CHAP-4-POPULATION ECOLOGY:

A population is a collection of the same species (individuals of one kind) that live together in a region. Population ecology is the study of populations (especially population abundance) & how they change over time.

The *aims* of population ecology are threefold:

1- **To elucidate general principles explaining these dynamic patterns.**
2- **To integrate these principles with mechanistic models & evolutionary interpretations of individual life history tactics, physiology & behaviour.**
3- **To apply these principles to the management & conservation of natural populations.**

Community ecology:* *studies the structure & dynamics of animal & plant communities. Population ecology provides modelling tools that can be used for predicting community structure & dynamics.

Population Characteristics:

A) Population size(N) & density:

- ***Total size is generally expressed as the number of individuals in a population.***
- ***The size of the population is represented by its fundamental property called Population density, defined as the number of individuals per unit area or per unit volume of environment. Larger organisms as trees may be expressed as 100 trees per hectare, whereas smaller ones like phytoplanktons (as algae) as 1 million cells per cubic metre of water.***

a) Crude density: ***It is the density (number or biomass) per unit total space.***

b) Ecological density or specific or economic density:

- ***It is the density (number or biomass) per unit of habitat space i.e. available area or volume that can be colonized by the population.***

B) Population dispersion or spatial distribution:

Dispersion is the spatial pattern of individuals in a population relative to one another. In nature, due to various biotic interactions & influence of abiotic factors, the following three population distribution can be observed.

a) Regular dispersion: - ***Here the individuals are spaced at equal distance from one another. This is rare in nature but in common in cropland. Animals with territorial behaviour tend towards this dispersion.***

b) Random dispersion: - ***Here the position of one individual is unrelated to the position of its neighbours, relatively rare in nature.***

c) Clumped dispersion: - ***Most populations exhibit this dispersion, with individuals aggregated into patches interspersed with no or few individuals.***

C) Age structure:

- ***In most type of populations, individuals are of different age. The proportion of individuals in each group is called age structure of that population. From an ecological viewpoint there are three major ecological ages in any population.***

Age pyramids: ***The model representing geometrically the proportion of different age groups in the population of any organism is called age pyramid. According to Bodenheimer (1938), there are following three basic types of age pyramids-***

a) **A pyramid with a broad base (or triangular structure):** - ***It indicated a high percentage of young individuals. In rapidly growing population birth rate is high & population growth may be exponential as in yeasty house fly, Paramecium etc.***

b) **Bell-shaped polygon**: - ***It indicates a stationary population having an equal number of young & middle-aged individuals.***

c) **An urn shaped structure:** - ***It indicates a low percentage of young individuals & shows a declining population.***

D) **Natality (birth rate)-** ***Population increases because of natality, a broader term covering the production of new individuals by birth, hatching, by fission. There are distinguished two types of natality -***

a) **Maximum natality**: ***also called as absolute or physiological natality, it is the theoretical maximum production of new individuals under ideal conditions which means that there are no ecological limiting factors & that reproduction is limited by physiological factors.***

b) **Ecological natality:**

- ***Also called realized natality, it is the population increase under an actual, existing specific condition. This is also designated as fertility rate. Natality is expressed as-***

$\Delta N_n / \Delta t$ = Absolute natality rate (B)

$\Delta N_m / N\Delta t$ = Specific natality rate (b) (i.e. natality rate per unit of population).

Where N = initial number of organisms

n = new individuals in the population.

t = time

There are two aspects of reproduction- a) Fecundity: is a physiological notion that refers to an organism's potential reproductive capacity under ideal conditions. This limit is set by genotype i.e. reproduction is limited by genetic potential, not by the environment

b) Fertility: is an ecological concept that is based on number of viable offsprings produced during a period of time under prevailing environmental conditions.

E) **Mortality (death rate):** - ***Mortality means the rate of death of individuals in the population. Like natality, mortality may be of following types-***

a) **Minimum mortality**: ***It is a constant for a population, also known as specific mortality rate of a population expressed by survivorship curves-are of three general types:***

I) ***A highly convex curve (type I) is characteristic of the species in which the population mortality rate is low until near the end of the life span e.g, deer, man, mountain sheep.***

II) *A highly concave curve (type III) is characteristic of those where the mortality rate is high during the young stages e.g. in oysters or shell fish (extreme mortality during free swimming larval stage).*

III) *Type II curve which falls between type I & type III, the rate of mortality is constant at all age groups e.g, birds, human beings exposed to poor nutrition & hygiene.*

b) **Ecological or realized mortality**- *It is the actual loss of individuals under a given environmental condition.*

Biotic Potential OR Reproductive Potential (Introduced by Chapman):

Each population has the inherent power to grow. When the environment is unlimited, the specific growth rate (i.e. the population growth rate per individual) becomes constant & maximum for existing conditions.

$$r = b - d$$

- **The index r is the difference between the instantaneous specific natality rate & the instantaneous specific death rate.** *This maximal growth rate for a given population is known as its biotic potential.*

POPULATION GROWTH CURVES:

Two types of population growth patterns may occur depending on specific environmental conditions:

A) Exponential Growth: -

- *Exponential population growth will occur in an ideal environment where resources are unlimited.*
- *In such an environment there will be no competition to place limits on a geometric rate of growth.*
- *Initially population growth will be slow as there is shortage of reproducing individuals that may be widely dispersed.*
- *As population numbers increase the rate of growth similarly increases, resulting in an exponential (J-shaped) curve.*
- *The following equation exhibits J-shaped growth*

$$dN/dt = rN$$

Where dN/ dt represents rate of change in population size, r is biotic potential & N stands for population size.

B) Logistic Growth: -

- *Logistic population growth will occur when population numbers begin to approach a finite carrying capacity.*
- *The carrying capacity denoted by* **K** *is the maximum number of a species that can be sustainably supported by the environment.*
- *As a population approaches the carrying capacity, environmental resistance occurs, slowing the rate of growth.*
- *This results in a sigmoid (S- shaped) growth curve that plateaus at the* **K**

The S-shaped sigmoid growth form is represented by the following equation:

dN/ dt = rN (K – N/K) = rN (1 – N/K)

Where, dN/dt is the rate of change in population size.

r is biotic potential: N is population size: (K – N/K) or (1 – N/K) is for environmental resistance. The term (K – N/K) indicates how much of the resources are still available to populations. When N is much less than K, the term (K – N/K) becomes Approx. 1 & the equation becomes dN/ dt = rN (equation for exponential growth). As N almost becomes equal to K. the term (K – N/K) is almost zero & dN/ dt i.e. the growth also becomes zero.

***In the logistic model, the greatest population growth rate is achieved at half the carrying capacity* (K/2) *& the populations with a greater value* r *will reach* K *more rapidly (in less time) than populations with lesser values of* r. *Populations far from the* K *will have high growth rates- positive if the population is below* K *& negative if it is above* K. *As the population approaches* K, *growth rates approach zero*.**

POPULATION REGULATION:

Growth of population is kept in optimum range by the interaction of various factors. These are:

1- **Exogenous or Extrinsic factors e.g, Density Dependent, Density Independent factors.**
2- **Endogenous or Intrinsic factors.**

a) **Density Dependent factor**: ***These factors which vary in their intensity of action on the size or density of population are called DD Factors. They increase in intensity as the population level rises & decreases as the population level declines i.e. By intra specific competition interactions either cause birth rate to decline & death rate to increase. Density dependent influences often include resources that are in limited/ short supply as space, water, nutrients.***

Density dependent factors can be- Positive- when rate of population growth increases as density increases. This phenomenon is referred to as* Allee effect *(after w. Allee, who first described it).

Negative- When rate of growth decreases as the population density increases.

The most important DD Factors are competition, emigration, predation, parasitism, disease, & physiological stress.

b) **Density Independent Factors**: ***The level at which population become stabilized is determined by factors as climate, space, food supply, toxic substances in the environment. These factors are largely density independent since their magnitude is primarily determined by the physical or abiotic conditions of environment. Most populations particularly those of insects & other invertebrates are influenced more by DI Factors & those periods of unfavorable environmental conditions ultimately determine the size of the population.***

2-Endogenous Factors: ***Factors developed by natural selection within the population & resulted from the interactions of the individuals, making up the populations. These include: a)* Physiological mechanism-*Under very high-density physiological mechanism***

get disturbed due to hyperactivity of pituitary & hypothalamus, contributing to increased death rate. b) Behavioural mechanism*- In birds during breeding season territorial behaviour become more pronounced which influences population as is the case in mammal's dispersal behaviour to avoid high population density.*

METAPOPULATION: - *A set of local populations connected by dispersing individuals is known as metapopulation. A classic metapopulation is a regional population composed of many local populations, a situation seen or occurs when patches of suitable habitat are separated by uninhabitable areas. It is an important concept for understanding population dynamics in patchy habitats.*

r & K Strategists:

The concept of r & K- strategist links population dynamics to life history in an unpredictable & predictable environmental condition.

Synonyms for r-strategists are r-selected species, fugitive species & opportunistic species. For K-strategists, the synonyms K-selected species & stable species have been used. The two opposing selective forces were designated by Mc Arthur & Wilson.

Difference in Characteristics:

	r-selected species	K-selected species
Environment:	***Variable & unpredictable.***	***Fairly constant or predictable, more certain.***
Mortality:	***Non-directed, density independent.***	***More directed, density dependent.***
Survivorship Curve:	***Often type III***	***Type I & type II***
Population size:	***Variable in size, nonequilibrium, usually well below K of environment.***	***Fairly constant, in time, equilibrium, at or near K of the environment.***
Selection favours:	***Rapid development, early reproduction, small body size, semelparity-single reproduction, many small offsprings, low level of social organization.***	***Slower development, delayed reproduction, large body size, iteroparity-repeated reproduction, fewer & large offsprings, high level of social organization.***
Life span:	***Short, usually less than a year***	***Longer, usually more than a year.***
Successional stage:	***Early.***	***Late, Climax.***
Examples:	***Algae, bacteria, rodents, most insects.***	***Human beings.***

CHAP-8-ENVIRONMENTAL HEALTH:

NAME OF THE DISEASE:	CAUSATIVE AGENT:	SYMPTOMS:	TRANSMISSION:	TREATMENT:
Diphtheria	***Cornybacterium diphtheriae***	**Thick mucopurulent**	**Air borne transmission by way of**	**Diptheria toxin or DPT vaccine (Diphtheria,**

		nasal discharge, fever, cough.	nasopharyngeal secretions.	Pertusis, Tetanus vaccine).
Tuberculosis	*Mycobacterium tuberculosis*	Fever, weight loss, cough with bloody sputum.	Transmission to humans from susceptible animal species & their products.	Rifampin, ethambutol, pyrazinamide.
Pertusis: (Whooping cough)	*Bordetellapertusis*	Prolonged coughing.	Highly contagious, inhalation of the bacterium in droplet released from infectious person.	Erythromycin, tetracycline or Chloramphenicol.
Tetanus	*Clostridium tetani*	Tension or cramping & twisting in skeletal muscle, tightness of jaw muscle.	Transmission to humans occurs with skin wounds.	Tetanus toxoid, diphtheria toxoid & pertusis vaccine.
Cholera	*Vibrio cholera*	Abdominal muscle cramps, vomiting, fever & watery diarrhea.	Ingesting food or water contaminated by faecal matter from patients or carrier.	Oral rehydration therapy with NACl plus glucose, tetracyclines, ciprofloxin.
Typhoid fever	*Salmonella typhi*	Fever headache, abdominal pain, & anorexia.	Ingestion of food & water contaminated by faeces of infected human or animal.	Ceftriaxone, trimethoprim, sulfamethoxazole, or ampicillin.

BACTERIAL TOXINS: *A toxin is a substance that alters the normal metabolism of host cells & has delirious effects on the host. Bacterial toxins fall under two main categories: 1- Exotoxins: These are soluble, heat-labile proteins. Exotoxins travel from the site of infection & exert their effect to other body tissues or target cells*.

Toxin	*Organism*	*Mechanism of Action (Pathogenicity)*
Botulinum toxin	*Clostridium botulinum*	*Decreases peripheral presynaptic Ach release, causes flaccid paralysis.*
Cholera toxin	*Vibrio cholerae*	*Increase cAMP level, causes secretory diahorrea.*
Diphtheria toxin	*Cornybacterium diphtheria*	*Inhibit protein synthesis & cause cell death.*
Pertusis	*Bordetella pertusis*	*Block signal transduction mediated by G proteins.*

Tetanus toxin	***Clostridium tetani***	***Decrease neuro -transmitter release from inhibitory neurons, causes spastic paralysis.***

Endotoxins: ***Lipopolysaccharide (LPS) present in the outer membrane of cell wall of gram-negative bacteria causes toxicity to specific hosts & is released when microorganisms lyse. Endotoxins cause fever, shock, diarrhea, blood coagulation & inflammation.***

Patterns of Transmission in Communicable diseases:

Mode of Transmission:	***Definition:***
Vertical.	***Transmission is from parent to offspring via the ovum, sperm, placenta etc.***
Horizontal.	***Disease is spread through a population from one infected individual to another:*** ***Direct (contact transmission)- involves physical contact between infected person & that of the new infectee.*** ***Types: Touching, kissing, droplet contact, in which fine droplets are sprayed directly upon a person during sneezing & coughing.*** ***Indirect Transmission: Infectious agent must pass from an infected host to an intermediate conveyor (a vehicle) & from there to another host. Infected individuals contaminate objects, food, or air through their activities.*** ***Types: a) Formite: - inanimate objects that harbors & transmits pathogens (doorknobs, telephone receiver, tables, chair) b) Vehicle: - a natural, nonliving material that can transmit infectious agents.*** ***Air- small particles evaporate & remain in the air & can be encountered by a new host; like- aerosols, are suspensions of fine dust or moisture particles in the air that contain live pathogens.*** ***Water, soil- microbes resistant to drying live in & can be transmitted from soil, infected food.***
Vector Transmission:	***Types: Mechanical vector: - Insect carries microbes to the host on its body parts.*** ***Biological vector: - Insect injects microbes into host, part of microbe life cycle completed in insect.***

PATHOGENICITY OF MOST COMMON DISEASES:

A) **Tuberculosis:** ***- Robert Koch identified Mycobacterium tuberculosis as the causative agent of tuberculosis (TB). Infection results when the bacteria are phagocytosed by macrophage in lungs, infected macrophages often die attempting to destroy bacteria, thus releasing viable bacteria into respiratory spaces. The incubation period is 4 – 12 weeks & the disease develops slowly. The symptoms of TB are fever, night sweats, weight loss, cough with bloody sputum. A hypersensitivity response results in the formation of small nodules called tubercles composed of bacteria, macrophage, T cells. Tubercles, characteristic of tuberculosis & give the disease its name.***

B) **Influenza:** ***- Influenza (Italian, un influenza di freddo- to be influenced by the cold) or the flu. Influenza is a respiratory system disease caused by RNA viruses that belong to the family Orthomyxoviridae. The three genera are Influenzavirus A, Influenzavirus B,***

Influenzavirus C; only types A & B cause significant human diseases. All influenza viruses are acquired by inhalation or ingestion of virus-contaminated respiratory secretions. During an incubation period of 1 to 2 days, viral particles adhere to host respiratory epithelium & initiate the replication cycle. Two envelope spikes, hemagglutinin (HA) & neuraminidase (NA) play critical roles. HA binds to host cells & thereby triggers receptor-mediated endocytosis, facilitated by NA, which hydolyze the mucus that covers the epithelium. NA aids in the release of newly assembled influenza virus virions from infected cells.

There are16 HA (H1 -H16) & 9 NA (N1 -N9) antigenic forms known. Pigs can transfer it to humans & humans back to pigs. Recombinations between human & avian strains thus occur in pigs, leading to novel HA/NA combinations causing major antigenic shift. Influenza A viruses having H1, H2 & H3 HA antigens along with N1 & N2 NA antigens are predominant in nature, infecting humans.

Treatment: - Annual immunization is still recommended as immunity using the inactivated virus vaccine typically lasts only 1 to 2 years.

C)Hepatitis*: - Inflammation of the liver is called hepatitis (pl; hepatitides; Greek hepaticus, liver). Hepatitis A (infectious hepatitis) usually is transmitted by fecal contamination of food or drink. The disease is caused by hepatitis A virus (HAV) of the genus Hepatrovirus in the family Picornaviridae.The virus reproduce in the liver, enter the bile, & are released into small intestine. After about a 4-week incubation period, symptoms develop that include anorexia, fever, chills, jaundice ensues.*

Control/ treatment: - Control of infection is by proper hygienic measures, sanitary disposal of excreta & HAV vaccine.

Disease	*Genome*	*Classification*	*Transmission*	*Characteristic*	*Prevention*
Hepatitis A	*RNA*	*Hepatovirus*	*Fecal-oral route.*	*Acute infection.*	*Killed HAV vaccine*
Hepatitis B	*DNA*	*Orthohepadnavirus*	*Blood, needles, body secretions, placenta.*	*cirrhosis, primary hepatocarcinoma*	*rHBV Vaccine.*
Hepatitis C	*RNA*	*Hepacivirus*	*Blood, sexually*	*Cirrhosis, primary hepatocarcinoma*	*Routine screening of blood*
Hepatitis E	*RNA*	*Hepevirus*	*Fecal-Oral*	*Acute infection.*	*Improve sanitary hygiene*

D)* Typhoid: - Typhoid (Greek typhodes, smoke) fever is caused by Salmonella enterica serovar Typhi & is acquired by ingestion of food or water contaminated by faeces of infected humans or person-to-person contact. The incubation period for typhoid fever is about 10 to 14 days. The bacteria colonize the small intestine, penetrate the epithelium &*

spread to lymphoid tissue, blood, liver & gall bladder. After approx. 3 months most individuals stop shedding bacteria in their faeces, but few individuals continue to shed the pathogen for extended periods without symptoms. In these carriers, the bacteria continue to grow in the gallbladder & reach the intestine through the bile duct.

E) **Cholera: -** ***Cholera (Greek chole, bile) is an acute diarrheal disease caused by bacterium, Vibrio cholera. The disease is characterized by profuse watery diahorrea, vomiting & leg cramps. These symptoms result from rapid loss of body fluids leading to dehydration & shock. Cholera is transmitted by ingesting food or water contaminated by faecal matter from infected individuals. The incubation period is 3 to 72 hours, infected individuals excrete 'rice-water stool' so named because of flecks of mucus floating on watery diarrhea.***

OCCUPATIONAL DISEASES: - ***Any disease or illness associated with a particular occupation or industry. 'or' A disease resulting from exposure to a substance (e.g. chemicals, dust, fumes or viruses) related to a particular process, trade, or occupation in an industry.***

1-Asbestosis: - Is a chronic lung disease caused by inhaling asbestos fibers of chrysotile, crocidolite, tremolite etc. (a building material).

Symptoms: Shortness of breath, persistent dry cough, chest congestion, may develop COPD complication.

Treatment: New generation drug, ADI-PEG20 (Pegargiminase) combined with chemotherapy shows promising results.

2-Silicosis: - is an incurable lung disease caused by inhaling crystalline silica dust, leading pneumoconiosis or 'dusty lung' resulting in permanent damage to lungs. Silicosis that develops a few weeks to 5 years after exposure to high concentrations of respirable silica dust, also known as 'silicoproteinosis'.

Symptoms: cough, sputum & progressive shortness of breath, often leads to death.

Treatment: Not cured, but managed by avoiding silica exposure, oxygen therapy, lung transplant, flu vaccines & regular TB testing, practice proper personal hygiene.

(FOR MALTHUSIAN ESSAY & DEMOGRAPHIC TRANSITION, KINDLY CONSULT JK BOSE TEXT BOOK)

YOU HAVE REACHED THE END OF THE CHAPTER.