# Collegedunia NCERT Solutions

*Step-by-step solutions, alternate methods & exam tips for Class 12 Biology*

## Chapter 11: Organisms and Populations

## About this Chapter

ncert biology class 12 solutions pdf chapter 11 Organisms and Populations. Step-by-step coloured solutions for the 2026-27 NCERT (Latest Edition) covering every Exercise question of Class 12th Biology Chapter 11. You will master **population attributes**, the **exponential** and **logistic growth** equations, and the six **interspecific interactions** (mutualism, competition, predation, parasitism, commensalism, amensalism) with worked examples drawn directly from the NCERT textbook.

**Topics covered:** Populations • Population Attributes • Exponential & Logistic Growth • Life History Variation • Population Interactions

**Quick Formula Sheet**

**Population balance equation:** $N_{t+1} = N_t + [(B+I) - (D+E)]$

**Exponential growth (unlimited resources):** $\frac{dN}{dt} = rN \quad \Rightarrow \quad N_t = N_0\, e^{rt}$

**Logistic (Verhulst–Pearl) growth:** $\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$

**Per capita rate:** $r = b - d$ (intrinsic rate of natural increase)

**Also see for this chapter:** Revision Notes | Formula Sheet | Exemplar Solutions

## Exercises

**Q 11.1** **List the attributes that populations possess but not individuals.**

**SOLUTION**

**Concept used.** A **population** is a group of individuals of the same species occupying a defined geographical area, sharing or competing for similar resources, and capable of interbreeding (sexual or asexual). An individual is a single organism. Several measurable properties exist for the population as a whole that cannot logically be defined for a single individual: these are called the **population attributes**. The NCERT chapter (Sec. 11.1.1) explicitly contrasts each attribute against the corresponding individual-level property.

**Step 1.** **Birth rate (natality) and death rate (mortality).** An individual is either born or dies once in its lifetime; only a population can have a *rate* of births and deaths expressed per capita per unit time.
Example from NCERT: if a pond contains 20 lotus plants and 8 new plants are added in a year, then

$$\text{birth rate} = \frac{8}{20} = 0.4 \text{ offspring per lotus per year.}$$

**Step 2.** **Sex ratio.** An individual is either male or female; a population is described by the proportion of males to females (e.g. "60% females, 40% males").

**Step 3.** **Age distribution / Age pyramid.** An individual has one specific age at a given moment, but a population contains individuals of *many* ages. Plotting the percentage of individuals in each age class gives the **age pyramid**, whose shape indicates whether the population is growing, stable or declining (Fig. 11.1).

**Step 4.** **Population density ($N$).** An individual is one organism and cannot have a density; a population has a measurable density, expressed as number of individuals, biomass, or per cent cover per unit area, depending on the species.

**Step 5.** **Population growth rate ($dN/dt$) and intrinsic rate of natural increase ($r$).** An individual cannot grow numerically; only a population can show net change in number. The growth rate couples natality, mortality, immigration and emigration via $N_{t+1} = N_t + [(B + I) - (D + E)]$.

> **Final Answer:** Population-level attributes: *birth rate, death rate, sex ratio, age distribution (age pyramid), population density, and population growth rate (with the intrinsic rate of natural increase $r$).*

### ☞ Two-mark answer

For a 2-mark question simply list the five attributes; for 3–5 marks add one-line definitions and an example for each. Mention the NCERT lotus example (birth rate $= 0.4$/yr) to score the application mark.

**EXPERT'S SOLUTION** *: Aanya Reddy, M.Sc Botany, Delhi University*

**Memory peg.** Whenever a property is a *ratio, rate, or distribution* across many organisms, it belongs to the population, not the individual. That single rule generates the whole list.

The contrast becomes clean when stated as pairs.

- **Individual:** born or dies. **Population:** *birth rate, death rate* (per capita, per unit time).
- **Individual:** male or female. **Population:** *sex ratio*.
- **Individual:** has one age. **Population:** *age distribution / age pyramid* (Fig. 11.1: expanding, stable, declining).
- **Individual:** one organism. **Population:** *density* $N$ (numbers, biomass, or per cent cover).
- **Individual:** no notion of growth in number. **Population:** *growth rate* $dN/dt$ and the *intrinsic rate of natural increase* $r = b - d$.

**Step 1.** Write the four-process balance equation on the answer sheet to anchor the rate idea:

$$N_{t+1} = N_t + \underbrace{(B + I)}_{\text{gain}} - \underbrace{(D + E)}_{\text{loss}}.$$

$B =$ births, $D =$ deaths, $I =$ immigration, $E =$ emigration during the time interval $t \to t + 1$.

**Step 2.** Cite one NCERT-style numeric example to lock the marks: a laboratory fruit fly culture of 40 individuals with 4 deaths in a week gives a death rate $4/40 = 0.1$ per fruit fly per week. The "per fly per week" phrasing only makes sense for a population.

**Step 3.** Close with the age-pyramid distinction: the shape (broad-based expanding, columnar stable, narrow-based declining) is a graphical attribute only the population can have, since a single individual is just a horizontal slice at one age.

**Why this matters.** Population ecology is the bridge between ecology and evolution: natural selection acts on populations (because selection needs differential birth/death rates), which is exactly why these rate attributes are so important.

> **Final Answer:** Population-only attributes: **birth rate, death rate, sex ratio, age distribution, population density, and population growth rate (with the intrinsic rate of natural increase $r$).**

**Q 11.2** **If a population growing exponentially doubles in size in 3 years, what is the intrinsic rate of increase ($r$) of the population?**

SOLUTION

**Concept used.** For a population growing exponentially under unlimited resources, the integral form of the growth equation (NCERT Sec. 11.1.2) is

$$\boxed{N_t = N_0\, e^{rt}},$$

where $N_0$ is the population density at time zero, $N_t$ is the population density after time $t$, $r$ is the **intrinsic rate of natural increase** (with units of time$^{-1}$), and $e = 2.71828\ldots$ is the base of the natural logarithm. "Doubling in size in 3 years" means $N_t = 2N_0$ at $t = 3$ years.

☞ **Logarithm laws used**

$\ln(e^x) = x$ for any real $x$; $\ln(2) = 0.6931$ (a constant worth memorising for exponential-growth problems).

**Step 1.** Write the exponential-growth equation and substitute the doubling condition $N_t = 2N_0$ at $t = 3$:

$$N_t = N_0\, e^{rt} \quad \Longrightarrow \quad 2N_0 = N_0\, e^{r\cdot 3}.$$

**Step 2.** Cancel $N_0$ from both sides (since $N_0 \neq 0$):

$$2 = e^{3r}.$$

**Step 3.** Take the natural logarithm of both sides to bring down the exponent. Using $\ln(e^{3r}) = 3r$:

$$\ln(2) = 3r.$$

**Step 4.** Solve for $r$ and substitute $\ln 2 = 0.6931$:

$$r = \frac{\ln 2}{3} = \frac{0.6931}{3} = 0.2310 \text{ per year.}$$

**Step 5.** **Sanity check.** For the human population in India in 1981 the NCERT text quotes $r = 0.0205$; for the Norway rat $r = 0.015$ and for the flour beetle $r = 0.12$. Our answer $r = 0.23$ per year is roughly an order of magnitude larger than the human value, which makes sense because doubling in just 3 years is much faster than typical human-population doubling (which took $\sim 35$ years at that growth rate).

**Final Answer:** $r = \dfrac{\ln 2}{3} \approx \mathbf{0.2310}\ \text{yr}^{-1}$ (i.e. about **0.231 per individual per year**).

**✗ Common Pitfall**

Do *not* write "$r = N_t/N_0 = 2$" – that is a ratio, not a rate. The intrinsic rate of natural increase $r$ has units of time$^{-1}$, never dimensionless. Always take the logarithm.

**EXPERT'S SOLUTION** : *Pranav Sharma, M.Sc Biotechnology, AIIMS Delhi*

**Strategic angle.** The whole question reduces to "invert $N_t = N_0 e^{rt}$ for $r$ when the doubling time is given". The **doubling-time formula** that drops out is

$$T_d = \frac{\ln 2}{r} \quad \Longleftrightarrow \quad r = \frac{\ln 2}{T_d},$$

which is worth memorising for board and competitive exams (NEET, specifically, has asked questions in 2018 and 2021 that hinge on it).

**Step 1.** State the exponential growth law from NCERT Sec. 11.1.2 explicitly:

$$\frac{dN}{dt} = rN \quad \Longrightarrow \quad N_t = N_0\, e^{rt}.$$

Define each symbol: $r$ is the *per capita* difference of birth and death rates ($r = b - d$), $N_0$ the initial density, $N_t$ the density after time $t$.

**Step 2.** Identify "doubling time" as the time $T_d$ at which $N_t/N_0 = 2$. Substitute into the integrated form:

$$2 = e^{rT_d} \quad \Longrightarrow \quad \ln(2) = rT_d.$$

Hence $r = \dfrac{\ln 2}{T_d}$.

**Step 3.** For this question $T_d = 3$ years, so

$$r = \frac{0.6931}{3} = 0.23103 \text{ yr}^{-1}.$$

Numerator $\ln 2 = 0.6931$; division $0.6931 \div 3 = 0.23103$ (keep four significant figures).

**Step 4.** **Compare with NCERT benchmarks.** The text lists $r$ values: humans (India, 1981) $= 0.0205\,\text{yr}^{-1}$ (doubling time $\approx 34$ yr), Norway rat $= 0.015\,\text{yr}^{-1}$ ($T_d \approx 46$ yr), flour beetle $= 0.12\,\text{yr}^{-1}$ ($T_d \approx 5.8$ yr). At $r = 0.231\,\text{yr}^{-1}$ the population in this question is growing roughly twice as fast as flour beetles in laboratory culture – a very high but not biologically impossible value.

**Why this matters.** The doubling-time relationship is the bridge between the differential equation $dN/dt = rN$ and observable population data; it lets ecologists infer $r$ from a single census-pair without calculus.

**Final Answer:** $r = \dfrac{\ln 2}{3} \approx \mathbf{0.231}\ \text{yr}^{-1}$.

## Q 11.3 Name important defence mechanisms in plants against herbivory.

**SOLUTION**

**Concept used.** Plants cannot run from grazers, so over evolutionary time they have built up two broad classes of **anti-herbivore defences** (NCERT Sec. 11.1.4 under "Predation" for herbivory): physical (morphological) barriers and chemical (toxic/deterrent) compounds. Roughly 25% of all insects are phytophagous, which has driven this defence diversity.

**Step 1. Morphological defences (physical barriers).**

- *Thorns* as in *Acacia* and *Cactus* – modified branches that pierce browsing animals.
- *Spines* (modified leaves), e.g. on *Opuntia* (the prickly pear cactus the NCERT chapter cites as having invaded Australia in the 1920s before being controlled by a moth predator).
- *Sharp silica-rich edges* on the leaves of grasses, making them abrasive to mouthparts.
- *Trichomes (hairs) and stinging cells*, e.g. on *Urtica dioica* (nettle).

**Step 2. Chemical defences (secondary metabolites).**

- *Cardiac glycosides* produced by *Calotropis*, which is why cattle and goats refuse to browse on it (NCERT-specific example).
- *Alkaloids* such as **nicotine** (tobacco), **caffeine** (coffee), **quinine** (*Cinchona*), **strychnine** (*Strychnos*), **opium** (poppy) – listed explicitly in NCERT as chemicals evolved against grazers and browsers.
- *Tannins* – astringent polyphenols that inhibit digestion in vertebrates.
- *Terpenoids and essential oils* that deter feeding or disrupt insect reproduction.

**Step 3. What these chemicals can do to the herbivore.**

- Cause sickness on eating (cardiac glycosides slow the heart).
- Inhibit feeding or digestion (tannins bind dietary protein).
- Disrupt insect reproduction.
- In high doses, kill the herbivore outright (strychnine).

> **Final Answer:** **Morphological:** thorns, spines, prickles, trichomes, silica edges. **Chemical:** cardiac glycosides (*Calotropis*), nicotine, caffeine, quinine, strychnine, opium and other alkaloids, tannins, terpenoids.

### ☞ Two-bucket layout

Always organise the answer into the two NCERT-named buckets – *morphological* (thorns, spines, trichomes, silica) and *chemical* (alkaloids, glycosides, tannins). Name *Acacia* and *Calotropis* explicitly; both appear in the NCERT chapter and score the textbook-example mark.

**EXPERT'S SOLUTION** *: Karan Iyer, M.Sc Biotechnology, AIIMS Delhi*

**Structural angle.** Plants face a unique problem – they cannot run. Every defensive trait they have evolved either raises the cost of an attack (mechanical barriers) or lowers the value of the meal (chemical deterrents). Group the answer into these two evolutionary classes the NCERT chapter explicitly names, and supply a textbook example for each.

**Step 1.** **Morphological line – physical barriers.** Lead with the most familiar examples – *thorns* of *Acacia* and *Cactus*, which the textbook names side-by-side. Add *spines* (modified leaves on cacti), *prickles* (outgrowths of the stem epidermis as in roses), *trichomes / stinging hairs* (e.g. on the nettle *Urtica dioica*), and tough *silica-rich leaf margins* of grasses. Each device works by raising the energetic or physical cost of feeding – torn mouths, slower mastication, wear on tooth enamel.

**Step 2.** **Chemical line – secondary metabolites.** Cite *Calotropis* producing *cardiac glycosides* as the flagship NCERT example. The chapter explicitly says this is why "you never see any cattle or goats browsing on this plant". Then list the named alkaloids the textbook calls out: *nicotine* (tobacco), *caffeine* (coffee/tea), *quinine* (*Cinchona*), *strychnine* (*Strychnos*), *opium* (poppy). Add tannins and terpenoids for completeness.

**Step 3.** **Mechanisms by which chemicals act on the herbivore.**

- Make the herbivore sick on eating (cardiac glycosides slow the heart).
- Inhibit feeding (bitter tannins).
- Disrupt digestion (tannins bind dietary protein).
- Disrupt insect reproduction or development.
- Kill the herbivore at high doses (strychnine, certain alkaloids).

**Step 4.** **Evolutionary context – the extra-mark close.** About 25% of all insect species are phytophagous and plants cannot flee, so the evolutionary pressure has been intense. This has generated one of the most diverse classes of secondary metabolites known. Many compounds (caffeine, quinine, opium, morphine) are commercially extracted by humans for unrelated uses, but evolved originally as anti-herbivore weapons.

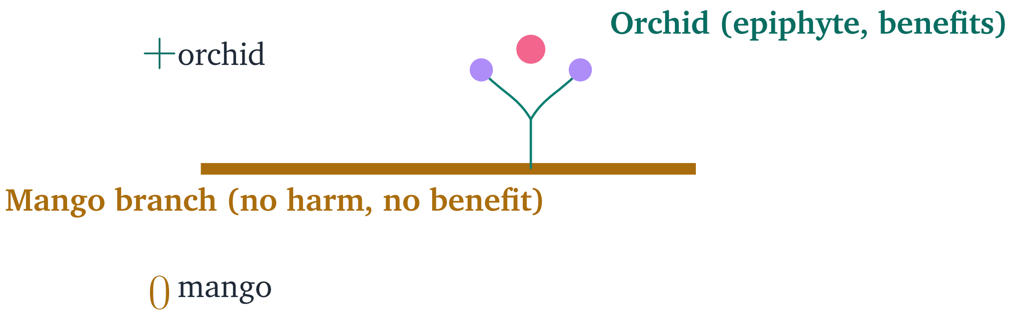
**Why this matters.** The chemicals plants evolved as anti-herbivore defences are the raw material of pharmacology: morphine, atropine, artemisinin, digitalis and many anti-cancer agents all began life as plant defences. Crop breeders also actively select *against* such chemicals (to make the crop edible) and *for* morphological defences (silica leaf-edges in rice, glands in cotton).

> **Final Answer: Morphological:** thorns (*Acacia*, cactus), spines, prickles, trichomes, silica edges. **Chemical:** cardiac glycosides (*Calotropis*), alkaloids (nicotine, caffeine, quinine, strychnine, opium), tannins, terpenoids.

**Q 11.4** **An orchid plant is growing on the branch of mango tree. How do you describe this interaction between the orchid and the mango tree?**

SOLUTION

**Concept used.** **Commensalism** is the interspecific interaction in which one species is benefitted $(+)$ and the other is neither benefitted nor harmed $(0)$. NCERT Sec. 11.1.4 lists six possible interspecific interactions ranked by their $+$, $-$, $0$ signs; the $(+, 0)$ combination defines commensalism. The orchid in this question is an **epiphyte** – a plant that grows attached to another plant, using it only for physical support, not for nutrition.




**Step 1.** **Identify the orchid's gain.** The orchid uses the mango branch as a perch high up in the canopy. This gives it (i) unobstructed access to sunlight for photosynthesis, (ii) better air circulation around its aerial roots, and (iii) escape from terrestrial herbivores and waterlogging on the forest floor.

**Step 2.** **Verify the mango is unaffected.** The orchid is an *epiphyte*, not a **parasite**: it does not penetrate the mango's vascular tissue, does not extract sap, and does not steal nutrients. Its roots only cling to the bark. The mango therefore neither gains nor loses anything material from the association.

**Step 3.** **Read off the interaction sign and name.** With orchid $= +$ and mango $= 0$, the NCERT table (Table 11.1) directly assigns the name **commensalism**.

> **Final Answer:** The orchid–mango interaction is **commensalism**: the orchid (epiphyte) is benefitted while the mango tree is neither benefitted nor harmed.

**♥ Sign-table thinking**

Always reach for Table 11.1 mentally before naming an interaction. Once you fix the sign for each partner you cannot misclassify: $(+,+)$ mutualism, $(-,-)$ competition, $(+,-)$ predation/parasitism, $(+,0)$ commensalism, $(-,0)$ amensalism.

**EXPERT'S SOLUTION** *: Sneha Kapoor, Ph.D Molecular Biology, NCBS Bangalore*

**Sign-table angle.** Treat every species-interaction question as a two-step process: (1) assign a $+$, $-$, or $0$ to each partner, then (2) look up the row in the interaction matrix (NCERT Table 11.1). The algorithm cannot go wrong if you do these two steps in order.

**Step 1.** **Partner A – the orchid.** An orchid is an *epiphyte*: a plant that grows attached to another plant, purely for support, with no nutritional dependency. Perched on the mango branch, it gains (i) canopy-level sunlight (vital for photosynthesis), (ii) good air circulation around its aerial roots (orchids absorb atmospheric moisture through specialised velamen tissue), and (iii) refuge from terrestrial herbivores, ground floods and leaf-litter rot. Without the mango it would have to grow at ground level with much less light. Hence the orchid is benefitted: assign **orchid** $= +$.

**Step 2.** **Partner B – the mango.** The orchid's roots cling to the bark but *do not* penetrate the cambium, xylem or phloem. It does not extract sap, nutrients or water from the mango. Therefore the mango neither gains (no service rendered) nor loses (no resource stolen). Assign **mango** $= 0$.

**Step 3.** **Look up the interaction matrix.** The pair $(+,0)$ appears in NCERT Table 11.1 against exactly one row: **commensalism**. No ambiguity.

**Step 4.** **Cite parallels from the NCERT chapter** to lock the application mark. Two other $(+,0)$ pairs the textbook lists: (i) the *cattle egret* foraging beside grazing cattle (egret $= +$, cattle $= 0$ – the cattle stir up insects the egret eats, but lose nothing), and (ii) *barnacles* on the back of a whale (barnacles $= +$, whale $= 0$ – barnacles get a free ride through nutrient-rich waters, the whale is unaffected). Naming any one parallel is a reliable way to earn the application mark.

**Step 5.** **Contrast with parasitism.** If the orchid *were* a parasite (e.g. *Cuscuta*, the dodder, which the NCERT chapter explicitly cites), it would pierce the host's vascular tissue with *haustoria* to extract sap; the host would weaken; the sign pair would be $(+,-)$ and the name would be parasitism. The fact that an orchid does *not* have haustoria is the diagnostic distinction.

**Why this matters.** Distinguishing commensalism from parasitism hinges on asking one focused question: *is the host losing anything?* If yes, it is parasitism. If no, it is commensalism. The orchid–mango case is the standard textbook benchmark for the "no, the host loses nothing" branch of this decision.

> **Final Answer: Commensalism** – the orchid (epiphyte) is benefitted, the mango tree is unaffected. Sign pair $(+, 0)$, NCERT Table 11.1.

**Q 11.5** **What is the ecological principle behind the biological control method of managing with pest insects?**

**SOLUTION**

**Concept used.** **Biological control** (or biocontrol) is the use of one species (the natural enemy) to regulate the population of another (the pest). The underlying ecological principle, stated in NCERT Sec. 11.1.4 under "Predation", is that *predators keep prey populations under control*: in the absence of natural enemies, prey species can attain very high densities and cause ecosystem instability, but the **prudent predator** keeps prey numbers around a sustainable equilibrium.

**Step 1.** **The principle.** A predator, parasitoid or pathogen that feeds on a target pest species, when introduced into a habitat where the pest has no natural enemies, reduces the pest's population density through density-dependent mortality. As the pest density falls, the predator's reproduction also falls (because food is scarcer), so the system tends to settle into a low-density equilibrium rather than driving the pest extinct.

**Step 2.** **The flagship NCERT example.** The prickly pear cactus *Opuntia* was introduced into Australia in the early 1920s and spread into millions of hectares of rangeland because its natural predators were absent. The invasion was finally controlled only after a cactus-feeding moth (*Cactoblastis cactorum*) was imported from *Opuntia*'s native habitat – a textbook demonstration that predator pressure can hold a runaway pest at manageable levels.

**Step 3.** **Why biocontrol is preferred over chemical control.**

- It is species-specific – the natural enemy targets the pest, sparing non-target species.
- It is self-sustaining – once established, the predator reproduces and disperses on its own.
- It avoids chemical residues in food and water.
- It cannot generate "resistance" the way insecticides do.

**Step 4.** **Caveat the NCERT chapter implies.** A predator that is too efficient (over-exploits the prey) drives the prey extinct, and then itself dies of starvation. Biocontrol species must therefore be screened to be *specialist* (won't attack non-pest natives) and *prudent* (regulating, not eradicating, the pest).

**Final Answer:** The ecological principle is that **predators (or parasitoids/pathogens) regulate prey populations**; releasing a host-specific natural enemy of a pest holds its density below the damage threshold without chemical pesticides. NCERT example: *Cactoblastis* moth controlling *Opuntia* cactus in Australia.

### ☞ Score the application mark

For a 3-mark version of this question, write the principle (1 mark), name one example (1 mark), and add one advantage of biocontrol over chemical pesticides (1 mark). The *Cactoblastis–Opuntia* pair from NCERT is the safest example to cite.

**EXPERT'S SOLUTION** *: Aditya Bhat, M.Sc Zoology, Banaras Hindu University*

**Quick reading.** Biocontrol = *the predation principle* applied to agriculture. The pest is the prey, the released agent is the predator (or parasitoid or pathogen), and the goal is to keep the pest below the *economic injury threshold* – not zero, but low enough that crop loss is acceptable.

**Step 1.** **State the principle.** In nature, predators control prey densities through density-dependent feeding: more prey ⇒ more predation, fewer prey ⇒ less predation. This negative-feedback loop is what stabilises prey numbers. Biocontrol deliberately reproduces this loop in a crop field by importing or releasing a host-specific natural enemy of the pest.

**Step 2.** **Anchor with the NCERT example.** *Opuntia* (prickly pear cactus) was introduced into Australia in the early 1920s. With no natural predator present, it spread across millions of hectares of rangeland – an exponential, J-shaped invasion. The moth *Cactoblastis cactorum*, imported from *Opuntia*'s native habitat in Argentina, lays eggs on the cactus pads; the caterpillars bore into and consume the cactus tissue. Within a few years cactus density was driven back to manageable levels. This is the canonical illustration of predation-based control.

**Step 3.** **Add a second, modern example to widen the answer.** The soil bacterium *Bacillus thuringiensis* (Bt) is sprayed on cotton and brinjal to kill lepidopteran larvae through its crystal toxin (Cry protein). The same predation principle applies, with the "predator" replaced by a pathogenic bacterium. Modern transgenic Bt cotton has the Cry gene engineered directly into the plant.

**Step 4.** **Caveat the chapter explicitly teaches.** A predator that is *too efficient* drives the prey extinct and then collapses for lack of food. NCERT states "predators in nature are *prudent*". Biocontrol agents are therefore screened in advance for two properties: (a) *host-specificity* (they will not attack non-pest native species), and (b) *prudence* (they regulate, not eradicate). This is why exotic biocontrol introductions are preceded by years of host-range testing in quarantine.

**Step 5.** **Add the diversity-protecting role for the extra mark.** NCERT mentions Paine's classic Pacific intertidal experiment: removing the starfish *Pisaster* caused more than 10 invertebrate species to go extinct within a year due to interspecific competition. Predators thus also protect biodiversity, not just suppress one prey species.

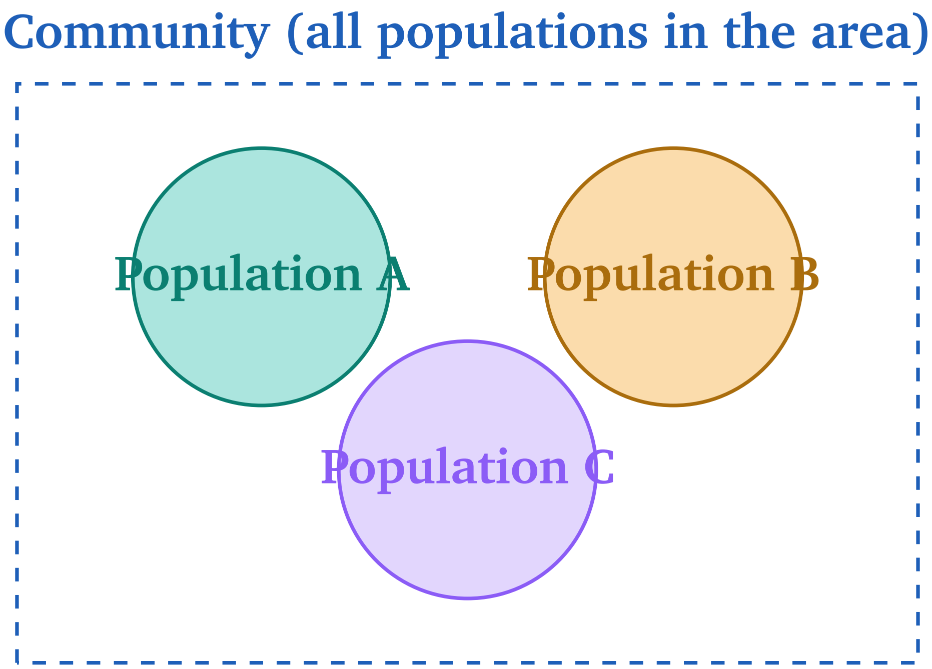
**Why this matters.** Biocontrol is the foundation of modern **integrated pest management** (IPM), which combines biological, cultural and minimal-chemical methods to keep pests below the economic injury threshold while protecting non-target organisms, pollinators and soil microbiota.

> **Final Answer: Predators regulate prey populations.** Biological pest control releases a host-specific natural enemy (predator, parasitoid or pathogen) of the pest, exploiting this regulatory predation pressure to suppress the pest below the damage threshold. NCERT example: the *Cactoblastis* moth controlling *Opuntia* in Australia.

## Q 11.6 Define population and community.

**SOLUTION**

**Concept used.** The NCERT chapter opens with the hierarchy of biological organisation: macromolecules → cells → tissues → organs → organisms → **populations** → **communities** → ecosystems → biomes. "Population" and "community" are the two levels Chapter 11 deals with; their definitions follow directly from Sec. 11.1.1 (population) and the introduction to Sec. 11.1.4 (community).




**Step 1. Population (definition).** A population is a group of individuals of the *same species* that live in a well-defined geographical area, share or compete for similar resources, and can potentially interbreed (sexual or asexual). NCERT examples: all the cormorants in a wetland; all the rats in an abandoned dwelling; all the teakwood trees in a forest tract; all the bacteria in a culture plate; all the lotus plants in a pond.

**Step 2. Community (definition).** A community (also called a **biological community** or **biotic community**) is an assemblage of *populations of different species* that occupy the same area at the same time and interact through feeding, competition, mutualism, etc. The community is the level at which interspecific interactions (mutualism, predation, parasitism, commensalism, amensalism, competition) operate.

**Step 3. Key distinction.** Population is intra-specific (one species); community is inter-specific (many species sharing one habitat).

> **Final Answer: Population:** group of individuals of the same species sharing a defined area and capable of interbreeding.
> **Community:** assemblage of all populations of different species that occupy and interact in the same area at the same time.

☞ **Hierarchy of biological organisation**

NCERT lists this hierarchy in order of increasing scale: macromolecules → cells → tissues → organs → individual organisms → *populations* → *communities* → ecosystems → biomes. Population and community are the two adjacent levels Chapter 11 unpacks.

**EXPERT'S SOLUTION** : *Rohit Verma, M.Sc Botany, Delhi University*

**Definition-pair angle.** Write the two definitions as a deliberate contrast: emphasise "*same species, one area*" for population and "*many species, one area*" for community. Examiners explicitly look for both phrases.

**Step 1.** **Population – full definition.** A population is a group of individuals of *one species* living together in a well-defined geographical area, sharing or competing for similar resources, and capable of interbreeding (sexual or, by extension in ecological usage, asexual). It is the basic unit of *intraspecific* (within-species) ecology and the unit on which natural selection acts (different birth/death rates among sub-groups within the population).

**Step 2.** **NCERT-listed population examples.** Cormorants in a wetland; rats in an abandoned dwelling; teakwood trees in a forest tract; bacteria in a culture plate; lotus plants in a pond. Pick any one for the example mark.

**Step 3.** **Community – full definition.** A community (or biological/biotic community) is the assemblage of *all populations of different species* that occupy the same area at the same time and interact through feeding, competition, mutualism, parasitism, etc. It is the unit of *interspecific* (between-species) ecology.

**Step 4.** **Community-level example.** A pond community contains lotus plants (Population A), fishes (Population B), algae, zooplankton, frogs and aquatic insects (further populations) – all interacting through predation (fish eat zooplankton), competition (algae compete with lotus for light) and other relationships.

**Step 5.** **Key distinction – one-line memory peg.** Population is *intra*specific (one species, many individuals); community is *inter*specific (many species sharing one habitat).

**Step 6.** **Where each fits in Chapter 11.** The population-level section (11.1.1–11.1.3) covers attributes, growth and life history. The community-level section (11.1.4 onwards) covers the six interspecific interactions. Together they set up Chapter 12 (Ecosystem), which adds the abiotic compartment.

**Why this matters.** Diagnosing the level (population vs community) is a recurring exam skill: "the orchid–mango interaction" is a population-pair question (commensalism), while "the forest floor biodiversity of the Western Ghats" is a community-level question (interspecific interaction web). Read the question once and identify the level before writing.

**Final Answer: Population:** group of individuals of one species in a defined geographical area, sharing resources and capable of interbreeding.
**Community:** assemblage of all populations of different species in the same area, interacting through ecological processes.

**Q 11.7 Define the following terms and give one example for each:**
**(a) Commensalism**
**(b) Parasitism**
**(c) Camouflage**
**(d) Mutualism**
**(e) Interspecific competition**

**SOLUTION**

**Concept used.** All five terms come from NCERT Sec. 11.1.4 (Population Interactions). Four of them ((a), (b), (d), (e)) appear in Table 11.1 with assigned $+/-/0$ signs; (c) camouflage is a prey-defence trait that arises out of predation pressure and is discussed in the "Predation" subsection. Treat each part as a one-line definition + one NCERT example.

**Step 1. (a) Commensalism.** An interaction in which one species is benefitted (+) and the other is neither benefitted nor harmed (0). *Example:* an **orchid** growing as an epiphyte on a mango tree branch – the orchid gets a perch in the canopy; the mango is unaffected. (Other NCERT examples: cattle egret beside grazing cattle; barnacles on the back of a whale; clownfish among the tentacles of a sea anemone.)

**Step 2. (b) Parasitism.** An interaction in which one species (the parasite) is benefitted (+) by deriving nourishment and shelter from another species (the host), which is harmed (−). Parasites often reduce host survival, growth and reproduction and make the host more vulnerable to predation. *Example:* the **human liver fluke** (a trematode) parasitises the human liver and uses a snail and a fish as intermediate hosts. (Other NCERT examples: lice on humans, ticks on dogs, *Cuscuta* on hedge plants, malarial parasite in human RBCs, cuckoo brood parasitism on the crow.)

**Step 3. (c) Camouflage.** A morphological prey-defence strategy in which the body colour, pattern or shape blends with the background, making the animal cryptically coloured and hard for a predator to detect. *Example:* the NCERT chapter cites "some species of **insects and frogs** are cryptically-coloured (camouflaged) to avoid being detected easily by the predator". The leaf insect

(*Phyllium*) and the stick insect (*Phasmida*) are classic illustrations.

**Step 4.** **(d) Mutualism.** An interaction in which *both* species benefit $(+,+)$. *Example:* the **lichen** – an intimate mutualism between a fungus (provides anchorage, moisture, mineral salts) and a photosynthesising alga or cyanobacterium (provides organic carbon from photosynthesis). The NCERT chapter also highlights the fig–wasp one-to-one mutualism (Fig. 11.4) and **mycorrhizae** (fungus-root associations) as flagship examples.

**Step 5.** **(e) Interspecific competition.** A $(-,-)$ interaction in which two species compete for the same limited resource (food, space, mates, light), with the fitness of each species reduced in the presence of the other. *Example:* the visiting **flamingoes** and resident **fishes** in shallow South American lakes compete for their common food, the zooplankton. (Other NCERT examples: the barnacles *Balanus* and *Chathamalus* on rocky Scottish coasts where *Balanus* excludes *Chathamalus* from the intertidal zone; the Abingdon tortoise vs introduced goats in Galápagos.)

> **Final Answer:** (a) Commensalism – orchid on mango branch. (b) Parasitism – liver fluke in human liver. (c) Camouflage – cryptically coloured frogs and insects. (d) Mutualism – lichens (fungus + alga). (e) Interspecific competition – flamingoes vs fishes for zooplankton.

### ✗ Common Pitfall

Do not confuse *interspecific* (between two different species) with *intraspecific* (between individuals of the same species) competition. Chapter 11's interaction table is built only for interspecific cases.

### EXPERT'S SOLUTION : *Diya Joshi, M.Sc Microbiology, JNU*

**Sign-table angle.** For each interaction-type part, the marker expects two things: (i) a one-line definition that names the $+/-/0$ sign pair, and (ii) one named NCERT example. Stick to the textbook examples – they are the safest under board marking schemes.

**Step 1.** **(a) Commensalism** $(+,0)$**.** One species benefits, the other is neither benefitted nor harmed. *Orchid on a mango branch* – the orchid (epiphyte) gains a canopy perch and sunlight; the mango is unaffected because the orchid does not pierce its vascular tissue. Backup textbook examples: cattle egret beside grazing cattle, barnacles on a whale, clownfish among sea-anemone tentacles.

**Step 2.** **(b) Parasitism** $(+,-)$**.** The parasite gains nourishment and shelter; the host is harmed (reduced survival, growth, reproduction; may become more vulnerable to predation). The *human liver fluke*, a trematode that depends on two intermediate hosts (a snail and a fish) to complete its life cycle, is the cleanest NCERT example. Backup examples: lice on humans, ticks on dogs, *Cuscuta* on hedge plants, *Plasmodium* (malarial parasite) in human RBCs, and brood parasitism by the cuckoo on the crow.

**Step 3.** **(c) Camouflage.** Note: camouflage is a *prey-defence trait*, not a sign-pair interaction; it does not appear in Table 11.1. It is the cryptic colouration, pattern or shape that hides prey from predators. Use NCERT's phrase: "some species of *insects and frogs* are cryptically-coloured (camouflaged) to avoid being detected easily by the predator". Backup examples: leaf insect (*Phyllium*), stick insect (*Phasmida*), the polar bear's white coat.

**Step 4.** **(d) Mutualism** $(+, +)$**.** Both species benefit. Three flagship NCERT examples, any one of which suffices: *lichens* (fungus provides anchorage and water; alga or cyanobacterium provides organic carbon from photosynthesis); *mycorrhizae* (fungi help plant roots absorb nutrients; plant supplies sugars); *fig–wasp* (one-to-one species-specific relationship, Fig. 11.4 – wasp pollinates fig; fig provides developing seeds as food for wasp larvae).

**Step 5.** **(e) Interspecific competition** $(-, -)$**.** Two species compete for the same limited resource (food, space, mates, light); each species' fitness, measured by its intrinsic rate of increase $r$, is reduced in the presence of the other. The *flamingo–fish* case in shallow South American lakes – both compete for the zooplankton – is short, neat and directly NCERT-quoted. Backup examples: *Balanus* excluding *Chathamalus* (Connell's barnacle experiment on rocky Scottish coasts), and the Abingdon tortoise vs introduced goats in Galápagos.

**Step 6.** **Score-maximising format.** Lay out the answer as a labelled list – (a)..., (b)..., (c)..., (d)..., (e)... – with the definition and example on separate lines. This gives the examiner discrete bullet points to tick off and is the safest way to lock 5 of 5 marks.

**Why this matters.** The five terms cover four of the six rows of Table 11.1 (commensalism, parasitism, mutualism, competition) plus one prey-defence trait (camouflage). They commonly appear together in 5-mark "define and give example" questions on board papers.

> **Final Answer:** (a) Orchid on mango (commensalism); (b) liver fluke (parasitism); (c) cryptically coloured frogs/insects (camouflage); (d) lichens (mutualism); (e) flamingoes vs fishes (interspecific competition).

**Q 11.8** **With the help of suitable diagram describe the logistic population growth**

**curve.**

SOLUTION

**Concept used.** In nature no habitat has truly unlimited resources, so exponential growth cannot continue indefinitely. As density rises, **intraspecific competition** for finite food and space slows down the per-capita growth rate. The **Verhulst–Pearl logistic growth equation** (NCERT Sec. 11.1.2 (ii)) captures this:

$$\boxed{\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)},$$

where $N$ is the population density at time $t$, $r$ is the intrinsic rate of natural increase, and $K$ is the **carrying capacity** of the habitat (the maximum population the environment can sustain).

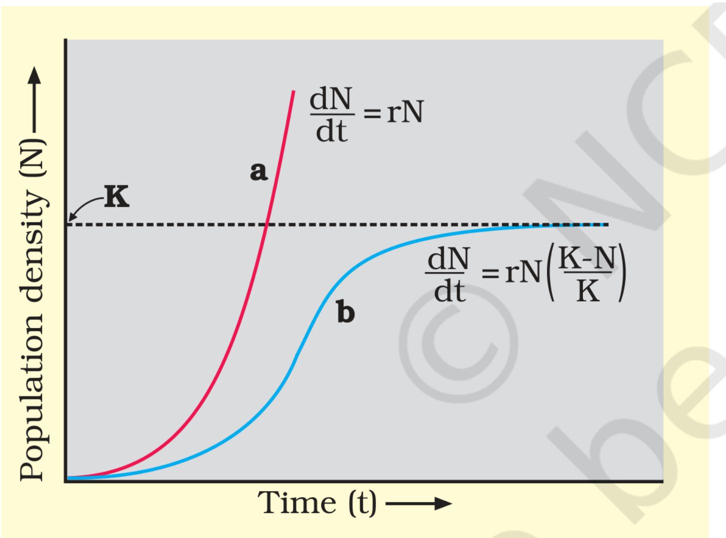



*Fig. 11.3 from NCERT Class 12 Biology, Chapter 11. Curve **a** = exponential growth ($dN/dt = rN$); Curve **b** = logistic growth ($dN/dt = rN(K-N)/K$); $K$ = carrying capacity.*

**Step 1. Read the limiting factor $(K - N)/K$.**

- When $N$ is very small compared to $K$, the bracket $(K - N)/K \approx 1$, so $dN/dt \approx rN$ – the logistic curve is indistinguishable from exponential growth.
- When $N \to K$, the bracket $\to 0$, so $dN/dt \to 0$ and growth stops.
- When $N = K/2$, $(K - N)/K = 1/2$, and the instantaneous growth rate $dN/dt = rN/2$ is at its *maximum* (the inflection point of the curve).

**Step 2. Describe the four phases of the sigmoid (S-shaped) curve** visible in Fig. 11.3 (Curve b).

- **Phase 1 – Lag phase.** The population establishes in the habitat; density rises slowly because the few individuals reproduce gradually.
- **Phase 2 – Acceleration (log/exponential) phase.** As $N$ rises but resources

are still abundant ($K - N \approx K$), growth accelerates rapidly and approximates exponential growth.

- **Phase 3 – Deceleration phase.** As $N$ approaches $K$, resources become limiting; competition, disease and emigration rise; per-capita growth rate falls.
- **Phase 4 – Stationary (asymptote) phase.** The population fluctuates around $K$; births and deaths balance, so $dN/dt \approx 0$.

**Step 3. Sketch result.** Plotting $N$ against time $t$ produces a *sigmoid* (S-shaped) curve that flattens at $N = K$. Compare with Curve a in Fig. 11.3, where unlimited resources produce a J-shaped exponential rise that never plateaus.

**Step 4. Sanity check.** For all real animal populations, resources are finite – NCERT explicitly states "the logistic growth model is considered a more realistic one" for natural populations, whereas exponential growth describes only initial colonisation or laboratory conditions.

**Final Answer:** The logistic population growth curve is described by $\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$. A plot of $N$ vs $t$ gives a **sigmoid (S-shaped)** curve with four phases – lag, acceleration, deceleration and stationary (asymptote at $N = K$) – because finite resources limit growth to the carrying capacity $K$.

### ♥ Where you'll meet logistic growth again

The logistic equation is the foundation of (i) fisheries management (maximum sustainable yield is at $N = K/2$), (ii) conservation biology (setting recovery targets relative to $K$), and (iii) epidemic models (the early COVID growth phase was roughly exponential; the plateau is logistic).

**EXPERT'S SOLUTION** : *Ananya Nair, Ph.D Molecular Biology, NCBS Bangalore*

**Picture-first.** The simplest way to remember the logistic curve is to draw the J-curve first (exponential), then bend it over horizontal when it hits the dashed $K$ line. The result is the S-curve (sigmoid). This visual trick makes the description impossible to forget.

**Step 1. Build the equation by inspection.** Start from the exponential law $dN/dt = rN$. Multiply the right-hand side by a bracket chosen to satisfy two boundary conditions: it must equal $1$ at $N = 0$ (so logistic matches exponential at low density) and equal $0$ at $N = K$ (so growth stops at the carrying capacity). The simplest bracket satisfying both is $(K - N)/K$. Substituting,

$$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right).$$

That *is* the Verhulst–Pearl logistic equation. This construction explains why it has exactly the right asymptote.

**Step 2. Identify the four phases on the S-curve** visible in Fig. 11.3 (Curve b). Lag → Acceleration → Deceleration → Stationary. Mark each on your hand-drawn S-curve before writing the description. Each phase scores 0.5 mark in board marking schemes, so all four must appear.

- *Lag phase*: few individuals, slow gross increase.
- *Acceleration phase*: density rises rapidly, $(K - N)/K \approx 1$, growth ≈ exponential.
- *Deceleration phase*: density approaches $K$, $(K - N)/K \to 0$, growth slows.
- *Stationary phase*: $N = K$, births balance deaths, $dN/dt \approx 0$.

**Step 3. Find the inflection point.** Differentiate $dN/dt$ with respect to $t$ and set the result to zero; this yields the inflection condition $N = K/2$. At that density the instantaneous growth rate is maximum:

$$\left(\frac{dN}{dt}\right)_{\text{max}} = r \cdot \frac{K}{2} \cdot \frac{K - K/2}{K} = \frac{rK}{4}.$$

This $N = K/2$ point is the famous *maximum sustainable yield* of fisheries science – the best harvesting density a manager can target without driving the stock toward collapse.

**Step 4. Contrast with exponential (Curve a in Fig. 11.3).** Exponential growth assumes unlimited resources: $dN/dt = rN$, $N_t = N_0e^{rt}$, J-shaped curve, indefinite rise. Logistic assumes finite resources: $dN/dt = rN(K - N)/K$, $N$ asymptotes at $K$, S-shaped sigmoid. NCERT calls logistic "more realistic" for natural populations because every real habitat eventually runs out of food, space or both.

**Step 5. NCERT-cited applications.** The chapter encourages students to plot India's census data over the last 100 years and check the growth pattern – early decades approximate exponential growth, recent decades show deceleration as India's effective $K$ becomes limiting (resources, agriculture, urban land).

**Why this matters.** The shape of a population's growth curve (J vs S) tells an ecologist whether the species is in early colonisation ($J$) or near its carrying capacity ($S$). The bend is what makes the logistic curve diagnostic, and the maximum-yield point at $N = K/2$ is the bridge from ecology to fisheries management, harvesting regulations and recovery targets in conservation biology.

**Final Answer:** Logistic (Verhulst–Pearl) growth: $\frac{dN}{dt} = rN(K - N)/K$. S-shaped sigmoid curve with four phases – lag, acceleration, deceleration, stationary – plateauing at the carrying capacity $K$; maximum growth rate $rK/4$ at $N = K/2$.



**Q 11.9 Select the statement which explains best parasitism.**

**(a) One organism is benefited.**

**(b) Both the organisms are benefited.**

**(c) One organism is benefited, other is not affected.**

**(d) One organism is benefited, other is affected.**

SOLUTION

**Concept used.** The six interspecific interactions in NCERT Table 11.1 are distinguished by the $(+/-/0)$ sign for each partner. Parasitism is defined as the interaction in which the parasite is benefitted $(+)$ by deriving nourishment and shelter, while the host is harmed $(-)$. The textbook explicitly notes that "majority of the parasites harm the host; they may reduce the survival, growth and reproduction of the host". Hence option (d), "one organism is benefited, other is affected (harmed)", is the correct match.

Step 1. **Decode each option against the sign table.**

- (a) "one organism is benefited" – incomplete; matches multiple categories (commensalism, predation, parasitism) because it doesn't say what happens to the other. **Reject.**
- (b) "both are benefited" $\rightarrow (+, +)$ **= mutualism**, not parasitism. **Reject.**
- (c) "one benefited, other unaffected" $\rightarrow (+, 0)$ **= commensalism**, not parasitism. **Reject.**
- (d) "one benefited, other affected (harmed)" $\rightarrow (+, -)$ **= parasitism. Accept.**

Step 2. **Reconfirm with a textbook example.** The human liver fluke (trematode) benefits by deriving nourishment from the human host's liver; the host suffers reduced liver function and weakened health. The interaction is therefore $(+, -)$, matching only option (d).

**Final Answer:** Correct answer: **(d) One organism is benefited, other is affected.**

✗ **Distractor trap**

Option (a) "one organism is benefited" is the most tempting wrong answer because it sounds parasitic. It is rejected not because it is false, but because it is *incomplete*: $(+,+)$ mutualism, $(+,0)$ commensalism and $(+,-)$ parasitism all share that opening clause. Always pick the option that names both partners' sign.

**EXPERT'S SOLUTION** *: Ishaan Desai, M.Sc Biotechnology, AIIMS Delhi*

**Elimination angle.** The fastest MCQ strategy for species-interaction questions is to convert each option into a $(+/-/0)$ sign-pair and match it against NCERT Table 11.1. Among the six interactions in the table, exactly one row has the pair $(+,-)$ that is offered here as an option and is named parasitism (predation also has $(+,-)$, but predation is not among the choices).

**Step 1.** **Decode option (a).** "One organism is benefited." This sentence is incomplete – it does not say what happens to the other partner. The pair could be $(+,+)$, $(+,0)$, or $(+,-)$ – i.e. mutualism, commensalism, or parasitism/predation. **Reject (a)** for being underspecified.

**Step 2.** **Decode option (b).** "Both are benefited." This is the sign pair $(+,+)$, which Table 11.1 names *mutualism* (lichens, mycorrhizae, fig–wasp). Wrong category for parasitism. **Reject (b).**

**Step 3.** **Decode option (c).** "One benefited, other unaffected." Sign pair $(+,0)$, which Table 11.1 names *commensalism* (orchid on mango, cattle egret with cattle). Wrong category for parasitism. **Reject (c).**

**Step 4.** **Decode option (d).** "One benefited, other affected (harmed)." Sign pair $(+,-)$. In Table 11.1 this matches two rows – parasitism and predation. Since predation is not offered and parasitism is, option (d) is the unique correct match. **Accept (d).**

**Step 5.** **Reality check with a textbook example.** *Plasmodium* (the malarial parasite) in human RBCs: the parasite gains nutrition and a site for reproduction; the host suffers fever, anaemia and, in severe cases, organ failure. The sign pair $(+,-)$ is unambiguous, confirming option (d). Other NCERT examples that fit the same pair: the human liver fluke; *Cuscuta* on hedge plants; lice on humans; ticks on dogs.

**Step 6.** **Common trap to avoid.** Some students pick option (a) because it "sounds parasitic". Option (a) is not wrong, it is just *insufficiently specific*; a multiple-choice question rewards the option that contains the full diagnostic information, which is (d).

**Why this matters.** Sign-pair thinking turns every species-interaction MCQ into a one-step lookup; you do not need to memorise the names if you can read the $+/-/0$

pair off the option text. This is a particularly useful tactic in NEET, where the same distractor pattern (one correct option + one underspecified-but-tempting option) recurs.

> **Final Answer: (d)** One organism is benefited, other is affected. The sign pair is $(+,-)$, matching *parasitism* in NCERT Table 11.1.

**Q 11.10** **List any three important characteristics of a population and explain.**

**SOLUTION**

**Concept used.** A **population** has measurable attributes (NCERT Sec. 11.1.1) that an individual does not. Three of the most important are **population density**, **natality and mortality (birth and death rates)** and **age distribution** (the age pyramid). Each is defined and then explained with an NCERT example.

**Step 1.** **1. Population density ($N$).** *Definition.* The size of the population per unit area or volume at a given time. NCERT denotes it $N$.
*Measurement.* It may be expressed as (i) total number of individuals, (ii) per cent cover, (iii) biomass, or (iv) an indirect index such as pug marks or fecal pellets (used in tiger census). The choice depends on the species – a single banyan tree with a vast canopy is functionally more important than 200 carrot grass plants, so per-cent cover or biomass is a better measure for trees.
*Why it matters.* Density is the single number against which all ecological processes – competition, predation, pesticide impact – are evaluated.

**Step 2.** **2. Natality and mortality (birth and death rates).** *Definition.* Natality is the number of births per individual per unit time; mortality is the number of deaths per individual per unit time. Both are *per capita* quantities.
*Example (NCERT).* If a pond had 20 lotus plants last year and 8 new plants are added this year through reproduction, the birth rate is

$$\text{birth rate} = \frac{8}{20} = 0.4 \text{ offspring per lotus per year.}$$

Similarly, 4 deaths out of 40 lab fruit flies in one week gives

$$\text{death rate} = \frac{4}{40} = 0.1 \text{ deaths per fly per week.}$$

*Why it matters.* The difference $b-d$ is the intrinsic rate of natural increase $r$, which drives $dN/dt = rN$.

**Step 3.** **3. Age distribution (age pyramid).** *Definition.* The percentage of individuals in each age class (pre-reproductive, reproductive, post-reproductive). Plotting these percentages gives the **age pyramid** (Fig. 11.1).

*Interpretation of pyramid shape.*

- Broad base, tapering top → **expanding (growing)** population.
- Columnar (roughly equal age classes) → **stable** population.
- Narrow base, broad top → **declining** population.

*Why it matters.* Demographers use age pyramids to project future population trends and set policy (housing, schools, pensions).

> **Final Answer:** Three population characteristics: **(1) Population density** $N$ (size per unit area/volume; multiple metrics); **(2) Natality and mortality** (per-capita birth and death rates, e.g. NCERT lotus example $= 0.4$/yr); **(3) Age distribution / age pyramid** (expanding, stable or declining).

### ☞ Pick the three with worked numbers

The exercise says "any three", so deliberately pick the three for which NCERT supplies a worked numerical example – density (banyan vs carrot grass), natality/mortality (lotus $0.4/\mathrm{yr}$, fruit fly $0.1/\mathrm{wk}$), and age pyramid (Fig. 11.1 shapes). Each calculation or labelled diagram is worth an extra application mark.

**EXPERT'S SOLUTION** *: Tara Pillai, M.Sc Botany, Delhi University*

**Pick-and-explain angle.** The exercise says "list any three", so pick the three with the cleanest one-line definitions, a memorable NCERT example, and a strong evolutionary or applied interpretation: density, natality + mortality, and age distribution. These three together also generate the rest of population ecology – the growth-rate equation $dN/dt$ comes out of natality minus mortality applied to a density.

**Step 1.** **Population density $N$ – the central quantity.** Population size per unit area or volume at a given moment. Multiple metrics are available, with the choice depending on the species: total count (small mammals), biomass (microbes), per-cent cover (vegetation), or indirect indices (tiger census via pug marks and fecal pellets). NCERT example: stating banyan density by number underestimates its ecological role compared with 200 carrot grass plants, so per-cent cover or biomass is the better measure for trees. Density is the variable against which every ecological process is evaluated.

**Step 2.** **Natality and mortality – the rate engine.** Per capita birth rate ($b$) and death rate ($d$) drive the change in density. NCERT lotus example: 8 new offspring among 20 plants in a year gives

$$b = \frac{8}{20} = 0.4 \text{ offspring per lotus per year.}$$

Fruit fly example: 4 deaths out of 40 flies in a week gives

$$d = \frac{4}{40} = 0.1 \text{ deaths per fly per week.}$$

Their difference is the intrinsic rate of natural increase $r = b - d$, which drives the exponential growth equation $dN/dt = rN$. Natality and mortality are therefore the two quantities ecology needs to predict population trajectories.

**Step 3.** **Age distribution and the age pyramid.** The percentage of individuals in each age class (pre-reproductive, reproductive, post-reproductive). NCERT Fig. 11.1 shows three pyramid shapes:

- *Broad-based, tapering top* → expanding / growing population (many young, high birth rate).
- *Columnar* (roughly equal age classes) → stable population (births ≈ deaths).
- *Narrow-based, broad top* → declining population (few young, low birth rate, ageing demographic).

Demographers use the age pyramid to project future population trends and to inform policy decisions (housing, schools, pensions). For wildlife populations, the same pyramid predicts whether a species is recovering or heading for extinction.

**Step 4.** **Other valid picks if asked for more.** *Sex ratio* (proportion of males to females), *population growth rate $dN/dt$, immigration $(I)$ and emigration $(E)$* (the spatial flux terms in the balance equation $N_{t+1} = N_t + [(B + I) - (D + E)]$). Any three of these are acceptable answers; the three chosen above are the highest-yield for the mark scheme because each has a calculable NCERT example.

**Step 5.** **Common application – wildlife census.** Combining all three: tigers in a reserve are censused for density (pug marks), natality and mortality (camera-trap records of cubs and carcasses), and age distribution (scat-DNA aging). Together these tell managers whether to add anti-poaching patrols, expand the buffer zone, or relocate breeders.

**Why this matters.** These characteristics are the raw data that feed the exponential and logistic models. Without them, an ecologist has no way to predict whether a population is heading for extinction, plateau, or runaway growth – and therefore no basis on which to prescribe conservation, harvesting, or pest-control action.

> **Final Answer:** Three key population characteristics: **population density** $N$; **natality and mortality** (per-capita birth and death rates, NCERT lotus example $= 0.4/\text{yr}$); and **age distribution / age pyramid** (expanding, stable, or declining).

### Key Takeaways

- **Populations are level** where natural selection operates; attributes include birth rate, death rate, sex ratio, age distribution, density and growth rate $dN/dt$.
- **Balance equation:** $N_{t+1} = N_t + [(B + I) - (D + E)]$. Density rises when births + immigration > deaths + emigration.
- **Exponential growth** (unlimited resources): $dN/dt = rN \Rightarrow N_t = N_0 e^{rt}$; J-shaped curve.
- **Logistic (Verhulst–Pearl) growth** (finite resources): $dN/dt = rN(K-N)/K$; S-shaped sigmoid, plateau at carrying capacity $K$. More realistic for natural populations.
- **Doubling-time formula:** $T_d = \ln 2/r$. A 3-year doubling implies $r = 0.231\,\text{yr}^{-1}$.
- **Six interspecific interactions:** Mutualism $(+,+)$, Competition $(-,-)$, Predation $(+,-)$, Parasitism $(+,-)$, Commensalism $(+,0)$, Amensalism $(-,0)$.
- **Plant defences against herbivory:** morphological (thorns of *Acacia* and cacti) and chemical (cardiac glycosides in *Calotropis*; alkaloids – nicotine, caffeine, quinine, strychnine, opium).
- **Biological control** uses the predation principle: host-specific natural enemy (e.g. *Cactoblastis* moth) suppresses pest density (e.g. *Opuntia* cactus) without chemical pesticides.

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**Same chapter — other resources:**

- Revision Notes
- Formula Sheet
- NCERT Book PDF
- Exemplar Book PDF
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- Handwritten Notes

**Continue learning:**

- Ch 11: Organisms and Populations
- Ch 13: Biodiversity and Conservation
- Class 12 Biology — All Chapters

End of Exercises