



# Biology

## Standard and Higher level

### C4.1 Populations and communities

#### Paper 1A

12 May 2025

**Zone A** afternoon | **Zone B** morning | **Zone C** afternoon

2 hours 30 minutes [Paper 1A]

---

#### Instructions to candidates

- Answer all questions.
- For each question, choose the answer you consider to be the best.
- A calculator is required for this paper.
- This paper generally presents questions in the same order the concepts are presented in the syllabus guide. The earlier questions are usually but not always easier than the later questions. Although most questions focus on this topic only, some are linked to other topics.
- This paper contains challenging IB-style problems. It is meant to enrich your learning and improve your mastery of the concepts presented in this topic after you have studied it.
- Many of the questions here are original and written by me. Several questions are taken from external sources, which are referenced at the end of the paper. None of the questions are from IB past papers.
- The duration of this paper was scaled according to the number of marks available and based on how much time, on average, each mark is worth in examination settings. Since this is a practice paper, expect to need more time to complete it.
- The maximum mark for this paper is **[100 marks]**.

1. What is a population?
  - A. Individuals with identical alleles living and interacting in a given area
  - B. Individuals of the same species living and interacting in a given area
  - C. Individuals with the same traits living and interacting in a given area
  - D. Individuals with similar traits living and interacting in a given area
2. What is random sampling of populations?
  - A. Every population has an equal chance of being sampled
  - B. Every individual has an equal chance of being sampled
  - C. Every species has an equal chance of being sampled
  - D. Every organism has an equal chance of being sampled
3. In a population of sheep of size  $N$ , which of the following sequences represent random sampling?
  - A. 1, 2, 3, 4, ...,  $N$
  - B. 8, 4, 6, 2, ...,  $N$
  - C. 9, 3, 6, 2, ...,  $N$
  - D. 16, 4, 12, 8, ...,  $N$
4. What is sampling error in population ecology?
  - A. The difference between the actual sample and estimated sample
  - B. The difference between the actual and estimated population sizes
  - C. The inevitable error resulting from random sampling
  - D. The inevitable error resulting from systematic sampling

5. How are populations of mobile organisms estimated?

- A. Simpson reciprocal index
- B. Lincoln index
- C. Capture–Mark–Release–Recapture index
- D. Capture index

6. In a mark-recapture study, a researcher finds that only smaller animals are recaptured during the second sampling, even though both small and large individuals were marked. Which assumption of the Lincoln index was violated?

- A. Random distribution of individuals after release
- B. Marking does not affect individual behavior
- C. Individuals do not leave or enter the population
- D. All individuals have an equal chance of being caught

7. After random sampling, 500 piranha are captured, tagged and released. A month later 10 piranha are captured, of which 2 are tagged. What is the estimated total population of piranhas?

- A. 2500
- B. 250
- C. 1000
- D. 100

8. After random sampling, 200 penguins are captured, tagged, and released. 2 months later, 180 untagged and 20 tagged penguins are captured. What is the estimated total population of the penguins?

- A. 200
- B. 2000
- C. 1800
- D. 180

9. A biologist nets 45 largemouth bass from a farm pond, tags their fins, and releases them unharmed. A week later, she nets 58 bass from the pond, including 26 with tags. What is the estimated total population of the bass in the pond?

A. 34  
B. 100  
C. 20  
D. 85

10. A student wants to estimate the number of rattlesnakes along a ridge in western Texas. They capture, tag, and release 37 rattlesnakes. A week later, they capture 52 rattlesnakes, of which 30 are marked. What is the estimated total population of the rattlesnakes?

A. 32  
B. 42  
C. 64  
D. 56

11. When sampling a motile species' population, favorable bait that is harmless may encourage released individuals to fall into the trap during the recapturing phase, causing sampling error. How can this error be reduced?

A. Using different bait  
B. Initially baiting all individuals without trapping  
C. Randomly placing the bait  
D. Randomly baiting and marking quickly

12. What is the carrying capacity of a population?

A. The maximum population size an environment can indefinitely sustain  
B. The maximum population size of a species an environment can support  
C. The maximum population size that a species' prey can support  
D. The maximum species size that a community can support

13. A fisherman wants to estimate how much fish should remain in a lake after fishing. What is the benefit of fishing  $0.5K$  of fish in the lake?

- A. The population will recover the fastest
- B. It minimizes fishing pressure
- C. It reduces intraspecific competition
- D. It keeps the population at the exponential phase

14. What is one limitation of the logistic model of population growth?

- A. It assumes the density of the population is not the only limiting factor
- B. It assumes the density of the population is the only limiting factor
- C. It assumes density-independent factors are the not the only limiting factors
- D. It assumes density-independent factors are the only limiting factors

15. What is the order of phases in the logistic model of population growth?

- A. Exponential > Transitional > Lag
- B. Lag > Exponential > Transitional > Plateau
- C. Plateau > Exponential > Transitional > Lag
- D. Exponential > Transitional > Plateau

16. Where in the phases of the logistic growth model is intraspecific competition the strongest?

- A. Lag phase
- B. Exponential phase
- C. Transitional phase
- D. Plateau phase

17. What is the reason for exponential growth in the sigmoid population model?

- A. Very little intraspecific competition
- B. Moderate intraspecific competition
- C. High intraspecific competition
- D. Very high intraspecific competition

18. When are birth rates higher than death rates?

- I. Exponential phase
- II. Transitional phase
- III. Plateau phase

- A. I only
- B. I and II only
- C. I and III only
- D. I, II, and III

19. What can change a population at carrying capacity?

- I. Natural disasters
- II. Human activities
- III. Seasonal changes

- A. I only
- B. I and II only
- C. I and III only
- D. I, II, and III

20. In which population is disease transmission most likely to cause a problem?

- A. Social species
- B. A population composed of mostly females and their offspring
- C. Solitary species
- D. Individuals of an endangered species living in separate cages in the zoo

21. Which of the following involve the death of individuals from one species?

- A. Competition
- B. Predation
- C. Parasitism
- D. Saprotrophism

22. [AHL] Which of the following is likely to exhibit exponential growth?

- A. A population of yeast with high turbidity levels
- B. A population of yeast that has been fermenting for 24 hours
- C. A population of yeast that was just incubated
- D. A population of yeast with sufficient ethanol levels

23. A conservation biologist is asked to estimate the size of the population of a rare flowering plant in Northern Europe. Which of the following characteristics of the population would they have to measure in order to obtain an accurate estimate of the population's size?

- I. Number of flowering plants
- II. Number of seeds on the ground
- III. Number of sterile individuals

- A. I only
- B. I and II only
- C. I and III only
- D. I, II, and III

24. What happens when multiple populations interact?

- A. An ecosystem forms
- B. Interspecific competition forms
- C. A metapopulation forms
- D. A community forms

25. Which of the following can be classified as a population?

- A. Genetically similar flowers of identical color
- B. Bacteria of the same species grown on many petri dishes
- C. A group of interbreeding wolves living in a forest
- D. Groups of fish in a lake

26. Which of the following can be classified as a community?

- I. Density-independent factors regulating a population of birds
- II. *Rhizobium* bacteria living with a legume plant
- III. Coral polyps providing shelter for zooxanthellae

- A. I only
- B. I and II only
- C. II and III only
- D. I, II, and III

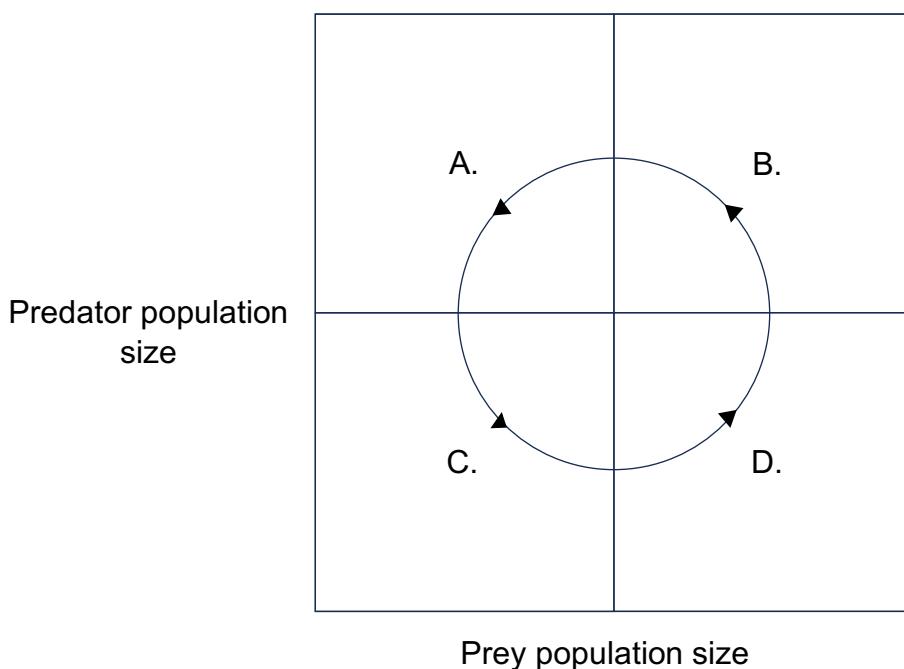
27. Which of the following is true about predator-prey cycles?

- A. The cycle prevents the extinction of the predator
- B. The predator population peaks before the prey population peaks
- C. The cycle stabilizes both the predator population and the prey population
- D. The cycle prevents the prey population from exceeding the carrying capacity

28. How does the population size change if birth rates exceed death rates?

- A. It increases
- B. It decreases
- C. It depends on density-dependent factors only
- D. It depends on density-dependent and density-independent factors

29. The graph shows the relationship between the population sizes of a predator and its prey. In what part of the graph are the predators about to exhaust most of the prey population?



30. A student is attempting to draft a sustainable fishing plan for an endemic fish species living in a lake. They claim that fishing  $0.50K$  of fish is more sustainable than  $0.75K$ . What is a valid critique of their claim?

- A. Growth rate is highest at  $0.50K$
- B. Growth rate is lower at  $0.75K$  than at  $0.50K$
- C. Environmental factors may cause the population to shoot below  $0.50K$
- D. Environmental factors may cause the population to shoot below  $0.75K$

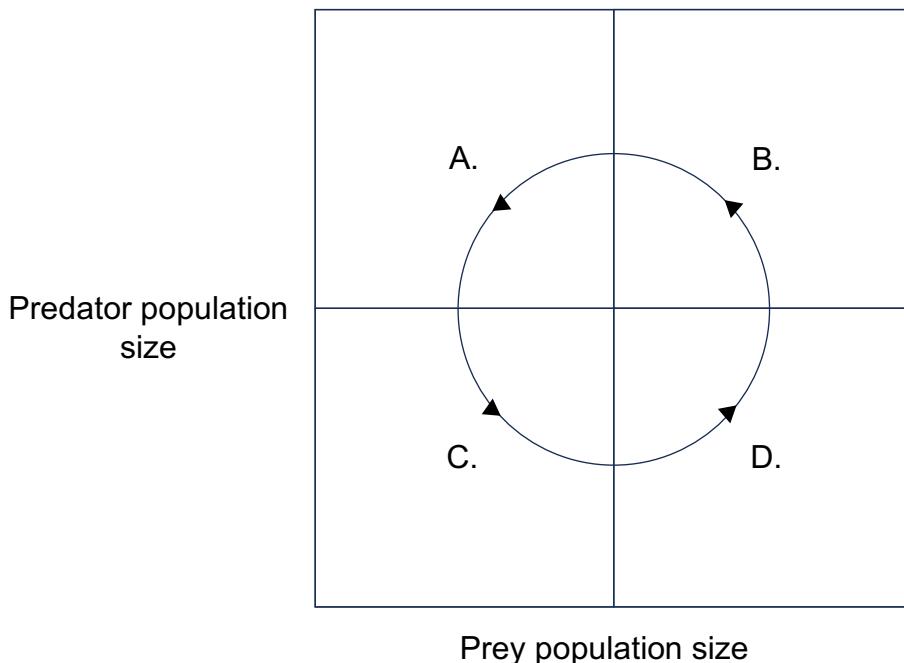
31. Why might a population's growth rate sometimes be more significant to find than its size?

- A. Growth rate is helpful in endangered populations
- B. Growth rate predicts future growth or decline
- C. Growth rate affects genetic diversity
- D. Growth rate finds the difference between births and deaths

32. An ecology student samples two species of rodents and piles all data to create one logistic model. They conclude that one species has a greater carrying capacity than the other. Which of the following does not explain why they are incorrect?

- A. Carrying capacity is the maximum size of a population the ecosystem supports
- B. Logistic models assume a single population
- C. Carrying capacity depends on the population the data is collected from
- D. Logistic models assume no interspecific interactions

33. The graph shows the relationship between the population sizes of a predator and its prey. In what part of the graph are the predator populations becoming less limited by bottom-up control?



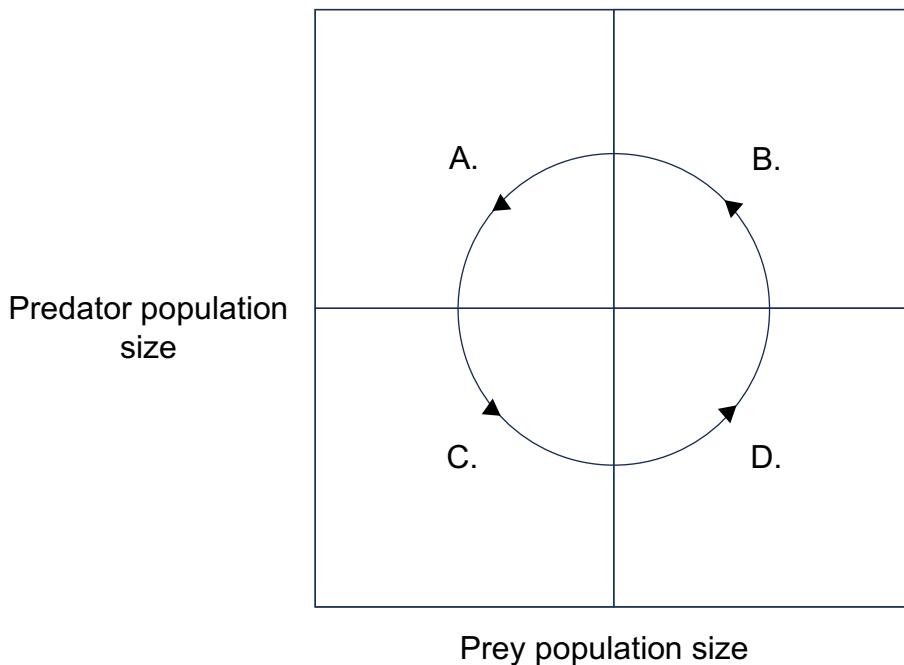
34. 5 years after introducing a few wolves in a national park, the population seems to stabilize far below the predicted carrying capacity. What might explain this?

- A. The logistic model is an oversimplification of complex systems
- B. The wolves reached their reproductive limit
- C. There is no top-down control on the wolf population
- D. Limiting factors were underestimated

35. A population at carrying capacity suddenly declines to  $0.25K$  after an epidemic. Years later, the population stabilizes at  $0.75K$ , even though the pathogen has been eradicated and resources remain unchanged. What is a possible explanation?

- A. The population is still recovering and will eventually return to  $K$
- B.  $0.75K$  helps to reduce the density-dependent effects of pathogens
- C. The population now has lower genetic diversity which reduced  $K$
- D. Other limiting factors are affecting the population

36. The graph shows the relationship between the population sizes of a predator and its prey. In what part of the graph are the prey populations least limited by top-down control?



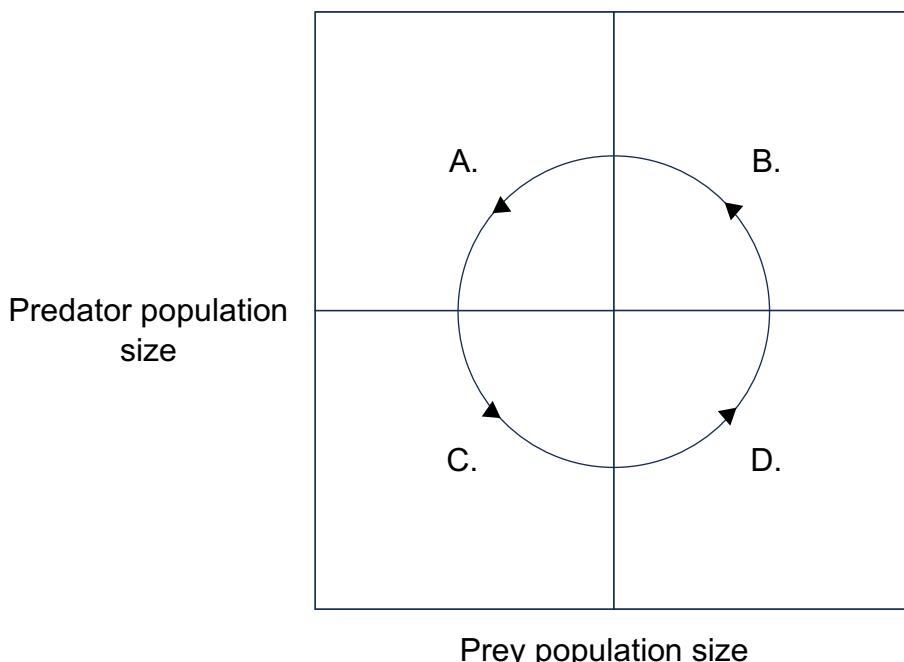
37. Malaria parasites inside a human body can either exploit more resources within the body, or invest in transmitting to another host. The more strains of the same parasite species in one host, the lower the rates of transmittance. What governs this?

- A. Intraspecific competition
- B. Interspecific competition
- C. Mutualism
- D. Symbiosis

38. A European starling population in Alaska increased from 3 birds in 1995 to 156 birds in 2005. What could have influenced the change in the starling population?

- A. Competitors
- B. Predators
- C. Food supply
- D. Flowering plants

39. The graph shows the relationship between the population sizes of a predator and its prey. In what part of the graph are both species' populations growing?



40. A scientist studying the blue-ringed octopus made the following observations:

- It inhabits shallow coral reefs where water temperatures are between 26–29°C.
- It feeds on crabs, shrimp and fish.
- It uses a toxin to paralyze its prey and defend itself from predators.

The toxin used by the blue-ringed octopus is produced by bacteria living in the nutrient-rich environment of the octopus's salivary glands. Which of the following statements is/are correct?

- I. Temperature is a biotic factor which restricts where the blue-ringed octopus can live
- II. The relationship between the blue-ringed octopus and the bacteria is an example of mutualism
- III. The blue-ringed octopus and the crabs, shrimp and fish that it eats make up a population of organisms

A. II only

B. III only

C. II and III only

D. I, II, and III

41. Which represents a community?

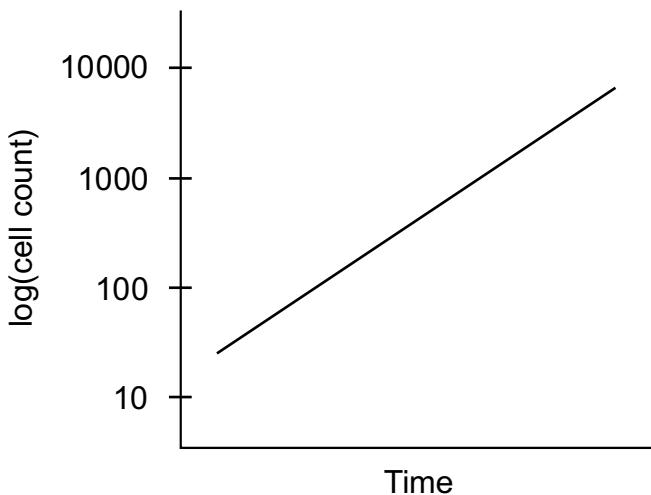
A. All *Paramecium candatum* in a pond

B. pH level of Lake Michigan

C. Different mutualisms in a forest

D. Mineral levels in soil

42. A student grows yeast on a plate and estimates the number of cells after 48 hours. The results are shown in the graph. Which of the following statements is/are correct?



- I. The population increases at a constant rate with time
- II. The initial population size is between 10 and 100
- III. The population is growing exponentially

A. II only

B. III only

C. I and III only

D. II and III only

43. As a population approaches  $K$ , which of the following might increase?

- I. Death
- II. Migration
- III. Resource availability

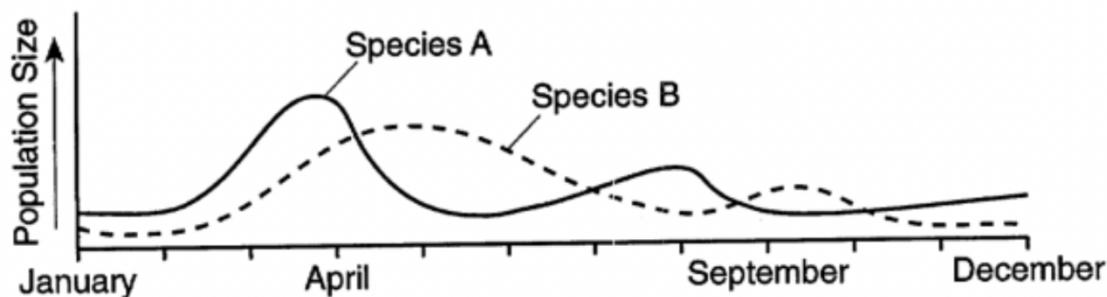
A. I only

B. I and II only

C. I and III only

D. II and III only

44. The graph shows population growth curves of two different species of aquatic organisms, A and B. Based on the graph only, what is a valid prediction?



- A. Species A will not be present from December to March
- B. Species A will eliminate species B after 1 year
- C. Species B will reach its carrying capacity each September
- D. Species B will decrease shortly after Species A decreases

45. Hawks and owls compete for the same type of mouse for food. What might result in the greatest conflict within this community?

- A. Increase in mouse population
- B. Increase in owl population
- C. Decrease in hawk population
- D. Decrease in owl population

46. Which of the following represents the correct order of increasing biological organization?

- A. ecosystems < biomes < communities < populations
- B. populations < communities < ecosystems < biomes
- C. biomes < ecosystems < communities < populations
- D. populations < communities < biomes < ecosystems

47. A student gathers the following information about two species of animal that are found in the same area of forest and grassland:

- In the spring and summer they eat the same plant food, but in the autumn and winter one eats nuts in the forest and the other eats roots on the grassland
- Both species are preyed upon by the same predator
- Numbers of root-eating animals are reduced most by predation, but they recover faster as they reproduce faster

What can be concluded about these two species of animals?

- I. They are part of the same community
- II. They occupy different trophic levels
- III. They occupy different habitats
- IV. They occupy different niches

A. I, II, and IV only

B. II, III, and IV only

C. I and II only

D. I and IV only

48. In a marine kelp forest, a decline in sea urchin numbers is linked to increased sea otter predation, while in a desert, plant growth is limited by precipitation. What type of control does each example illustrate, respectively?

A. Bottom-up and top-down

B. Density-independent and density-dependent

C. Top-down and bottom-up

D. Density-dependent and density-independent

49. How does predation rate change as prey density increases?

A. Increases

B. Decreases

C. Fluctuates

D. Stays the same

50. What terms best describe predator-prey cycles?

- A. Lagged and synchronous
- B. Lagged and asynchronous
- C. Disconnected and synchronous
- D. Disconnected and asynchronous

51. What is the difference between mutualism and symbiosis?

- A. Mutualism is a type of symbiosis
- B. Symbiosis is a type of mutualism
- C. Mutualism can be a type of symbiosis
- D. Symbiosis can be a type of mutualism

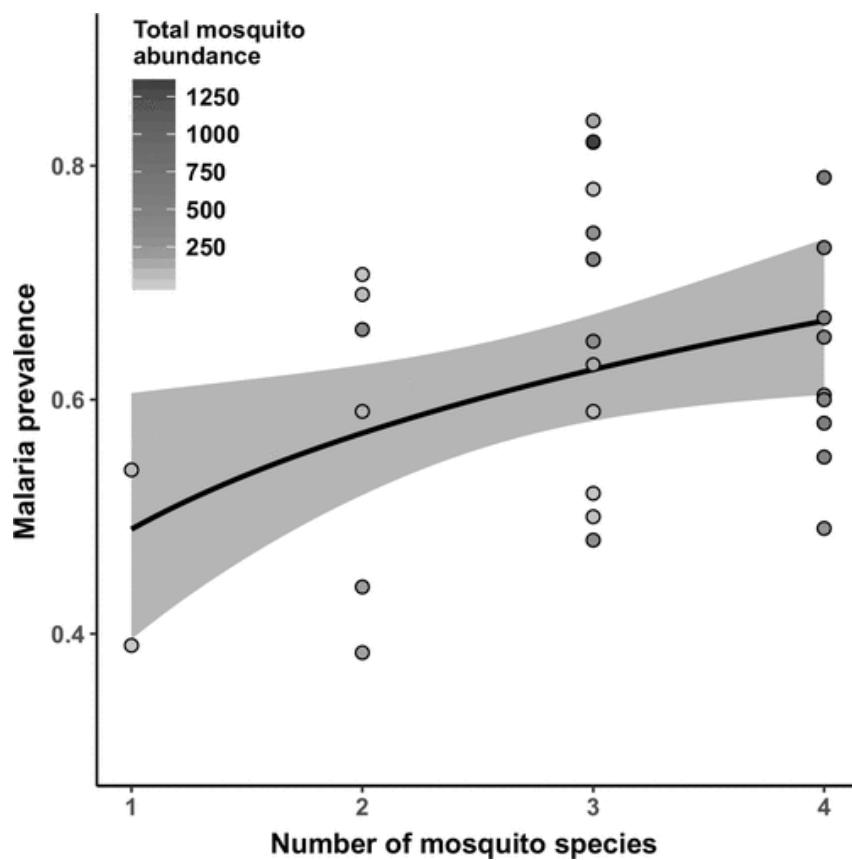
52. What is incorrect about pathogenicity and parasitism?

- A. Not all pathogens are parasitic
- B. Not all parasites are pathogenic
- C. Not all pathogens are non-living
- D. Not all parasites are non-living

53. What is the difference between herbivory and predation?

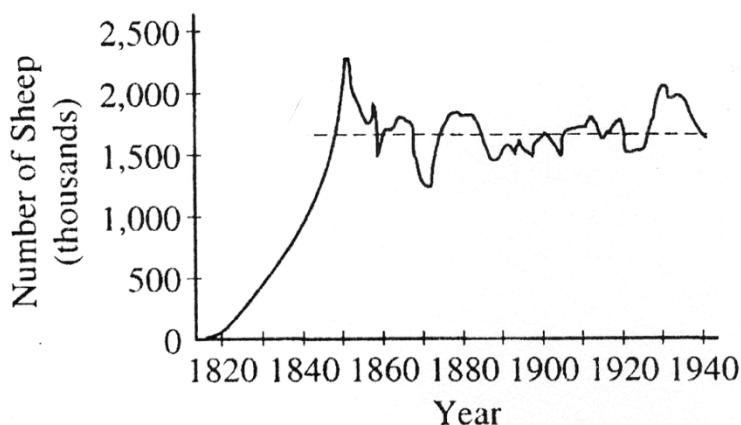
- A. The species of organism being eaten
- B. The trophic level of the organism being eaten
- C. The type of organism being eaten
- D. The classification of the organism being eaten

54. The graph shows the relationship between the number of mosquito species, mosquito abundance, and the prevalence of malaria in villages in Kenya (each circle is a village). Which of the following conclusions is **not** supported by the data?



- A. Parasite communities with more species diversity show higher malaria prevalence
- B. Different parasite communities have different malaria prevalence patterns
- C. Mosquito population size is positively correlated with the number of mosquito species
- D. The highest malaria prevalence occurs in villages with the greatest mosquito populations

The graph shows changes in a population of wild sheep that were introduced to the island of Tasmania in the early 1800s. Use this graph to answer questions **55** and **56**.



**55.** What is the name of the type of growth from 1820 to 1850?

- A. Sigmoidal
- B. Linear
- C. Exponential
- D. Positive

**56.** How is the sheep population most likely to change after 1940?

- A. It will eventually crash since it is currently experiencing major fluctuations
- B. It will stabilize at around 1750 thousand sheep
- C. It will continue the downward decline observed after 1930
- D. It will be regulated by density-independent factors

**57.** Which of the following is not a characteristic of predator-prey cycles?

- A. A rise in the population of predators is followed by a decrease in the population of prey
- B. Camouflage is an adaptation that protects prey
- C. The production of large numbers of offspring within very short periods of time ensures the survival of some prey populations
- D. The population of predators often eliminates the population of prey

58. Which of the following is an environmental factor that allows invasive species to outcompete native species?

- A. Broad diet
- B. Lack of predators
- C. Faster reproduction
- D. Good colonizing ability

59. Which of the following is an intrinsic characteristic of invasive species?

- I. Good dispersal ability
- II. Exponential growth
- III. High mutation rates

- A. I and II only
- B. I and III only
- C. II and III only
- D. None of the above

60. Which interaction would not reduce a population's size?

- A. Interspecific competition
- B. Intraspecific competition
- C. Mutualism
- D. Symbiosis

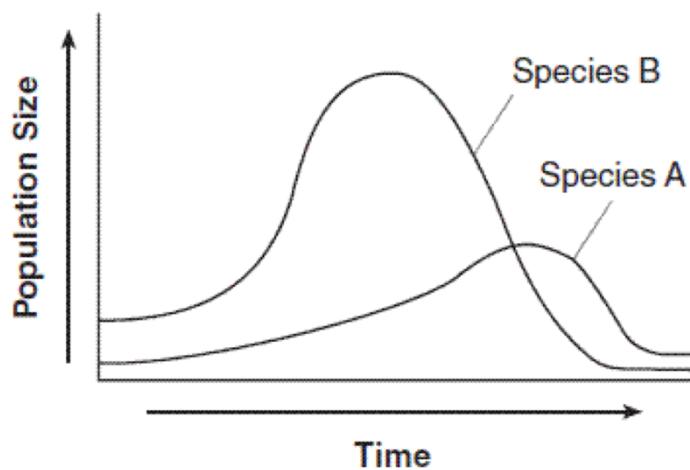
61. Which of the following sampling methods should be used to census the population of a rare flower in a desert covering 500 km<sup>2</sup>?

- A. Transects
- B. Mark and recapture
- C. Random plot sampling
- D. Basic count

62. Barnacles can root on a male crab. The barnacle changes the crab's reproductive behaviour and leads to the crab looking after the barnacle as if it was a brood of eggs. Male crabs do not normally look after eggs. What is the best description of the relationship between the barnacle and the crab?

- A. Pathogenicity
- B. Parasitism
- C. Symbiosis
- D. Predation

63. The graph shows changes in the populations of two species that interact with each other over time. Which option best describes both species?

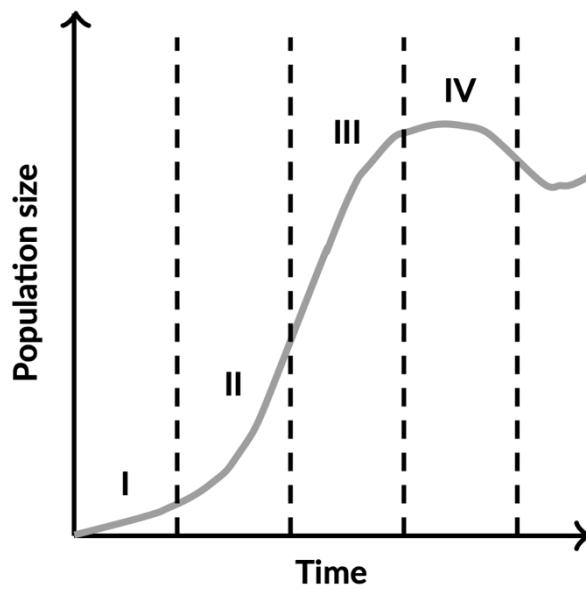


- A. Species A is a host and species B is its parasite
- B. Species A is a scavenger and species B is its decomposer
- C. Species A is a producer and species B is its consumer
- D. Species A is a predator and species B is its prey

64. A particular species of unicellular organism inhabits the intestines of termites, where the unicellular organisms are protected from predators. Wood that is ingested by the termites is digested by the unicellular organisms, forming food for the termites. What is the relationship between the two species?

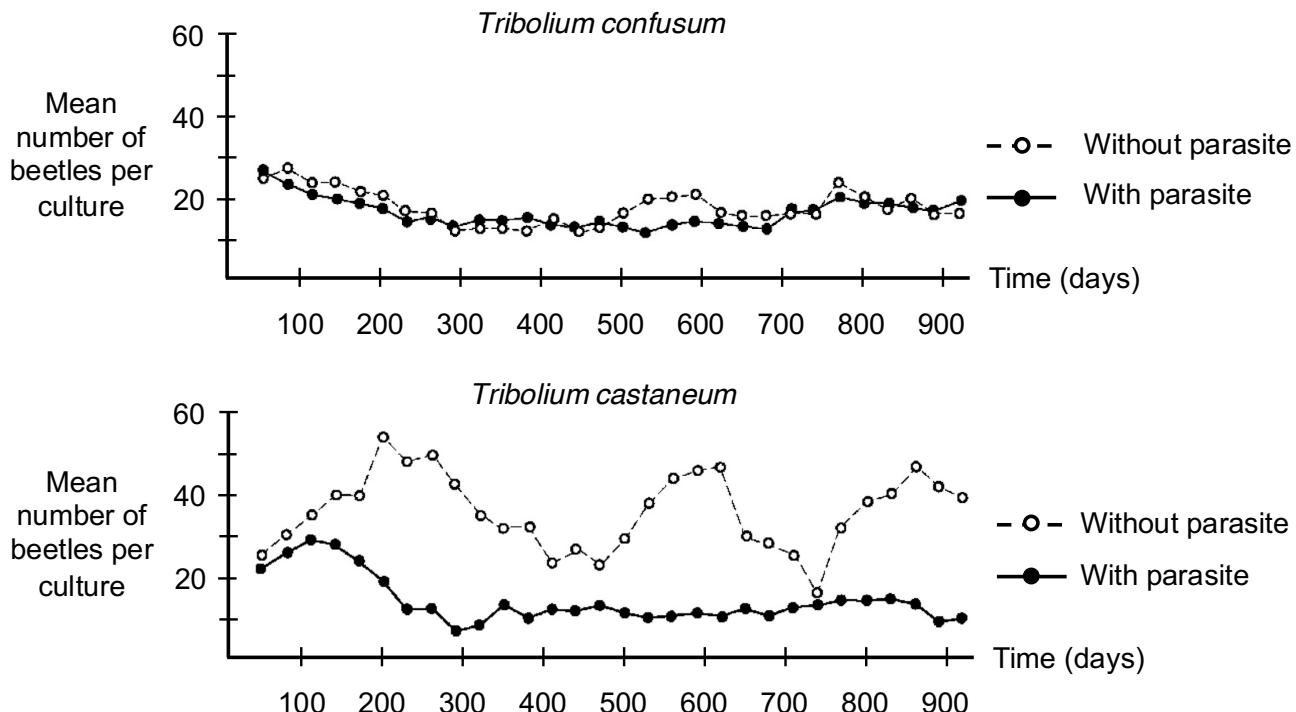
- A. Symbiotic
- B. Mutualistic
- C. Parasitic
- D. Pathogenic

65. A group of researchers measured the size of a population of mockingbirds over time. Their results are shown in the graph. Which of the following parts of the graph best represent when the growth of the mockingbird population was limited by the availability of resources?



- A. I only
- B. I and II only
- C. III only
- D. III and IV only

Two species of flower beetles, *Tribolium confusum* and *Tribolium castaneum*, were grown in cultures with and without a parasite. Each data point represents the mean population size from ten culture dishes of equal size and food content. The graphs show the results from each species across time. Use this information to answer questions 66 – 69.



66. Under which of the following conditions is the observed number of beetles per culture dish the greatest?

- T. confusum* with parasite at 500 days
- T. confusum* without parasite at 300 days
- T. castaneum* with parasite at 100 days
- T. castaneum* with parasite at 600 days

67. The data over the duration of the experiment provide the strongest support for which of the following conclusions regarding the effect of the parasite on *Tribolium* populations?

- T. confusum* is negatively affected by the parasite but *T. castaneum* is not
- T. castaneum* is negatively affected by the parasite but *T. confusum* is not
- Both *T. confusum* and *T. castaneum* are negatively affected by the parasite
- Both *T. confusum* and *T. castaneum* show higher fitness in the presence of the parasite

68. What can the difference between the two curves for *T. confusum* be attributed to?

- A. The difference between controlled laboratory conditions and the natural environment
- B. The effect of the host on its parasite
- C. The influence of competition for limited resources
- D. The natural variation among populations

69. If the experiment was continued for an additional 500 days, the population density of *T. castaneum* with the parasite would most likely stabilize at a value closest to which of the following?

- A. 5 beetles per culture dish
- B. 10 beetles per culture dish
- C. 20 beetles per culture dish
- D. 25 beetles per culture dish

70. Scientists hypothesize that a host infected with a parasite whose individuals have more dissimilar than similar genotypes experiences more damage due to more intense intraspecific competition. Which observation would support this?

- A. Hosts infected with a parasite composed of genetically similar individuals have higher parasite populations than parasites with dissimilar individuals
- B. Hosts infected with a parasite composed of genetically similar individuals have lower parasite populations than parasites with dissimilar individuals
- C. Hosts infected with a parasite composed of genetically dissimilar individuals suffer more tissue damage than parasites with similar individuals
- D. Hosts infected with a parasite composed of genetically dissimilar individuals suffer less tissue damage than parasites with similar individuals

71. A student conducts a chi-squared test on two herbivore species during the dry season and finds that they occur together much less than expected ( $p < 0.05$ ). Which of the following is a valid interpretation of the results?

- A. The species may be symbionts that are both affected by the dry season
- B. The species may be competitors that are both affected by the dry season
- C. The species may be mutualists that are both affected by the dry season
- D. There is not enough data to make a reasonable interpretation

72. The table shows the results of a mark-recapture study used to estimate the size of an animal population. What is the value of Y?

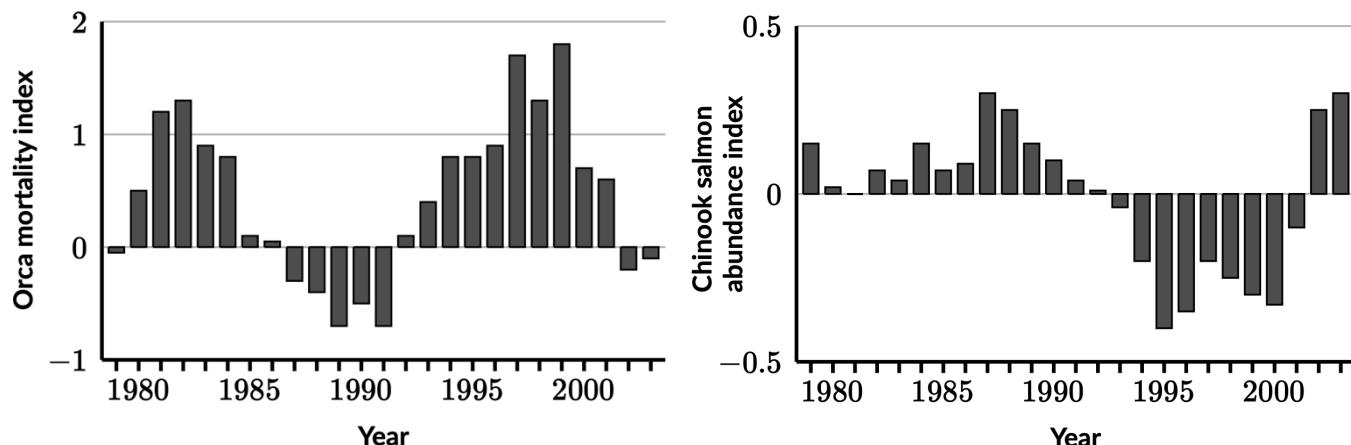
	Number of marked individuals	Total number of individuals
Recapture group	14	88
Entire population	180	Y

- A. 1131
- B. 685
- C. 1584
- D. 282

73. What is the difference between top-down and bottom-up control?

- A. One of them involves feeding
- B. One of them affects organisms with higher biomass
- C. One of them involves herbivory
- D. One of them affects organisms aerobically respire

74. A group of scientists studied a population of orcas living in the northeastern Pacific Ocean. They calculated the orca's mortality rate over time (mortality index) and the abundance of Chinook salmon over time (abundance index). Orcas eat many types of salmon, including Chinook salmon, and other types of fish. Which conclusion is best supported by the data?



- A. Lower mortality rates in the orca population coincide with lower Chinook salmon abundance
- B. Fewer orcas died in years when Chinook salmon were scarce
- C. More orcas died in years when Chinook salmon were plentiful
- D. Higher mortality rates in the orca population coincided with lower Chinook salmon abundance

75. Oxpeckers eat bugs and parasites off zebras. When a predatory animal is nearby, the oxpeckers make noise, alerting zebras to the presence of predators. What is the relationship between the two species?

- A. Mutualism
- B. Symbiosis
- C. Commensalism
- D. Parasitism

76. What is an example of symbiosis?

- A. Two species benefiting from each other
- B. Only one species benefiting from the other
- C. Two species living together for most of their lives
- D. Two species competing with each other

77. Three predatory insects – A, B, and C – share the same caterpillar prey. Species A preys on B and also hunts the same caterpillars as C. In experimental plots where A is removed, B's population increases and C's density falls. Which statement best explains why C's population decreases when A is removed?

- A. A exerts top-down control on B, which allows C to persist
- B. A mutualistically protects C by preying on B
- C. Removing A reduces total prey availability, which disproportionately harms C
- D. Removing A causes B to compete with C

78. What is the difference between primary and secondary metabolites?

- A. Only one is universal across all domains of life
- B. Both are universal across all domains of life
- C. Only one is involved in growth and defense
- D. Both are involved in growth and defense

79. A researcher planted walnut seedlings (known for releasing juglone, a toxin) and tomato seedlings in one pot. After two weeks, tomato growth in the walnut-soil pot is stunted compared to control. Which conclusion is best supported?

- A. Tomatoes and walnuts compete for soil minerals
- B. Walnuts are more resistant to abiotic factors than tomatoes
- C. Juglone reduces tomato growth
- D. Juglone protects walnuts from leaf-eating insects

80. After a natural disaster, soil composition in a farm is altered and nitrogen availability is reduced for native plants. Which intervention would best address this issue?

- A. Applying artificial fertilizer rich in nitrogen
- B. Introducing *Rhizobium* bacteria and plants from the legume family
- C. Adding more organic waste from the animal farms to the soil
- D. Adding more mycorrhizal fungi to the soil

81. Which observation would best demonstrate allelopathy in a salt marsh?

- A. Two competing species never occupy the same quadrat
- B. Species Y produces more seeds alone than when other plants exist near it
- C. Species X always growing taller than species Y when water is limited
- D. Species X inhibiting growth of species Y in the lab

82. What is true when the chi-squared value is less than the critical value?

- A. The alternative hypothesis is accepted
- B. The null hypothesis fails to be rejected
- C. The p-value is less than 0.05
- D. The degree of freedom is greater than 1

83. What is the difference between experiments and observations?

- A. Experiments test causal claims, observations test correlational claims
- B. Experiments test correlational claims, observations test causal claims
- C. Only experiments are useful for testing hypotheses as they are more rigorous
- D. Only observations are useful for testing hypotheses as they are more rigorous

84. What is the difference between field observations and field manipulations?

- A. Only manipulations have an independent variable
- B. Only observations have an independent variable
- C. Only manipulations have a dependent variable
- D. Only observations have a dependent variable

85. A biologist wants to know whether two snail species that occur together in quadrats directly compete for limited algae under similar environmental conditions. Which type of test is most suitable for this?

- A. Field observations
- B. Comparative studies
- C. Field manipulations
- D. Laboratory experiments

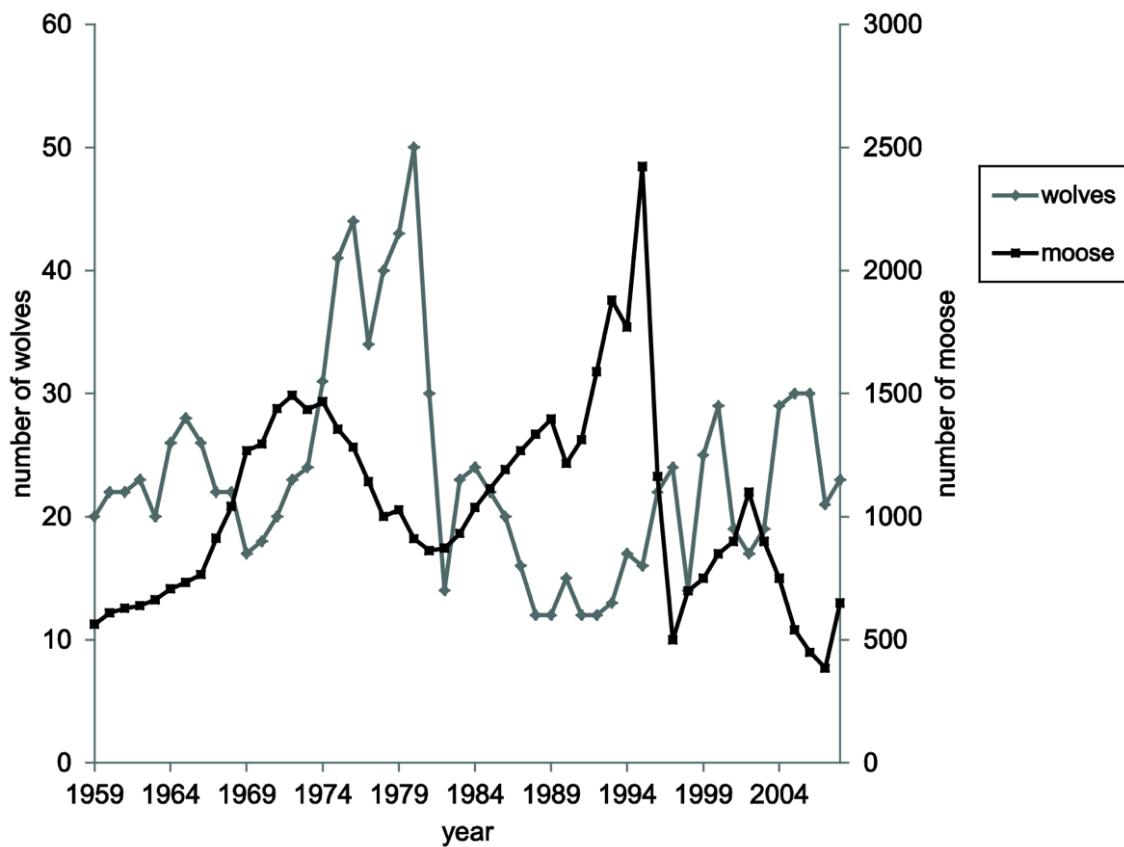
86. A student wants to determine whether a grass species is outcompeted by a shrub in a grassland region in Saskatchewan, Canada. Which study should they conduct first?

- A. Random quadrat sampling followed by an association test
- B. Planting the grass and shrub next to each other in a lab
- C. Plant grass species alone and with shrubs in a lab
- D. Field manipulation by removing shrubs from random regions of the grassland

87. After observing that a predatory beetle declines where a competing beetle species is abundant, a student wants to test if the competing beetle's presence actually limits its population in nature. Which study should they conduct?

- A. Laboratory experiment in which the independent variable is the presence or absence of the competing beetle
- B. Laboratory experiment in which the independent variable is the presence or absence of the predatory beetle
- C. Field manipulation in which half of the competing beetles are removed
- D. Field manipulation in which half of the predatory beetles are removed

88. An isolated island in Canada has populations of moose and wolves. Moose are the main source of food for the wolves. The graph shows changes in the populations of the two species of animal from 1959 to 2008.



Which of the following statements is/are correct?

- I. Increases in wolf population are often after increases in moose population
- II. The wolf population is always lower than the moose population
- III. When the wolf population is low there is an increase in the moose population

A. I and II only

B. I and III only

C. II and III only

D. I, II, and III

89. What is indicated by a p-value that is less than 0.05?

- 95% or more of the variation in the data is not explained by random chance
- 95% or more of the variation in the data is explained by random chance
- 5% or less of the variation in the data is not explained by random chance
- 5% or less of the variation in the data is explained by the dependent variable

90. Why is the degree of freedom for chi-squared tests of association usually 1?

- Because data is usually collected from two species
- Because data is usually divided into two classes
- Because data can be explained by random chance or by a specific cause
- Because the chi-squared value can be greater or less than the critical value

91. A student is conducting random quadrat sampling to investigate the relationship between mycorrhizal fungi and a plant from the family Orchidaceae. What would the observed and expected frequencies be?

	Observed frequencies	Expected frequencies
A.	More quadrats with both present than with one or neither	More quadrats with both present than with one or neither
B.	More quadrats with both present than with one or neither	Both equally likely to be present or absent in the same quadrat
C.	Both equally likely to be present or absent in the same quadrat	More quadrats with both present than with one or neither
D.	Both equally likely to be present or absent in the same quadrat	Both equally likely to be present or absent in the same quadrat

92. What is true about the alternative hypothesis in chi-squared tests?

- It assumes the variables are independent
- It is only accepted when the p-value is greater than 0.05
- It suggests that variables are unlikely to be independent
- It confirms that observed frequencies align with expected frequencies

93. A student is conducting random quadrat sampling to test for an association between two plant species. Based on the contingency table that summarizes their results, which of the following statements is/are correct?

	Species B present	Species B absent	Row total
Species A present	60	11	71
Species A absent	10	19	29
Column total	70	30	100

- I. The expected frequency for quadrats where both species are present is lower than the observed frequency
- II. The chi-squared value is greater than the critical value of 3.841
- III. Random variation explains most of the results

A. I and II only

B. I and III only

C. II and III only

D. I, II, and III

94. Why is it more correct to state that the null hypothesis “failed to be rejected” rather than “it was accepted”?

A. Experiment evidence attempts to confirm the null hypothesis

B. Accepting the null hypothesis indicates strong experimental support for it

C. Failing to reject the null hypothesis indicates that the alternative hypothesis was proven false

D. Failing to reject the null hypothesis does not prove that it is true

95. Symbiosis can be mutualistic or parasitic. What is the difference between these two types of symbiosis?

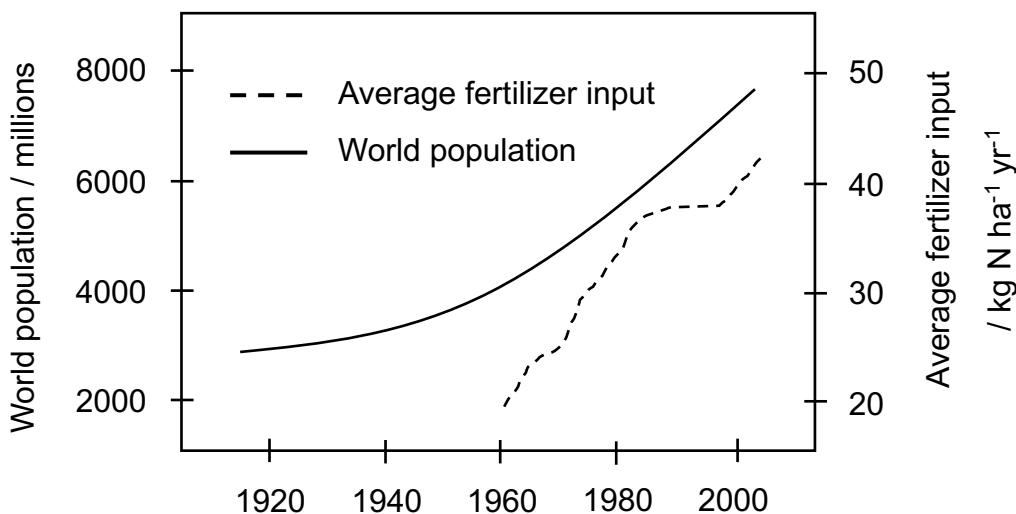
A. Parasitism only is always symbiotic

B. Mutualism only is always symbiotic

C. Both parasitism and mutualism are always symbiotic

D. Both parasitism and mutualism can be symbiotic or not

96. The Haber Bosch process enabled the mass production of nitrogen fertilizer, an essential plant nutrient. The graph shows the changes in the human population and average fertilizer input with time. Which of the following conclusions is/are correct?



- I. Human populations are controlled by bottom-up mechanisms
- II. More nitrogen fertilizer caused human populations to increase
- III. Nitrogen exerts positive density-dependent control on humans

A. I only

B. I and II only

C. I and III only

D. II and III only

97. If a species of the malaria parasite *Plasmodium* spreads to a nonendemic country, which of the following determine whether it has become invasive or not?

A. It evolves resistance to antimalarial drugs

B. It causes a few fatal human cases

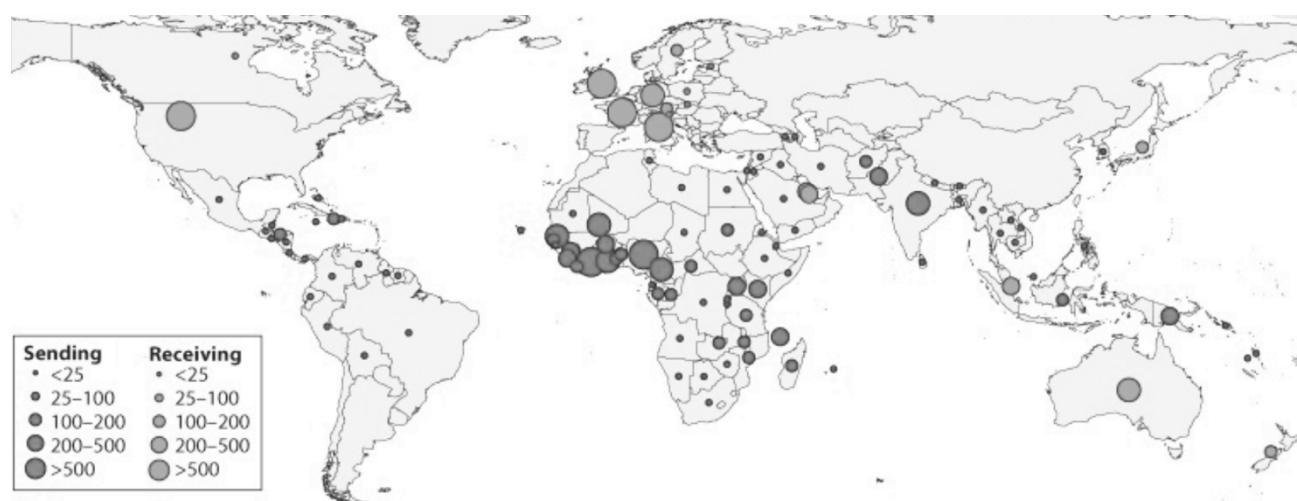
C. It competes with other mosquito-borne parasites

D. It establishes high transmittance in the country

98. Which of the following is an example of a mutualism?

- A. Mosquitoes feeding on infected hosts aid in the transmission of the parasite
- B. Birds eating mosquitoes which reduces human malaria cases
- C. Humans developing immunity from past malaria parasite exposure
- D. Mosquito gut microbiome benefiting malaria parasites

99. The diagram shows the average annual number of malaria cases exported from endemic to nonendemic countries (dark grey) and imported to nonendemic from endemic countries (light grey). Which of the following conclusions is/are true?

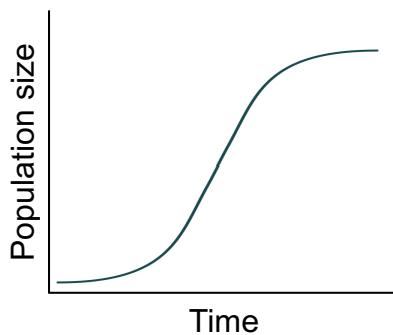


- I. The parasite may not act as an invasive species in nonendemic countries
- II. The parasite is weaker in nonendemic countries
- III. The impact of the parasite is not affected by herd immunity

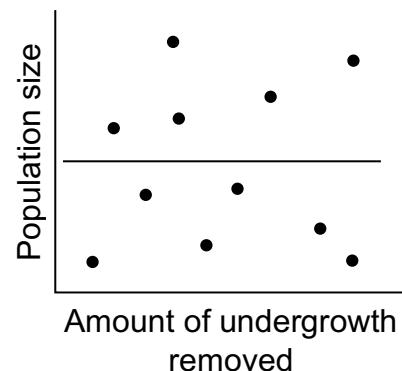
- A. I only
- B. I and II only
- C. I and III only
- D. I, II, and III

100. A study compared the woodpecker population in two sites: a managed forest in which tall dead trees and undergrowth were removed, and a control site. The woodpecker population was 1000 in the controlled site and 100 in the managed site. Which graph can correctly conclude the factor limiting the woodpecker's population?

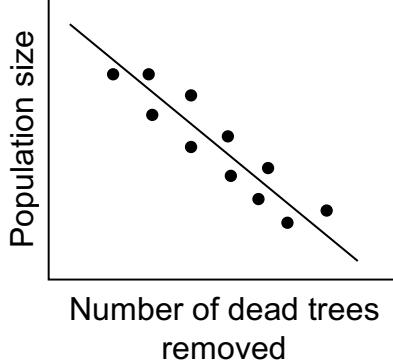
A.



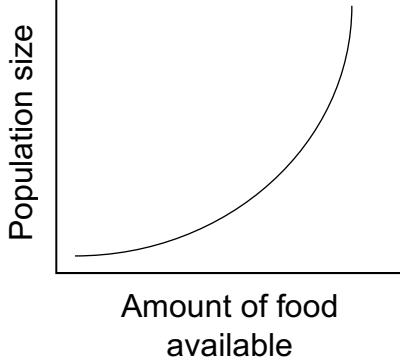
B.



C.



D.



**References:**

- Hoi, Amber Gigi, et al. “Deconstructing the Impact of Malaria Vector Diversity on Disease Risk.” *The American Naturalist*, vol. 196, no. 3, May 2020, pp. E61–70. <https://doi.org/10.1086/710005>.
- [https://www.deanza.edu/faculty/heyerbruce/b6c\\_pdf/3b\\_Estimating%20Population%20Size.pdf](https://www.deanza.edu/faculty/heyerbruce/b6c_pdf/3b_Estimating%20Population%20Size.pdf)
- [https://www.varsitytutors.com/ap\\_biology-help/determine-relationships-of-living-organisms](https://www.varsitytutors.com/ap_biology-help/determine-relationships-of-living-organisms)
- Ziegenbalg, Dirk & Zander, Judith & Marschall, Roland. (2021). Photocatalytic Nitrogen Reduction: Challenging Materials with Reaction Engineering. *ChemPhotoChem*. 5. 10.1002/cptc.202100084.