

## INTRODUCTION TO PARASITOLOGY

Parasitology is the Science which deals with organisms that take up their abode, temporarily or permanently, on or within other living organisms for the purpose of procuring food. In a broad sense Parasitology includes Plants such as Bacteria and Fungi; Animals such as Protozoa, Helminths, and Arthropods; and boarderline forms such as Spirochetes and Viruses. In the more restricted sense employed here the term applies only to animal parasites.

The science of Parasitology in relation to disease has been developed by Zoologists and Medical men. While Zoologists have studies the Morphology, Physiology, and Life History of the parasites, Physicians have concerned themselves with the reaction of the host to the parasite (Symptomatology, Pathology and Immunity) and with the treatment of the infected host. The combined efforts of medicine and zoology are continually intensifying the importance of Parasitology, particularly in the broad field of disease prevention. The medical aspect is concerned primarily with the parasites of man, but a knowledge of the parasites of other animals sheds light upon human Parasitology. When information concerning the human forms is incomplete, studies of closely related species in animals foretell with considerable accuracy the probable development of similar species in man. Likewise, the knowledge derived from the study of the structure, life cycle and activities of similar free-living forms may provide valuable information concerning the less known parasite species.

### THE PARASITE AND ITS ENVIRONMENT

All animals and plant forms originated and developed as free-living organisms which were obliged to compete with others for their existence. Only those which developed satisfactory adjustments and adaptations were able to survive. Among this group were many species in different phyla of the animal and plant kingdoms which came to depend on their associates for shelter and food. In some instances the remarkable adaptations to a parasitic life suggest that this interrelationship has existed for a long time, probably measured in tens of thousands of years. Other groups of parasites appear to have more recently acquired a parasitic mode of life, and a few of these have not yet become irreversibly committed to parasitism.

### ANIMAL ASSOCIATIONS

The majority of animals live independently in their natural habitats, seeking their own food materials and utilizing free water and oxygen for their metabolic processes. Between some animals, however, a variety of patterns of association has developed, and these may be broadly divided into two groups: Homogenetic associations – those between individuals of the same genotype; and eterogenetic associations – those between individuals of different genotype.

Individuals of the same species may form loosely united communities, such as herds of cattle or flocks of sheep, while others, such as some species of ants or bees, may form elaborately organized communities in which individual members often exhibit considerable division of labour or specialization.

Heterogenetic associations are in general much more complex and a number of terms have been developed to describe them. Like many terms used in biology, these are essentially operationsl words which are definable only within broad limits and not in absolute terms. They do, nevertheless, serve a useful role in enabling us to file data into convenient, though not water-tight, compartments. Terms such as **Commensalism**, **Phoresis**, **Symbiosis**, **Mutualism** and **Parasitism** have been widely used in the biological literature for various types of heterogenetic association, and their definition has been discussed by a number of workers. These terms were developed in a period when little data on the possible physiological and/or mathematical basis of such an association were available. Within recent years, the situation has changed somewhat, and although information is still meager, the general increase in knowledge of animal physiology, biochemistry and population dynamics enables these associations to be considered on a broader basis than was hitherto possible. Crofton (1971), in

particular, has attempted to define parasitism in quantitative terms and stresses the importance of considering the phenomenon as an ecological relationship between two populations of two different species. He shows that the infection process produces or tends to produce an overdispersed distribution of parasites within the host population.

Nevertheless, the relativity on any definition must be emphasized, for this will depend on the relative weight placed on certain aspects by a particular observer. Thus different workers have emphasized factors such as:

- (a) the intimacy of the association;
- (b) its pathogenetic effect;
- (c) Its metabolic or physiological dependence;
- (d) Whether or not the host 'recognizes' the parasite as 'foreign';
- (e) the ability of the parasite to 'recognize' the host site as being a suitable ecological niche.

These factors are not, of course, independent, and complex interactions between them may occur in any particular host-parasite situation.

If the degree of association is considered first, most workers would agree that the terms **Commensalism** and **Phoresis** represent only loose associations whereas the terms **Symbiosis**, **Mutualism** and **Parasitism** represent intimate associations in which the metabolism of one species is dependent to some degree on permanent association with an individual of another species. The concept developed here is that it is the metabolic dependence of one species on another which separates these intimate kinds of association very markedly from those of the looser kind. Mutualism and symbiosis are here considered as special cases of parasitism in which mutual metabolic dependence occurs.

Although we are concerned with the phenomenon of parasitism in particular, it is worth while to consider briefly the other types of heterogenetic associations in order to place parasitism in its true perspective.

## COMMENSALISM

The term literally means 'eating at the same table' and there are a number of often quoted classical examples of this type of loose association between animals of different species. One of the best known is that between certain species of hermit crabs and sea-anemones, in which the anemone lives on the shell sheltering a hermit crab. The sea anemone benefits directly, having access to the remains of food caught and scattered by the crab, whereas the crab benefits by the presence of the sea-anemone which assists in warding off undesirable predators. In many cases, although this type of association is beneficial to one or both organisms, it is not usually obligatory for their existence. An exception is the association between the hermit crab, *Eupagurus prideauxi*, and the anemone, *Adamsia palliate*, in which neither of the partners is able to survive alone. The crab crawls into a shell which is too small for itself and uses the pedal disc of the anemone as cover for the unprotected portion of its body.

Other examples of commensalism are of an even less intimate nature. For example, the association between the oxpicker bird and various African mammals. The birds feed on the lice and ticks of mammals such as rhinoceros and serve to warn them of approaching enemies by displaying their own independent reactions.

Commensalism may thus be considered a type of loose association in which two animals of different species live together **without either being metabolically dependent on the other**, although one or both organisms may receive some benefit from the association. It is important to stress the absence of **metabolic** dependence in this type of association, for it is the absence of this feature which separates a commensal sharply from a parasite. The association is not intimate – since the tissues of the commensals are not in organic contact – nor need it be permanent.

## PHORESIS

There appears to be no difference of opinion on this term, which is used for a particular type of association in which one organism merely provides shelter, support or transport for another organism of a different species. The term **phoresis** however, is not widely used in Biological terminology and will be only briefly mentioned here.

The classical example is that of fishes belonging to the genus *Fierasfier* which lives within the respiratory trees of holothurians or occasionally in starfish. These fish are relatively helpless and are readily attached and devoured by other species. The holothurians appear to be undisturbed by the presence of the fish.

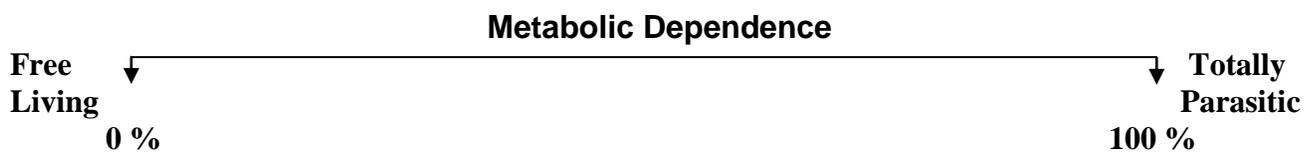
In phoresis, as in **commensalism** then, there is no metabolic dependence of either of the associates on the other. This type of phenomenon could clearly represent a stage similar to that in the early evolution of parasitism, since chance contact followed by the use of one species as shelter by the other is likely to have been the first step in an association leading to the parasitic way of life.

## PARASITISM, MUTUALISM AND SYMBIOSIS

In this type of association which forms the subject matter of our study, contact between the individuals of two different species differs markedly from that already described in that it is intimate and continuous. Many parasites have free-living stages in their life cycles and only during the periods when they make contact with their hosts can they actually be considered to lead a parasitic existence.

## PARASITISM

Of all the types of animal associations, perhaps the term parasitism has been the most difficult to describe. This appears to be largely due to the failure to recognize that the term has only a relative meaning. It has also been complicated by the insistence of many authors that a parasite must necessarily be harmful to its host: Crofton (1971) proposes further that the term parasite should be restricted to organisms which are potentially capable of killing their host. In the writer's opinion, emphasis on the harmful effects of a parasitic association more than any other single factor, has somewhat bedeviled a broad, biological approach to considerations of the phenomenon. It must be recognised, however, that any worker is entitled to restrict his usage of any term in any way, provided that he clearly defines his understanding of the term.



**Fig.: Diagram showing the relative concept of parasitism based on the degree of metabolic dependence. A free-living organism shows zero dependence; a cestode shows virtually 100% dependence. All degrees between these two extremes are encountered**

A parasite is thus considered here to be an organism which is not only in continuous, intimate association with another organism – the host, but also metabolically dependent, directly or indirectly, on it to some degree. The relative nature of this association is stressed and it is possible to draw up a list of parasite species which show an increasing degree of metabolic dependence on their hosts. At one end of this hypothetical scale (Fig. above) is zero dependence, i.e., a free-living organism; at the other end is 100% dependence or total parasitism. In between these two extremes lies a range of organisms which satisfy their metabolic requirements to a varying extent at the expense of the host.

We must make clear here what we mean by 'metabolic dependence'. Although at first sight it would appear that most parasites are only dependent on their hosts for food materials, a closer examination shows that the situation is more complex than this. Examples can be given of parasites which are dependent on their hosts for one or more of the following:

- (a) developmental stimuli;
- (b) nutritional materials;
- (c) digestive enzymes
- (d) control of maturation and (more rarely) mitosis.

## MUTUALISM AND SYMBIOSIS

An association in which both associates benefit has long been referred to as **mutualism** by some authors and **symbiosis** by others. The literature on the definition of these words is confused. Mutualism is derived from the Latin **mutuus** (= **exchanged**), whereas symbiosis comes from the Greek **sympion** (= **to live together**). The term **symbiosis** could thus broadly be used to include all the different kinds of relationship that exist in nature. By usage, however, it has come to be restricted to associations of a special kind in which the participating species are dependent on each other for existence. This is clearly only a convention, but general agreement to restrict the use of the word in this way would do much to clarify the terminology. In cases of mutualism, on the other hand, the association is not obligatory to existence. On the metabolic view put forward above, both mutualism and symbiosis are merely recognised as special cases of parasitism in which some metabolic byproducts of the parasite are of value to the host. There are several well-known examples of the phenomenon. The association between wood-eating termites and hyperflagellates in their intestine is of the symbiotic type of parasitism. The termites are entirely dependent on the flagellates for certain nutritional requirements, notably the supply of nitrogen and carbohydrates obtained by the breakdown of wood. The flagellates are similarly dependent on the host for nutriment and the physical environment in which they live. The dependence of the host on the flagellates may be readily demonstrated by raising the termites to a temperature which is lethal to the protozoans, thus defaunating them. Under such conditions, the termites fail to survive, as they lack the enzyme systems necessary to digest a wood diet.

The association between intestinal ciliates and their ruminant hosts is of a similar nature. Several genera of ruminant dwelling protozoans produce the enzymes cellulase and cellobiase, thus enabling them to split cellulose and utilize the breakdown products for their metabolism. The rate of fission of these ciliates is extremely rapid, and they soon die. On disintegration, they provide the host with about one-fifth of its total nitrogen requirements.

An example of an association which could be considered mutualistic is that between the coelenterate *Hydra viridis* and the alga *Zoochlorella* which lives within its endodermal cells. The alga produces oxygen which *Hydra* utilizes and *Zoochlorella* makes use of the nitrogenous waste products of *Hydra* for its synthetic processes. It is possible that a mutualistic association exists in many cases of parasitism, but sufficient physiological studies have not been made to reveal their existence.

## PARASITE AND PARASITISM – AN ECOLOGICAL APPROACH

Life has assumed many forms, shapes and sizes. The known number of species of plants and animals may be close to 2 million but this is only a small fraction of all those that actually may exist. Some estimate that it could be 10, 20, 40 or even 50 millions, but others say it would be close to one billion. Whatever the exact numbers be, the fact remains that all species are unique in their structure and functions and they live in different ecozones of the world, each one is suitably adapted to the habitat it dwells. Of all structural and physiological adaptations, the most important being the ways and means to obtain food. Needless to say that all organisms require food for providing energy to their bodies which is essential for carrying out their life activities that are necessary for survival. The various mechanisms involved in obtaining food and the organs for feeding are as divergent as the species themselves. Each ecosystem has producers and the consumers, the latter occur in various grades, e.g., primary, secondary, tertiary and quaternary. Based on the manner of obtaining food, the organisms may be classified as microbivorous, saprophagous, herbivorous, carnivorous, predaceous, etc. The feeding leads to food chains and varied interactions amongst organisms.

In Nature, there are two rather distinct ecological phenomena happening simultaneously but in quite contrast to each other. It is a well-known fact that for the health of an ecosystem the composition of its component species must remain more or less at an equilibrium. The constancy in populations is essential for maintaining proper feeding interactions among various biota. But in quite contrast to this, we find that every species be it of a plant or animal, under normal conditions produces large, sometimes excessively large numbers of individuals than are actually required for the ecosystem in which they live. This is a well-known biological fact and an essential part of Darwin's theory of Evolution. The reasons for this are rather very obvious. If more individuals than those actually required for an ecosystem are not produced, the Natural Selection can neither operate nor those possessing suitable variations can be selected in preference over those which lack these. The reproductive processes of the organisms are thus the most vital factors for the biotic ecosystem equilibrium as it would help in replacing individuals of species which die on account of ageing, disease, accident, wear and tear of body organs while performing various life activities, etc. In order to maintain a population balance, Nature must eliminate the old and sick individuals who have crossed the average life span of a species as also those young ones which are devoid of suitable variations that are required for a particular kind of ecosystem. The existence of an efficient mechanism therefore is a necessity in order to get rid of these two kinds of individuals which would otherwise be a burden on the ecosystem. It is indeed for this very purpose that parasites and predators are needed in every ecosystem and Nature has ensured their presence because of the vital role they have to play. The task of reducing populations of species over and above the required levels is efficiently performed by them. It would thus be quite appropriate to say that the parasites and predators are "Nature's Hangmen". This would be evident from the fact that each species of animals is parasitized and predated upon. Generally, in Parasitology, stress is laid on "The Five Ps" identified as Parasites, Pathogens, Parasitoides, Pests and Predators. To the above list, a Sixth "P" – 'The Prey', can be added, but its role is quite in contrast to the others. In the overall context of Parasitology, the study of all these organisms is of great significance.

Of special interest to us from the point of view of today's deliberations are those organisms that we call parasites. The parasites do not have the capability to obtain food directly from the ecosystem and hence they have no option but to adapt to live in or on some other organisms (host) and derive their food either ecto- or endo- parasitically from it. In the act of feeding, the parasites may or may not cause any appreciable damage to their hosts, but if they do cause some disease or discomfort, such parasites are regarded pathogens. Though the latter term has generally been applied to micro-organisms such as bacteria, viruses, fungi, etc. The pathogens are therefore those parasites which cause certain pathogenicity to organisms which are their hosts. This way, we actually have two kinds of parasites, one of these are pathogenic parasites causing damage and disease and the others are non-pathogenic parasites which do not cause any apparent pathogenicity though both types derive their nourishment from the hosts. Some parasites such as *Entamoeba histolytica*, the most common cause of amoebic dysentery, may under certain conditions of its host be non-pathogenic, but

should these conditions change it can become pathogenic. A parasite is physiologically dependent on its host and cannot survive in its absence. The physiological compatibility is sometimes such that the host and its parasite may co-evolve, though not necessarily at the same pace. The bird lice, *Mallophaga* and the cyst-forming nematodes, *Heterodera* and *Globodera* are excellent examples of co-evolution. But these co-evolving parasites are very host specific otherwise they cannot evolve together. In those parasites which have the ability to live in or on many hosts (e.g., root-knot nematode, *Meloidogyne*) are in other words polyphagous, hence co-evolution is not possible in these parasites and their hosts. Strange is the example of an eyeworm of birds of the genus *Oxyspirura* some species of which are very host specific and occur only in a single host, while there are other species that may have 2-5 species of birds as their hosts. Parasitism occurs throughout the animal kingdom but the parasitic species are mostly found among the invertebrate animals such as protozoans, platyhelminths, nematodes and arthropods. In Chordates only the hag-fishes (*Myxine*) are parasitic in the true sense. From *Amoeba* to man, all species are attacked by some species of parasite(s). Quite frequently a single species of host is parasitized by not only one but many species of different kinds of parasites, though a single species of parasite may not always be able to parasitize several species of hosts. As an example, as many as 36 species only of nematodes are known to parasitize Man. Add to this a large number of species of protozoan, trematodes, cestodes and insect parasites of Man. The situation is not very different for other vertebrate species, particularly the large ones. But even the invertebrates are no different, as they also do suffer from parasitic attacks and many of these incidentally also serve as carriers, vectors or intermediate hosts of parasites such as species of insects, ticks, mites, snails, etc.

Some zoologists regard parasitism to be quite close to symbiosis. In both phenomena, the relationship is an intimate one, in symbiosis both may benefit but not in parasitism. To simply say that the parasite is an organism that feeds and lives on or in another organism would be too simplistic. Some biologists say that all animals are parasites because they have to rely on other living organisms for their food, be these plants or animals. In more specific terms the parasites live in or on other organisms that are much bigger in size than the parasites themselves. The parasites, this way obtain food, but the host usually suffers due to the *effects* of their feeding as also due to the fact that they release metabolic wastes into its body. The host-parasite association as it grows older generations after generations, the impact of pathogenicity would theoretically become less and less due to mutual physiological and biochemical adaptability. This may, however, not always be true. Take the example of a single-celled protozoan parasite such as *Plasmodium* which is highly pathogenic and its infection may cause heavy mortality in Man. In spite of the fact that they are known to be very ancient parasites their virulence has not tapered *off* till date even a bit. Malaria is regarded as one of the most dreadful diseases of mankind with high levels of mortality the world-over.

The traditions of research on the parasites and parasitism are very old in this country, but these are relevant even today. There are innumerable exciting topics on which valuable research contributions could be made. The structural and biological characteristics of the parasites, the various modifications in the organs of the attachment, the mechanism of feeding, their life cycles inside and outside the host, the biochemical adaptations of the parasites enabling them to stay alive inside the host, etc. Even the classical Parasitology which includes the study of taxonomy, morphology and life history though much out of fashion these days is no less important and exciting than the so-called modern areas of research. Who could forget the rather classical contributions of Yamaguti from Japan, academician K. I. Skrjabin from Russia or Swell's work on *Cercaria indica* and the pioneering work of Sir Ronald Ross on the life cycle of malarial parasite that were carried out in India.

The other exciting areas for research in Parasitology, include life cycle studies of various groups of parasites attacking not only man and live-stock but also all species of vertebrates and a majority of invertebrates. Though it is vitally important, but is not an easy task. We should remember that all parasites are related to one another in many ways and much progress in the field of Parasitology has been achieved by studying first the animal parasites. It is already well known that related species of animals possess similar, if not exactly identical parasites. In the same way the Primates possess species of parasites that are closely related to our own parasites. A lot of work in

fact was, first done on these species, prior to tackling human parasites. Of interest are the various modes and avenues that different parasites use to reach their final hosts, e.g. orally, through skin, blood, etc. This is often followed by a cycle of migration within the definitive host before they are able to finally reach their favoured site. More diverse are the avenues of escape of the parasites from their hosts and the part of life cycle that they spent outside the bodies of the hosts. These may involve either a vector or an intermediate host, often not only one but two or even more. Many a times some stage(s) in their life cycle are free-living (miracidium, coracidium, cercaria, etc.). The nematode, *Strongyloides stercoralis* which is an intestinal parasite of Man may undergo several cycles of free-living generations under favourable conditions outside the body of the host before returning once again to the parasitic phase of its life within the host.

Another very interesting phase of the life cycle of parasites is the asexual multiplication at one or two or more stages in their life. This is because of the fact that parasitism is a chance phenomena and it cannot always be guaranteed that the parasite-host contact would be established. The parasites have overcome this problem by excessive egg production in the first place, but as if this was not enough, by further asexual multiplication into subsequent larval or intermediate stages as well (sporocyst, redia, coenurus, hydatid cyst, sporozoites, merozoites, etc.). In spite of many environmental hazards, the parasites ultimately manage to overcome all these and transform themselves into subsequent stages of life under very trying conditions and finally "knock at the door" of their hosts. In addition to these, the eggs of parasites are also unique in many ways, not only structurally but functionally as well. I am sure you are aware with the mechanism of release of eggs of blood flukes, *Schistosoma* spp. from the bodies of their hosts and the pathogenicity involved with it. The production of relatively inactive stages (cysts or eggs) that are resistant to environmental factors such as desiccation, ultra-violet radiation and extreme temperatures represents a few other important parasitic adaptations. Many nematode species have developed the strategy of going into Cryptobiosis (hidden life) in order to overcome extreme environmental conditions. This enables them to be highly resistant and thereby escape certain death. The perfectly synchronized life cycles of malarial parasites and the filarial worms are indeed outstanding examples of host-parasite-intermediate host/vector interactions which show how perfectly the parasites are adapted to the ways of their life.

The parasites are, by and large, regarded as degenerate organisms because of the absence of organs relating to sensory perception, motility and digestion, and also due to reduced biosynthetic and bioregulatory capabilities. The recent genetical studies comparing the parasites and their close non-parasitic relatives have shown that no reduction whatsoever has occurred in the size of their genomes. This shows that the parasites are not at all degenerate in any way, in fact they are highly specialized and a well adapted group of animals. Many species of parasites can survive as adults in warm-blooded animals and in their larval stages either in cold-blooded animals or may be in water or soil. It is believed that this is possible only due to their precise genetical programming which enables them to respond to varying developmental stresses by changing their body metabolism with the help of heat-shock proteins which they are known to possess.

The story of parasites and parasitism is without an end. One could go on and on like this as the various aspects are not only important but quite interesting too. What about the host-parasite and parasite-parasite relationships as also the relationships between the definitive and intermediate hosts of the parasites? One cannot ignore the mechanisms involved in host's immunity as also in its breakdown sometimes. We also cannot side-track the issues pertaining to drugs and vaccine development against parasites as also the mechanisms and underlying principles that are involved in its delivery to the host.

The humanity shall have to be freed from excessive parasite burden, particularly in the Third world countries. India is not only unfortunately very rich in its parasite diversity but it also carries a heavy parasite burden resulting into dreadful diseases and discomfort to its human population particularly those below the poverty line. This not only leads to severe health problems, even mortality and also loss of precious human resource.

## PARASITE AND PARASITISM

### TYPES OF PARASITSE

In general, **parasitism** includes any reciprocal association in which one species depends upon another, but in its usual medical usage it is an association in which one animal, the host, is injured in some degree through the activities of the other animal, the parasite. This association may be accidental and temporary or fixed and permanent.

In **symbiosis** there is a permanent association of two organisms that can not exist independently, protection or other advantages being provided for one or both, in **mutualism** both symbiotic organisms are benefited and in **commensalism** one partner is benefited and the other is unaffected, a commensal being an organism living on or within another but not acting as an injurious parasite.

The term parasite is ordinarily applied to a weaker organism that obtains food and shelter from another and derives all the benefit from the association. The host may show no noticeable harmful effects or may suffer from a wide range of functional and organic disturbances. There is such a wide range of parasitic types that it is difficult to draw a sharp distinction between a permanent parasite and a temporary resident such as a biting insect.

Various descriptive names denote special types or functions of parasites.

1. **Ectoparasites** are organisms (e.g., fleas, lice, ticks) that live on the outside of their hosts, usually attached to the skin, feathers, hair, gills etc., such forms can never lead a completely parasitic existence, but utilize oxygen from outside the host. Many maintain only periodic contacts with their hosts and, according to the definition given earlier, cannot be considered parasites but essentially special kinds of predators.
2. **Endoparasites** are parasites living within their hosts, in the gut, body cavity, lungs or other tissues; such forms nearly always live a completely parasitic existence.

Certain parasites fall in both these groupings. The itch mite (*Sarcoptes scabiei*) for example, burrows in tunnels in the skin and could satisfy the criteria of either an ectoparasites or an endoparasite. Again then, these terms cannot always be accurately defined, but they are convenient general terms.

3. Parasites are termed **Facultative** when they are capable of leading both a free and parasitic existence, and
4. **Obligate**, parasites which are obliged to live a parasitic existence and are incapable of surviving outside the host environment i.e., they are completely dependent upon the host. In the latter definition the emphasis must be on a ‘naturally occurring’ environment, for many ‘obligate’ parasites can now be cultured in artificial environments of a complex nature.
5. An **Incidental** parasite is one that establishes itself in a host in which it does not ordinarily live.
6. An **Occasional** or **Periodic** parasite seeks its host intermittently to obtain nourishment.
7. **Temporary** parasites are free-living during part of their existence, while
8. **Permanent** parasites remain on or in the body of the host from early life until maturity, sometimes for their entire life.
9. **Pseudoparasites** are artifacts mistaken for parasites.
10. **Coprozoic** or spurious parasites are species that have passed through the alimentary tract without infecting the host.

## NOMENCLATURE

Animal parasites are classified according to the International Code of Zoological Nomenclature. Each parasite belongs to a Phylum, Class, Order, Family, Genus, and Species. At times the further divisions of subclass, suborder, superfamily, subfamily, and subspecies are employed. The names are Latinized and the scientific designation is uninominal for subgenera and higher groups, binomial for species, and trinomial for subspecies.

The law of priority obtains as to the oldest available name, even if only a portion of the parasite or its larva has been described. To be valid a generic name must not have been given already to another genus of animals. The names of genera and species are printed in italics; the generic name begins with a capital and the specific name with a small letter. The name of the author is written without italics and without punctuation after the name of the parasite. The data follows the author's name represented by a comma, e.g., *Diplozoon kashmirensis* Kaw, 1940. When a species is transferred to another genus or when the specific name is combined with another generic name, the name of the original author is placed in parentheses and the name of the author of the new combination follows the parentheses, e.g., *Ancylostoma duodenale* (Dubini, 1843) Creplin, 1845.

The family name ends in “idea”, the superfamily in “oidea”, and the subfamily in “inae”. The terminations of certain divisions are indicated by the following examples

Division	:	Example
Phylum	:	Platyhelminths
Class	:	Trematoda
Order	:	Prosostomata
Suborder	:	Distomata
Superfamily	:	Fascioloidea
Family	:	Fasciolidae
Genus	:	<i>Fasciola</i>
Species	:	<i>Fasciola hepatica</i>

## CLASSIFICATION

Animal parasites may be divided into two main groups, Protozoa and Metazoa. The former are unicellular organisms. The latter are multicellular animals, the cells of which are differentiated to perform special functions but are dependent upon one another for their existence. The metazoan cell differs in structure and function from the protozoan cell in the absence of differentiation into ectoplasm and endoplasm, in reproduction by mitotic division only, and in the structure of the nucleus.

Animal parasites are legion. They are represented throughout the animal kingdom, and some classes are entirely parasitic, e.g., SPOROZOA, CESTOIDEA and TREMATODA. The distribution of parasites in 12 phyla of the animal kingdom is indicated in the following table. The parasitic species are chiefly confined to the PROTOZOA, PLATYHELMINTHS, NEMATOIDEA, ACANTHOCEPHALA, and ARTHROPODA.

## Table showing distribution of Parasites in the Animal Kingdom

<b>Phylum</b>	<b>Class</b>	<b>Parasitic Species</b>	<b>Human Parasites</b>
<b>Protozoa</b>	Sarcodina	<b>Many</b>	+
	Ciliata	<b>Many</b>	+
	Mastigophora	<b>Many</b>	+
	Sporozoa	<b>All</b>	+
<b>Coelenterata</b>	–	<b>Few</b>	–
<b>Porifera</b>	–	<b>Rare</b>	–
<b>Arthropoda</b>	Insecta	<b>Very many</b>	+
	Arachnida	<b>Very many</b>	+
	Crustacea	<b>Many</b>	–
<b>Platyhelminthes</b>	Cestoidea	<b>All</b>	+
	Trematoda	<b>All</b>	+
	Turbellaria	<b>Few</b>	–
<b>Nemertea</b>	–	<b>Few</b>	–
<b>Nematoidea</b>	–	<b>Very many</b>	+
<b>Acanthocephala</b>	–	<b>All</b>	+
<b>Nematomorpha</b>	–	<b>All (Larva)</b>	?
<b>Annelida</b>	–	<b>Rare</b>	+
<b>Mollusca</b>	–	<b>Few</b>	–
<b>Chordata</b>	–	<b>Rare</b>	–

Parasites also have been classified from the standpoint of epidemiology. Kozar separates parasites into three classes according to their ability to parasitize man and lower mammals:

1. **ZOOPARASITES**, in which the parasites are highly specific for animals, but man is completely insusceptible (absolute), or the parasites may be less highly specific for animals, and man occasionally susceptible (relative);
2. **ANTHROPOPARASITES**, in which the parasites are highly specific for man, but animals are completely insusceptible (absolute), or the parasites may be less highly specific for man, and animals occasionally susceptible (relative), and
3. **ANTHROPOZOOPARASITES**, in which the parasites have approximately equal specificity for man and animals.

Garnham divides zoonoses of parasites into two groups:

1. **ENZOOSES**, a very limited group in which man is essential for the life cycle of the parasite, e.g., *Taenia solium* and *T. saginata*; and
2. **PARAZOOSES**, an important but unstable and changeable group that includes many parasites with which man is only accidentally involved.