AY2026 Entrance Examination for the Master's Program, Graduate School of Bioagricultural Sciences, Nagoya University

Subject chosen	Ecology	For this subject Total page (1) Page number (1)

Answer all the following questions (Questions 1-5).

Question 1. Choose five out of the following eight terms and explain each in about 40 words or less.

1) Bergmann's rule
2) Detritus food chain
3) *r*-strategy
4) Beta diversity
5) Microevolution and macroevolution
6) Trophic level
7) Net primary production
8) Biodiversity hotspot

Question 2. Explain the mechanism determining species richness on an island using the terms "migration rate" and "extinction rate."

Question 3. Interactions among organisms are classified from various aspects.

1) Based on the combination of gain (+), loss (−), and none (0), the relationships between the two species (Ⅰ and Ⅱ) are categorized as shown in the right diagram.
What are the relationships A, B, C, and D termed?

Species II \ Species I	+	0	−
+	A	B	C
0	B		
−	C		D

2) Explain two specific examples of the relationship A, focusing on their ecological functions.

Question 4. Answer the following questions about natural selection.

1) Describe the three conditions necessary for natural selection to operate.

2) Regarding directional selection acting on quantitative traits, draw a graph showing changes in phenotypic frequency and explain directional selection.

3) Frequency-dependent selection includes positive and negative frequency-dependent selections. Which selection acts to maintain phenotypic and genetic diversities within a population? Explain why it acts in that way.

Question 5. Describe the geographical distribution of biomes in the world.

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Question 1. Purpose: To test basic knowledge about essential terms in ecology.

1) Bergmann's rule

Bergmann's rule is the tendency found in homeothermic animals: individuals inhabiting colder regions are bigger in body size in the same species, and among closely related species, bigger species inhabit colder regions.

2) Detritus food chain

This is the food chain starting with decomposers that utilize organic matter (detritus) such as dead bodies of plants and animals and animal's excrement as resources.

3) *r*-strategy

This is the reproductive strategy in organisms characterized by small body size and short lifespan, but rapid development and high population growth rate, production of numerous small eggs or seeds.

4) Beta diversity

Beta diversity is the index showing differences in species composition between different populations (samples, survey sites, regions, ecosystems) to understand biodiversity.

5) Microevolution and macroevolution

Microevolution refers to genetic changes occurring within a species or population, while macroevolution refers to species-level evolution (speciation) and evolution occurring at higher taxonomic levels above the species level.

6) Trophic level

A classification of organisms' roles in ecosystems: producers (plants) that synthesize organic matter from inorganic substances using solar energy; consumers (animals) that prey on producers or other consumers; and decomposers that break down the remains and excretions of organisms.

7) Net primary production

Net primary production is the amount of carbon fixed during photosynthesis by primary producers, such as plants in an ecosystem (gross primary production), minus the amount of carbon used for respiration.

8) Biodiversity hotspot

A biodiversity hotspot is a region that shows high species diversity, including many endemic species and a significant number of threatened species. There are 36 biodiversity hotspots in the world.

Question 2. Purpose: To test logical-thinking ability regarding establishment processes of species diversity.

The number of species on an island is related to migration-to-island and extinction-on-island, and depends on the island's size and distance from the mainland. Migration rate decreases as the number of already-established species increases, as the distance from the mainland increases, and as the island's area decreases. This is because more established species reduce available ecological niches, and because an island with more distant location and smaller size is harder for organisms to reach. Extinction rate increases as the number of established species increases. Furthermore, a smaller island is more susceptible to environmental change and has lower carrying capacity, increasing extinction risk. Therefore, equilibrium is reached when migration rate to the island equals extinction rate there, resulting in a fixed number of species.

Question 3. Purpose: To test comprehensive understanding on relationships between species.

1) A: Mutualism, B: Commensalism, C: Parasitism or predator-prey relationship, D: Competition

2) Example 1: Digestive symbiosis
Bacteria inhabit the stomach of cattle, aiding digestion by secreting cellulase enzymes.

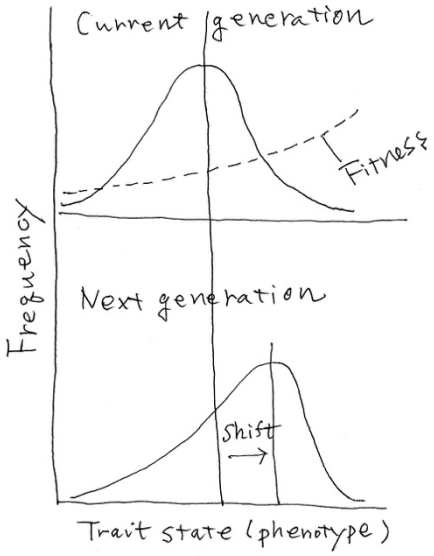
Example 2: Defensive symbiosis
Acacia trees secrete nectar from their leaf tips and provide it to ants. The attracted ants exclude herbivorous animals and insects, thereby protecting the trees from feeding damage.

Example 3: Pollination symbiosis
Plants that rely on cross-pollination attract insects, birds, and bats with nectar or pollen as a reward, enabling them to transport pollen to other flowers of the same species for fertilization.

Question 4. Purpose: To test basic knowledge about natural selection.

1) The three conditions are: 1) the phenotype of a trait varies among individuals, 2) the trait is heritable, and 3) the differences in the phenotype of the trait cause individual differences in survival and reproduction.

2) Directional selection occurs when fitness increases toward one end of the frequency distribution of a quantitative trait. The average trait state shifts toward that end (see graph below). This occurs when a population's environment changes such that the average trait state is no longer optimal.



3) Negative frequency-dependent selection

In negative frequency-dependent selection, individuals with a low-frequency phenotype (minority) have higher fitness than individuals with a high-frequency phenotype (majority). The minority increases in frequency due to its higher fitness, but once it becomes the majority, its fitness declines and its frequency decreases. As a result, individuals with different phenotypes always coexist within the population, maintaining phenotypic and genetic diversity.

Question 5. Purpose: To test basic knowledge about biomes.

There are approximately 10 major biomes, including tropical rainforests, tropical seasonal forests, savannas, deserts, sclerophyll forests (scrub forests), temperate evergreen forests, temperate deciduous forests, temperate grasslands, boreal forests, and arctic tundra. Because these biomes are mainly characterized by temperature and precipitation patterns, which determine the vegetation and animal life that can thrive in a region, the geographical distribution of biomes generally aligns with climate zones.