



SMR.478 - 58

THIRD AUTUMN COURSE ON MATHEMATICAL ECOLOGY

(29 October - 16 November 1990)

Glossary of Epidemiology

Andrew P. Dobson
Princeton University
Department of Ecology
and Evolutionary Biology
Princeton, NJ 08544
U.S.A.

These are preliminary lecture notes, intended only for distribution to participants.

Glossary of Epidemiology

Andy Dobson

Glossary

ADJUVANT - Anything that aids in removing or preventing a disease. Most common usage implies a substance that aids the action of antibodies.

AETIOLOGY - The study of the agents and factors involved in the causation of disease (USA: etiology).

AGE-STRUCTURED MODELS - A class of mathematical models which take into consideration the partitioning of the host population into different age classes. They can thus be used to consider the population consequences of such factors as age-dependent infection or mortality rates or age-specific vaccination schedules.

ANTENATAL - Prenatal, time from conception until birth of offspring.

ANTIBODY - A protein produced in the blood of vertebrates following the introduction of an antigen. The antibody produced is able specifically to combine with the antigen and thus aid in its inactivation.

ANTIGEN - Any foreign protein or other large molecule that when present in a host's tissue elicits the production of a specific antibody by the host, a reaction which leads to the subsequent rejection of the antigen.

ANTHELMINTHIC - A drug used specifically against helminth or worm infections.

ARBOVIRUS - A virus which utilizes Diptera and Ixodidae (Arthropods) as vectors and is transmitted in their saliva to the definitive host.

AUTOSOME - Any chromosome which occurs as one of a homologous pair in a diploid nuclei, i.e., any chromosome which is not a sex chromosome.

BACTEREMIA - The presence of bacteria in the blood.

BACULOVIRUS - A group of viruses that are highly pathogenic to insects (see Falcon, this volume).

BACTERIOPHAGE - A virus that is a parasite on bacteria. Phages attack bacteria cells by transferring their DNA (or occasionally RNA) into the bacteria after having penetrated the cell membrane; the DNA then takes control of the bacterial cell, replicates its own DNA, and thus produces more virions.

BREAKPOINT or TRANSMISSION BREAKPOINT - A critical average worm burden below which mating frequency is too low to maintain a dioecious parasite species.

CARRIER STATE - The state in which an infected individual shows no symptoms but is capable of transmitting an infection; occurs in many bacterial diseases such as typhoid.

CARRYING CAPACITY - The equilibrium number of individuals of a species an area or defined habitat can support. The density at which the population should remain in the absence of interspecific competition, predation, disease, and stochastic fluctuations.

CHEMOTHERAPY - The treatment of disease by means of chemicals which have a specific toxic effect upon the disease-producing organism.

CHEMOPROPHYLAXIS - The treatment of disease by means of chemicals designed specifically to break the life cycle of the pathogen at some particular stage.

CO-EVOLUTION - Changes in the genotypes of two or more species that are a direct consequence of the species' interaction with one another.

COMMENSALISM - The loosest and least obligatory form of interspecific association: the species show a minimal metabolic dependence on each other and can usually survive independently of their association, although at some disadvantage to those individuals of the same species which remain in association. Ecologists usually use the term to describe pairwise associations in which one species benefits while the other is unaffected (+0).

COMPETITION - The detrimental interaction between two or more organisms of the same or different species which utilize a common limited resource (--).

CONTACT RATE - The average frequency with which infected individuals contact, or otherwise put themselves in a position to transmit an infection to, uninfected individuals. It is thus a detail-independent function of host behavior.

DEFINITIVE HOST - In macroparasites the host in which the parasites or pathogen reproduces sexually.

DENSITY-DEPENDENT - Population mechanisms or effects whose intensity of action increases with increasing population density; as they usually reduce fecundity or increase mortality, such effects are capable of regulating the net population growth rate. Mathematicians would call such effects nonlinear.

DETERMINISTIC MODEL - Mathematical models which assume that all parameters and variables are constants and not random variables.

DIRECT LIFE CYCLE - A cycle in which the life-style of a parasite or disease is transmitted directly from one host to the next without utilizing an intermediate host or vector of another species.

EFFICACY - An index of the potency of a drug or disease treatment, usually estimated as the average proportion of the worm burden in any host killed by a single dose or short-term course of the treatment.

ENDEMIC - A term to describe diseases or parasitic infections whose abundances do not exhibit wide fluctuations through time in a defined spatial location.

EPIDEMIC - A sudden, rapid spread or increase in the prevalence and intensity of a parasite or disease.

EPIGENETIC - The mechanisms that cause phenotypic effects to be expressed by the genes of the genotype.

EPIZOOTIC - A disease affecting a large number of animals simultaneously, equivalent to an epidemic in human populations; often results from the introduction of a new or novel pathogen (or genetic strain of a pathogen) to a previously unexposed host population.

EXOPHILIC BEHAVIOR - Protection afforded against pathogenic organisms or compounds due to either the production of skin or body surface secretions or behavior that prevents their contact with the body surfaces.

FECUNDITY - The capacity of a population to produce offspring.

FITNESS - A term used to denote the relative contribution of offspring to the next generation of an individual. When associated in any way with the presence or absence of a particular gene in the individual's genotype, it may also be termed the relative selective value of that gene.

FREQUENCY-DEPENDENT - A population mechanism or genetic trait whose intensity of action or quality varies with its prevalence within the total population, i.e., is of the maximum benefit to those individuals possessing it when it is rare.

HANDLING TIME - A finite amount of searching time spent by a predator in quelling, killing, and eating prey (a term borrowed from predator-prey theory). It affects the dynamics of parasites or pathogens transmitted by an actively searching vector.

HELMINTHS - Worms, in particular the five classes of parasitic worms: Monogenea, Digenea, Cestodes, Nematodes, and Acanthocephalans.

HERD IMMUNITY - A term used to describe the immunological status of a population of hosts (as opposed to an individual organism) with respect to a given parasite. The level of herd immunity is determined by the net rates at which individuals acquire (by recovery from infection) and lose (by death, or decay of specific antibody protection) immunity.

HOLOENDEMIC - Diseases or parasites whose prevalence is fairly uniform throughout a region, country, or continent.

HYGIENE - The methods used to reduce disease prevalence through cleanliness and care of the body.

IMMUNITY (sometimes confusingly termed Resistance, or more correctly, Specific Resistance) - The ability to combat diseases due to the presence of antibodies. Essentially it can be divided into three types: a) acquired immunity is conferred on an individual after recovery from a disease; b) natural immunity is inherited from parents and is thus under some form of genetic control,

IMMUNITY - (cont'd.)

or in some cases antibodies may also be passed across the placenta and therefore are present in the blood at birth. c) Artificial immunity may be induced by the injection of either a vaccine, denatured antigens of a disease (which induces production of antibodies and thus gives active artificial immunity), or antiserum which contains antibodies and thus may be used when the patient is already suffering from the disease. As well as strengthening the host's resistance, this also confers passive artificial immunity against any subsequent infection.

IMMUNOSUPPRESSION - A reduction in the ability to utilize the antibody defense system.

INCUBATION PERIOD - The time that elapses between infection and the appearance of symptoms of a disease.

INDIRECT LIFE CYCLE - A life cycle which requires one or more intermediate hosts or vectors before the definitive or final host is reinfected.

INFECTIOUS PERIOD - Usually denotes the time period during which infecteds are able to transmit an infection to any susceptible host or vector they contact. Note that the infectious period may not necessarily be associated with symptoms of the disease.

INOCULUM - The quantity of pathogen/microorganism used to initiate a colony of microparasite infection within any individual.

INTENSITY - Traditionally the mean numbers of parasites within any infected member of the host population. It is also used to describe the mean parasite burden within infected and uninfected hosts. The former usage carries meaning to the traditional epidemiologist, the latter to the mathematical epidemiologist; both should take pains to indicate which convention they are adopting, since unless prevalence is 100%, they are different statistics.

LATENT PERIOD - The time from when an individual is infected until when he is capable of transmitting an infection. In helminths it is termed the pre-patent period.

LIFE EXPECTANCY - The average length of life, or longevity, of the individuals of a population under the stated conditions (e.g., life expectancy from birth).

LINKAGE - The tendency for two or more non-allelomorphic genes (i.e., genes in the same chromosome which do not exhibit independent assortment) to remain associated through several generations.

LINKAGE DISEQUILIBRIUM - The extent to which gene frequencies differ from the values they would have if the gene loci segregated independently.

LOCUS - The position occupied by a particular gene in a chromosome.

MACROPARASITES - Parasites which in general do not multiply within their definitive hosts but instead produce transmission stages (eggs and larvae) which pass into the external environment, e.g., the parasitic helminths and arthropods. The immune responses elicited by these metazoans generally depend on the number of parasites present in a given host and tend to be of a relatively transient nature.

METAZOANS - All multicellular animals.

MICROPARASITES - Parasitic organisms which undergo direct multiplication within their definitive hosts (e.g., viruses, rickettsia, bacteria, fungi, and protozoa), they are characterized by small size, short generation times, and a tendency to induce immunity to reinfection in those hosts that survive the initial onslaught. Duration of infection is usually

MICROPARASITES - (cont'd.) short in relation to the expected life span of the host (there are, however, important exceptions, e.g., the slow viruses).

MOLLUSCICIDES - Chemical substances put in water to kill snails or other molluscs living and breeding in the water.

MORBIDITY - State of feebleness, weakness, unhealthiness, or other debility produced by a disease or parasite.

MORTALITY - The death rate in a population. The net mortality rate is defined as the sum of all the instantaneous forces of mortality operating at any one time (formally, the reciprocal of the population life expectancy). The force or impact of any mortality factor varies directly with the numbers of individuals in a cohort dying due to that cause of mortality. Three types of interaction between mortality rates were identified by Hassell et al. (this volume). Mortality rates were defined as operating additively if the elimination of one source of mortality produced a net decrease in the total population mortality rate but no detectable increase in the observed instantaneous rates of mortality of the other operating factors. Mortality was said to be compensatory if removal of one source of mortality produced an increase in deaths from alternate sources such that the observed net mortality rate was maintained at its previous level. Depensatory mortality was said to operate if removal of one mortality factor produced not only a reduction in net mortality rate but also a reduction in deaths due to other causes, e.g., if the two mortality factors had interacted in some way (such as parasite-induced susceptibility to predation).

MULTIPLE INFECTION - An infection in which an individual contains pathogens of more than one species.

MUTUALISM - An association between two species from which both species benefit (++). Such mutualism is called obligate if a species cannot survive in the absence of the other.

NOTIFIABLE DISEASES - Diseases, usually of an infectious nature, whose occurrence is required by law to be made known to a health officer or local government authority.

OVERDISPERSION - The nonrandom or aggregated distribution of organisms. Macroparasites are invariably overdispersed in their host populations, the majority of hosts harboring a few or no parasites while a few hosts harbor large parasite burdens. Overdispersed distributions are often well described empirically by the negative binomial distribution.

PANDEMIC - A widely distributed epidemic.

PANZOOTIC - A widely distributed epizootic often affecting more than one host species.

PANMICTIC - Characterized by, or resulting from, random matings.

PARASITE - An organism exhibiting a varying but obligatory dependence on another organism, its host, which is detrimental to the survival and/or fecundity of that host.

PARASITOID - An abundant group of insects (about 10% of known insect species) which, having utilized the egg, larval, or pupal stage of some other insect as a host for a significant period of their own development, then kill that host by emerging to continue the next stage of their life cycle (see Table 1, May (this volume)).

PARTHENOGENESIS - Reproduction without fertilization; asexual reproduction.

PATHENOGENICITY - The variable character of a parasite or disease which determines the degree to which the pathogen debilitates its host. Its expression is affected by conditions prevailing in the host, particularly nutritional status.

PERINATAL MORTALITY - Death of the fetus after the 28th week of pregnancy and death of the newborn child during the first week of life. Mortalities in this class are usually results of difficulties at birth and congenital abnormalities of the baby.

POLYMORPHISM - The term used to describe different forms of individuals within the same species, or more specifically, gene loci at which there are variant alleles at intermediate frequencies. If the frequencies of the alleles are stable, i.e., return to their previous values following a perturbation, the polymorphism is said to be balanced. If the polymorphism only occurs sporadically, it is said to be transient.

POSTNATAL - Subsequent to childbirth.

PREDATOR - An animal that kills its victim, the prey item, and then feeds on it in order to subsist until the next kill (see Table 1, May (this volume)).

PRE-PATENT PERIOD - The time from infection until when a female starts to produce eggs in helminth infections, equivalent to latent period in micro-parasitic infections.

PREVALENCE - The proportion or percentage of the host population infected by a disease or parasite at any time. A measure of the extent or occurrence of a disease. Prevalence models divide the host population into a series of compartments containing, for example, susceptible, latent, infectious, and immune individuals.

PROPHYLACTIC - Any substance, object, treatment, or action which reduces the spread of disease through a population of hosts.

PROTOZOAN - Any unicellular animal.

REPRODUCTIVE RATE - There are three types mentioned in the text:

- 1) **Basic Reproductive Rate, R_0** - A dimensionless parameter which encapsulates the biological details of different transmission mechanisms. For microparasites, R_0 is defined as the average number of secondary cases of infection to which one primary case gives rise throughout its infectious period if introduced into a defined population consisting solely of susceptible individuals. For macroparasites, R_0 is the average number of female offspring (or just offspring in the case of hermaphroditic species) produced throughout the lifetime of a mature female parasite, which themselves achieve reproductive maturity in the absence of density-dependent constraints on parasite establishment, survival, or reproduction.
- 2) **Effective Reproductive Rate, R** : The number of secondary cases (microparasites) or female offspring (macroparasites) produced in a host population not consisting entirely of susceptible individuals (microparasites) or within which density-dependent constraints limit parasite population growth. Under conditions of stable endemic infection, $R=1$.
- 3) **Gross Reproductive Rate, \bar{L}_m** - The total mean number of offspring born to a female which also survive throughout her reproductive life.

RESISTANCE - Two distinct concepts: one is concerned with the reduction in susceptibility of pathogens or vectors to chemotherapy due to genetic selection by the prophylactic measure at one or more gene loci; the other concerns the ability of a host to resist a

RESISTANCE - (cont'd.) pathogen. This is divided into two classes, specific and nonspecific resistance. The former is the resistance an organism possesses by virtue of its antibodies and immune system, while the latter includes all other forms of mechanisms that resist the invasion of pathogens, e.g., physical barriers such as the skin and phagocytic cells, and non-specific secretions such as lysozyme and the secretions of the mucus membranes.

SELECTION COEFFICIENT, s - A measure of the strength of selection operating against a genotype, e.g., the difference between the relative selective value or fitness and 1. Formally s is defined as the proportionate reduction in the genetic contribution of a particular genotype compared with a standard genotype.

SEROLOGY - The study of antigen-antibody reactions.

SEROTYPE - The possession of certain antibodies by an individual.

SPOROGENY - Spore formation, reproduction by fission in protozoans and other microparasites.

STOCHASTIC MODEL - A mathematical model which takes into consideration the presence of variability in one or more of its parameters or variables. The predictions of the model therefore do not give a single point estimate but a probability distribution of possible estimates.

SUBCLINICAL INFECTION - An infection in which symptoms are sufficiently mild or inapparent to escape diagnosis other than by positive confirmation of the ability to transmit the infection.

SUSCEPTIBLE - An individual accessible to or liable to infection by a pathogen.

SYMPTOM - A condition of the body felt by an individual when he is suffering from a disease, here it has been more loosely used to cover any piece of evidence used in diagnosis or identification of infected individuals.

THERAPEUTIC - Any form of nonspecific help in curing or alleviating pain due to a disease or pathogen.

TRANSMISSION - The process by which a pathogen passes from a source of infection to a new host. There are two major types: horizontal and vertical transmission. The majority of transmission processes operate horizontally, e.g., by direct contact between infected and uninfected individuals or between disease vectors and susceptibles. There are five main methods of horizontal transmission: 1) ingestion of contaminated food or drink, 2) inhalation of contaminated air droplets, 3) direct contact, 4) injection into a tissue via an animal's saliva or bite, and 5) invasion via open wounds. Vertical transmission occurs when a parent conveys an infection to its unborn offspring, as occurs in syphilis in man or in many arboviruses of arthropods.

TRANSMISSION THRESHOLD - Occurs for all parasites and diseases when the basic reproductive rate $R_0=1$. Below this threshold level the disease is unable to maintain itself within the host population (or populations, in the case of indirectly-transmitted infections).

VACCINE - A sterile liquid medium containing avirulent strains of a specific pathogen and often an adjuvant, introduced into the body of a susceptible individual to stimulate the production of antibodies and thus induce active artificial immunity against a pathogen.

VECTOR - Any animal (or object) which transmits causative agents of a disease or parasite. In diseases with indirect life cycles the intermediate hosts are often referred to as vectors, while in diseases transmitted by contamination a variety of nonspecific organisms can act as vectors.

VECTORIAL CAPACITY - In vector-borne infections such as malaria, the vectorial capacity is a concept analogous to the contact rate in directly-transmitted diseases. It is thus a function of a) the vector's density in relation to its vertebrate host, b) the frequency with which it takes blood meals on the host species, c) the duration of the latent period in the vector, and d) the vector's survival function or life expectancy.

VIREMIA - The presence in the blood of a virus.

VIRION - A single, mature virus particle which attacks one cell of its host.

VIRULENCE - The case mortality rate of a disease or parasite.

ZOONOSIS - An infectious disease or parasite naturally transmitted between man and other vertebrate species.