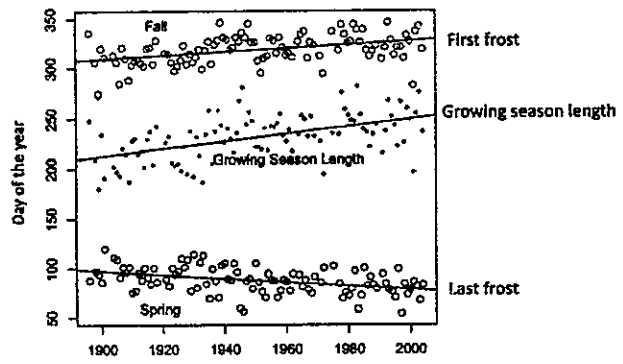
I. Multiple choices (2 points each)

1. How many of the following five ecological concepts or disciplines require researchers to take evolution into consideration? (I) behavioral ecology, (II) fundamental niche, (III) adaptation under global warming, (IV) phenotypic plasticity, (V) intraspecific polymorphism

A. 2
B. 3
C. 4
D. 5

2. The length of the growing season is defined by the period between the last frost and the first frost. During the period shown in the graph below, the length of the growing season has increased by about _____ days.



A. 10
B. 20
C. 40
D. 80

3. Scientists are concerned about the increasing rate of permafrost melting because permafrost melting leads to direct release of _____ into the atmosphere.

A. carbon dioxide
B. ethanol
C. water vapor
D. methane

4. John is investigating how different biotic and abiotic factors may affect the abundance of *Liocichla steerii*, an endemic bird species in Taiwan, in several forest patches in Xitou, a research station operated by National Taiwan University. John uses numbers of individuals as a proxy for abundance, and has decided that he will try to avoid data transformation as much as possible. Given the statement outlined above, which of the following method is most appropriate for John's data analysis?

A. ANOVA
B. General linear models
C. Generalized linear mixed models
D. Non-metric multidimensional scaling

5. Which statement below are CORRECT about osmoregulation in fish?

A. Sharks are slightly hyperosmotic.
B. Freshwater fish are hypoosmotic.
C. Marine teleost are hyperosmotic.

見背面

6. Which group of plants (I: C3 plants; II: C4 plants; III: CAM plants) has adapted to dry environments?
A. I and II
B. I and III
C. II and III
D. I, II, and III

7. Which of the following is NOT a density-dependent factor?
A. Disease
B. Competition
C. Predation
D. Flood

8. Which of the following population growth model implies overlapping generations and unlimited resources?
A. Exponential growth
B. Geometric growth
C. Logistic growth

9. Which statement about K, carrying capacity, is CORRECT?
A. In the real world, population size of most species remains at K without fluctuation when reaching carrying capacity.
B. A population grows the fastest when its size equals K/4.
C. Carrying capacity is a constant and does not change through time.
D. In animals, K selection species usually have low intrinsic rate of increase.

10. What is the main reason leading to a uniform dispersion pattern among individuals of organisms?
A. Competition
B. Mutualism
C. Resource availability
D. Environmental factors

11. Gross primary production (GPP) is _____.
A. the amount of solar energy captured by algae in oceans and converted into biomass.
B. total primary production by all primary producers in the ecosystem.
C. the amount of biomass produced by autotrophs, which is available to the consumers in the ecosystem.
D. the amount of biomass produced by heterotrophic consumer organisms.

12. After a volcanic eruption, which covers the landscape with a thick layer of volcanic ash, vegetation slowly recovers by primary succession. At the initial stage of the succession, after a thin layer of soil has been formed by algae, lichens and mosses, early successional plants are limited in growth by _____.
A. phosphorus.
B. nitrogen.
C. both nitrogen and phosphorus.
D. light availability.

13. You study the grassland community and are interested in the relationship between diversity (number of plant species per plot of fixed area) and productivity (amount of biomass produced by plants within a given year). You want to prove that the increased diversity of species increases biomass productivity. The best way is to _____.

接次頁

A. survey multiple grasslands across the landscape, select several locations with obviously different productivity (according to the height of the biomass), and in each location, survey the number of species and the amount of biomass produced by those species. Then, regress the amount of biomass against the number of species.
B. do a manipulative experiment, where you will create plots of grassland communities that differ in diversity (they have either 1, 2, 4, 8 or 16 grass species), let them grow for the whole season, and harvest biomass within each plot. Then, regress the amount of biomass against the number of species.
C. search published scientific studies focused on grassland communities, and select those which report both the amount of biomass (productivity) and the number of species (diversity). Then, regress the amount of biomass against the number of species.

14. To know the limiting soil nutrient in a studied forest community (e.g. cloud forest), you collect soil in your study locality and bring it to the greenhouse. You separate it into 12 pots, and in each pot, you grow three plant individuals of *Miscanthus sinensis* (芒草). You separate the set of 12 pots into three treatments: 4 pots are watered by only deionized water (control treatment), 4 pots are watered by phosphorus (P) fertilizer (P treatment), and 4 pots are watered by nitrogen (N) fertilizer (N treatment). After several months, you can see that plants in pots belonging to P treatment grow much better than plants in pots of N treatment and control. What does it mean?
A. Plant growth in the forest is limited by nitrogen (N).
B. Plant growth in the forest is limited by phosphorus (P).
C. Plant growth in the forest is limited by both phosphorus and nitrogen (P and N).
D. Plant growth in the forest is not limited by nitrogen (N) or by phosphorus (P).

15. Decomposition is a key process by which chemical compounds fixed in the biomass return to the ecosystem. Plant leaves will decompose faster if _____.
A. leaves are softer, contain a higher concentration of nitrogen (N) and a lower proportion of lignin.
B. leaves are harder, contain a lower concentration of nitrogen and a higher proportion of lignin.
C. the decomposition is happening in colder and wetter localities.
D. there are fewer microorganisms and fungi in the soil.

16. Anthropogenic climate change is a long-term trend caused by humans, which has the following consequences:
A. it decreases the global temperature and influences mostly the tropical and subtropical forests, which more often suffer from frost events;
B. it warms the ocean water and causes the change in the directions of the ocean currents; as a result, there is more rain in dry areas, leading to such anomalies as flowering deserts;
C. it increases the global temperature and makes the weather patterns more unpredictable;
D. it decreases the overall amount of precipitation, causing severe droughts in some regions (e.g. in the Sahara Desert, Africa).

17. Which statement is INCORRECT?
A. Primary succession occurs in the habitats with some seeds in the soil bank.
B. After a disturbance, the first stages of succession are called primary, and the later stages are called secondary.
C. During primary succession, the number of species in the community steadily increases until it levels out.
D. The succession of vegetation in the forest after the fire is an example of primary succession.

18. Larger islands tend to have more species than smaller islands, but only if _____.
A. they are closer to the mainland.
B. they are farther from the mainland.

見背面

C. they are frequently disturbed.
D. none of the above is correct.

19. Most studies on island diversity document positive species-area relationships (larger islands are more diverse than smaller islands). One study of uninhabited islands from northern Europe, however, reports exactly the opposite pattern: larger islands have fewer plant species than smaller islands. Without knowing any details, what do you think may be the most probable explanation?
A. Larger islands have fewer resources and are, therefore, less productive, decreasing overall species richness.
B. Larger island is more likely to be hit by lightning (since their area is higher), resulting in fires that will spread across the whole island and decrease overall plant richness.
C. Scientists are lazy and have no time to survey larger islands, so the recorded number of species is lower than on small islands.

20. Which of the explanation below is NOT the reason why tropical areas are the most species-rich?
A. because tropical areas are climatically more stable, with less climatic perturbation (caused, e.g. by ice ages);
B. because tropical areas are the most productive;
C. because tropical areas are the most environmentally heterogeneous;
D. because tropical areas have the slowest speciation rate.

21. The global positioning system (GPS), which is used in handheld devices during field surveys (and is also installed in some cars and most mobile phones), determines the exact position on the Earth's surface using _____.
A. aerial barometric pressure,
B. position of mobile phone signal towers in the immediate surrounding,
C. position of satellites,
D. a dense network of precise geolocators operated by local governments.

22. The decrease in ozone concentrations in the stratosphere has been caused by _____.
A. emissions from flights after they started to fly in higher altitudes.
B. DDT being spread across large areas to kill mosquitoes.
C. freons (chlorofluorocarbons) that were used in fridges as refrigerants and which started to accumulate in the atmosphere.
D. increased solar radiation during the past half-century.

23. Which of the statements about the greenhouse effect is CORRECT?
A. Greenhouse effect is not caused by methane (CH_4).
B. Greenhouse effect is not caused by carbon dioxide (CO_2).
C. Greenhouse effect is not caused by water vapour (H_2O).
D. Greenhouse effect is not caused by molecules of nitrogen (N_2).

24. In 2023, Earth will most likely be again affected by El Niño. El Niño is _____.
A. a climatic event which brings exceptionally wet or exceptionally dry conditions to different parts of the planet.
B. caused by climate change.
C. caused by extreme heating of the continental plates.
D. caused by Earth rotation.

25. Among human and natural sources of fixed nitrogen (N) in the biosphere, the main source is _____.
A. nitrogen released by burning fossil fuels.

接次頁

B. nitrogen produced by industrial fixation.
C. nitrogen created by lightning.
D. nitrogen created naturally by terrestrial fixation (by nitrogen-fixing bacteria).

II. Short answer questions (10 points each; answer in Chinese or English, expect for Question No. 30)

26. What are the differences between acclimation and adaptation? Provide an example for each case.

27. Climate change is among the biggest challenges humanity is facing. Please briefly describe the impact of climate change on individual, population, species, community, and ecosystem levels.

28. To make agriculture more sustainable, the United Nations has set a goal to reduce pesticide use by 50% by 2030. Biocontrol is an important approach towards this goal. Please list two biocontrol examples and explain the species relationships in these examples.

29. A student observed that plant species X (exotic) and Y (native) coexist from low to high altitude in Taiwan. However, species X is more dominant at low but not high altitude. Based on the observation, please A) develop your hypothesis to explain the observed pattern, and B) design a study to examine your hypothesis.

30. Briefly summarize the article below (modified from Emery 2022) in Chinese and provide your thoughts:
"For centuries, natural historians and scientists have observed that some species cycle very consistently between years. The classic example many of us are taught when we learn about ecology is the 10-year boom and bust population cycles of snowshoe hares monitored from fur trapping records over the past 300 years in Canada. Indeed, when the boom-and-bust cycles of snowshoe hares are plotted with lynx populations, a specialist predator of snowshoe hares, we see a remarkably consistent real-life example of the Lotka-Volterra predator-prey equation. Peaks and valleys in lynx populations follow shortly behind and are offset from those of the hare population. But ecological processes are hardly ever so consistent, and in other species for which population cycles are observed (lemmings/voles, moths in forests) scientists have argued about what causes cyclic population patterns, from climate oscillations, latitude, plant quality or specialist predator populations to self-regulation. The drivers of cyclicity have been hotly debated over the past 50 years, but research has been constrained by a lack of long-term data.

Data from insects monitored in agricultural fields over decades have been used, historically, to inform within-year management recommendations. These data also offer an expansion to the foundation of species being evaluated to assess the drivers of population cycles and may discount some hypotheses. If species have population cycles in annual agriculture crops planted every year, for example, it discounts the long-held hypothesis that changes in perennial plant quality drive population cycles of herbivores.

For decades, crop advisors and farmers in southern Sweden had observed that an agricultural pest in their winter oilseed rape (canola) fields, the cabbage stem flea beetle had consistent boom-and-bust cycles, just like the snowshoe hare. This was surprising, ecologically, for two reasons: 1) winter oilseed rape (or canola) is an annual crop planted and harvested in different fields each year, meaning plant quality is an unlikely driver of the cycles, and 2) annual cropping systems are exposed to high levels of disturbance, making a tightly coupled predator-prey system (e.g. lynx/hare) harder to imagine. Cabbage stem flea beetle adults feed and oviposit at the base of newly emerged winter oilseed rape plants from September through October. The damage of greater concern, however, is caused by stem and leaf mining from overwintering larvae.

We leveraged 50 years of data from over 3,000 winter oilseed rape fields in southern Sweden, where cabbage stem flea beetle larvae were monitored, to quantify synchrony and cyclicity. We find that when the population of cabbage stem flea beetle in

見背面

one subregion is booming, the others are too across all five subregions (high spatial synchrony). We verified farmer observations that there are 8-year population cycles of cabbage stem flea beetle.

In addition to quantifying both the cyclicity and synchrony of cabbage stem flea beetle populations across Southern Sweden, our results show that cold winters drive these cycles. Cold winters, in turn, are affected by The North Atlantic Oscillation weather system. This represents a significant step forward in recognizing that population cycles persist, even in highly disturbed landscapes, despite resource variability in location and area planted and pesticide use. It also highlights that climatic oscillations are an important driver of population cycles."

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