a sinner by killing him has helped it a good deal to multiply and carry on its injurious work in fields and gardens with impunity. Occasional shooting of one or two of them or trapping them in cages and transporting them far away beyond rivers or hill ranges will be found to give some relief. It may be added that in some countries monkeys are trained to gather fruits and nuts and help man. The langurs (*Semnopithecus*) or the bigger monkeys which have no cheek pouches and which make a loud howling noise generally infest only thickly wooded hill country and only confine their attacks to hill estates. The squirrels and rats are the chief representatives of the rodent mammals causing wide spread damage in various ways. The striped squirrel (*Sciurus palmarum*) is often found on all fruit trees and even steals grams and other food stuffs exposed for drying in the open. The damage done by rats, one of the most notorious and terrible pests among animals is too well known to receive any detailed record here. The commonest and most destructive of field rats is the southern mole rat (*Gunomys Kok* Gr). It attacks paddy, ragi, tapioca, lucerne, vegetables, and a variety of other cultivated plants. The domestic rat which belongs to one or two varieties of the (*Rattus* H), is a domestic pest all over S. India. The recent further notriety the rat has gained as the medium carrying the plague bacillus (*Bacillus pestis*) has added to our dread of this rodent pest not only as a field and domestic pest but as a disease carrier as well.

The injury caused to man and his belongings like crops, cattle etc. by such wild animals as the tiger, the leopard, the bear, the elephant, the wild pig, the porcupine are well known especially in areas adjacent to hills, and forests. In some parts of South Canara and Malabar elephants cause very serious damage to growing crops during certain seasons; one can easily imagine the nature of the damage caused when even one or two elephants spend a half hour or so in a banana, sugarcane, cardomamom, tea or coconut garden—The bear (*Melursus*) and the Porcupine (*Hystri*) are fond of roots and tubers; in addition the former is destructive to bee hives on trees and even to toddy pots in palms. The tiger, leopard and the cheetah are to be considered only as dangerous to the safety of man, cattle and poultry and not as crop pests. The toddy cat (*Paradoxurus*) is well known in South India as causing damage to palm trees and sometimes even to household things in dwellings near palm groves. The civet cat (*Viviera*) is a common creature found along the Malabar coast; it is however a beneficial

animal not only as an enemy of snakes and insects of sorts but also gives the civet, a secretion which has some commercial value. The Indian mungoose (*Herpests*) is also a beneficial creature having carnivorous and insectivorous habits; but it often attacks poultry. That bats are mammals, I am sure most of you are aware of; some of them are of economic importance both agriculturally and otherwise. Many of us are I believe familiar with the flying fox (*Pteropus*) which is sometimes found in thousands hanging from some big trees. The trees in which these roost are heavily loaded and completely hidden by hundreds hanging on to every branch. Very serious damage is caused by these creatures to all sorts of fruit trees for miles around their roosting tree. These are the biggest of bats and have faces like the fox, hence the name. There are species of smaller bats also some of which often fly about our houses feeding on mosquitoes and moths and doing some good work. Artificial enclosures known as "*Bat towers*" are made in some countries to give convenient homes to some of these bats and help their insectivorous activities especially mosquitoe feeding. Bat's dung or guano is also a very valuable manure used by fruit royetalle growers; I know that the melon growers of parts of Cuddappah use this stuff.

One member of the mammalian group the Pangolin or scaly ant eater (*Manis*) with a curiously plated body, a long prehensile tail and pointed snout is a very beneficial creature. It is nocturnal in habits and feeds on insects especially white ants the nests of which it tears open with its powerful claws. The economic zoology of the mammals includes besides the above groups which are of agricultural imporatance some others which have also begun to show great economic value; more important of these are the whales which give valuable substances like whale oil, whale bone, spermaceti, ambergris and guano; the seals which are hunted for their seal skin (Pelt) and oil and the fur bearing animals especially of the polar regions such as Weasels, artic fox, otter skun (Beaver etc.)

This concludes my necessarily brief survey of the various groups having relations to agriculture excepting the Arthropoda which I shall deal with next. Compared with the work done on the arthropoda, especially on the insects the agricultural zoology of other animal groups in India has received practically very little attention. I need hardly tell you that I have only touched the fringe of the subject. A good deal of further work awaits us in many branches especially in Helminthology, ornithology and mammalogy. I can only conclude this lecture by adding that intensive investigations on the food and breeding habits of many of these higher animals, their interrelations and their relations with members of the other groups of animals will add to our knowledge considerably and will help us to utilise to the best advantage the knowledge so gained, not only for agricultural purposes but also for several other needs of humanity.