Country Code: _____	Student Code: _____

The 21st INTERNATIONAL BIOLOGY OLYMPIAD

11th – 18th July, 2010

Changwon, KOREA

PRACTICAL TEST 4

ECOLOGY

Total Points: 51

Duration: 90 minutes

Dear Participants,

- In this test, you have been given the following 4 tasks:

  Task I: Characteristics of Coastal Animal Communities (16 points)

  Task II: Mark and Recapture Method (8 points)

  Task III: Interspecific Interaction (14 points)

  Task IV: Prey Choice Model (13 points)

- Write down your results and answers in the **Answer Sheet. Answers written in the Question Paper will not be evaluated.**

- Please make sure that you have received all the materials listed for each task. If any of the listed items is missing, please raise your hand.

- Stop answering and put down your pencil **immediately** after the end bell rings. The supervisor will collect the Question Paper and the Answer Sheet.

Good Luck!!

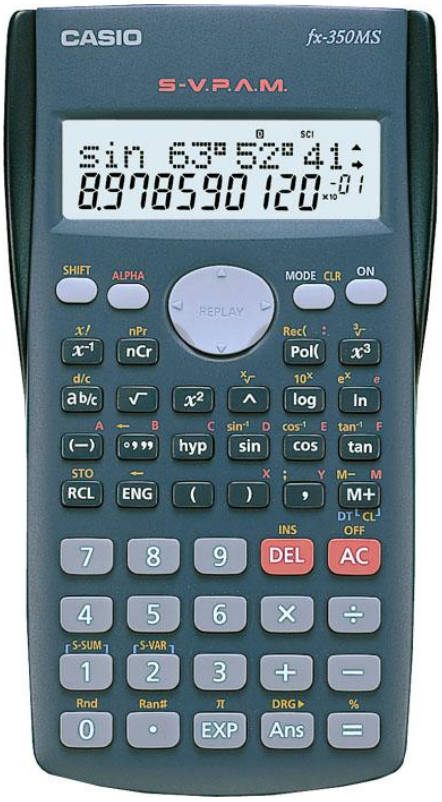
TASK I. (16 points) Characteristics of coastal animal communities

Materials	Quantity
1. Community model board (40 x 37 cm)	1
2. Transparent quadrat board (37 x 37 cm)	1
3. Electronic calculator	1

Introduction

A population is defined as a group of individuals of a single species inhabiting a specific area, and a community is a group of populations of different species inhabiting a specific area. Identification of the characteristics of populations and communities is a basic element in predicting ecological change due to environmental factors.

Using Calculator



1. Press **ON** to turn on the calculator
2. Calculation Examples

   To calculate 1 + 1 , press **1 + 1 =**

   To calculate ln 90 (= $\log_e$ 90), press **ln 9 0 =**

   To calculate $\sqrt{\frac{2^2}{5^2}}$, press $\sqrt{\ }$ **(2** x^2 **) ab/c (5** x^2 **) =**

3. To correct characters, move the cursor by pressing ◄ or ►, and press **DEL** to delete the character or **SHIFT DEL** to insert character
4. To clear all of the calculation you have entered, press **AC**.
5. Press **Shift AC** to turn off the calculator. Calculator will automatically turn off if you do not perform any operation for about 10 minutes.

Q1. (4 points) The model provided on the board is a coastal community consisting of nine animal species. Determine the population size (abundance, N) of each species in the community using a complete enumeration survey and the population density (per unit area, 1 m^2) of each species. The size of each quadrat is 1 m x 1 m. Round values to the nearest hundredth (two decimal places) during your calculations, and record the values in the answer sheet.

Species	Population size
Starfish 	
Razor clam 	
Sea slater 	**15**
Sea urchin 	
Fiddler crab 	**13**
Octopus 	
Oyster 	
Mudskipper 	
Sea anemone 	**13**

Q2. (2 points) The table below records species' population sizes in two different coastal communities. Calculate 'the proportion of relative abundance' of each species. Round values to the nearest hundredth (two decimal places) during your calculations, and record the values in the answer sheet.

Community A		Community B	
Species	Population size	Species	Population size
Starfish	13	Fiddler crab	2
Razor clam	18	Barnacle	18
Sea slater	13	Sea anemone	15
Sea urchin	12	Sea cucumber	2
Fiddler crab	11	Hermit crab	5
Gastropod	8	Gastropod	8
Oyster	12		
Mudskipper	9		
Sea anemone	10		
Total	106	Total	50

Q3. (4 points) A rank-abundance curve is a chart that displays the species in a community ordered from most abundant to rare based on relative abundance. Using the relative abundances you previously calculated (in Q2), make a rank-abundance curve for each community on the grid-line in the answer sheet. Indicate community A as 'A' and community B as 'B' on the curve, and write appropriate titles and scales for the X-axis and the Y-axis.

Q4. (4 points) Calculate the Shannon-Wiener species diversity index (H′) for each of the two coastal communities using the following equation. Round values to the nearest hundredth (two decimal places) during your calculations. Put the values in the box in the answer sheet.

$$H' = -\sum_{i=1}^{n}(p_i \ln p_i)$$

where,

p_i = the proportion of the i^{th} species

ln p_i = the natural logarithm of p_i

n = the number of species in the community

Q5. (1 point) Which statement is/are correct for your rank-abundance curves? Put checkmark(s) (√) in all appropriate boxes in the answer sheet.

A. Species evenness is higher in community A than in community B.

B. Species evenness is lower in community A than in community B.

C. Species richness is higher in community A than in community B.

D. Species richness is lower in community A than in community B.

Q6. (1 point) Which statement is correct for the species diversity index of the two communities? Put a checkmark (√) in the appropriate box in the answer sheet.

A. The area with the higher diversity index (H') should be conserved.

B. The species diversity index (H') indicates the species number inhabiting the coastal area.

C. The species diversity index (H') is inversely proportional to species evenness in an area.

D. The species diversity index (H') depends on both species richness and species evenness.

TASK II. (8 points) Mark and recapture method

Materials	Quantity
1. Pottery with beads	1
2. Sampling net (100 ml)	1
3. Electronic calculator	1

Introduction

A few individuals are captured, marked and released back into the population. The population is sampled again and the numbers of marked individuals in this sample counted. Assuming an equal recapture rate for all individuals and without repetitive counting of the same individual, the population size can be simply estimated by using a modified Lincoln Index as follows:

$$N = \frac{(M+1)(S+1)}{(R+1)} - 1$$

N: Estimation of population size

M: Number of individuals marked

S: Number of individuals captured in the second sample

R: Number of marked individuals recaptured

In this task, the pottery represents a pond with a diving beetle population (the beads). One bead represents one diving beetle. This population contains 40 individuals marked with a red sticker that had been captured during the first sampling. You will be performing the second sampling of this population.

Q7. (4 points) Using the sampling net, capture a sample of diving beetles from the pond (the second sampling). Take two full scoops and combine them. (Assume this population does not have birth, death, emigration, or immigration of individuals between the first and the second sampling events). Estimate population size to the nearest tenth (one decimal place) and record your result in the answer sheet.

Q8. (4 points) The mark and recapture method has a degree of uncertainty because it is an estimation by sampling, not by a total population count. We can measure uncertainty through the calculation of standard error (SE). Standard error (SE) can be obtained by the function given below.

$$SE = \sqrt{\frac{M^2(S+1)(S-R)}{(R+1)^2(R+2)}}$$

The 95% confidence interval can be obtained by this calculation: $N \pm t \cdot SE$. The 95% confidence interval means that the size of original population is within the range of the confidence interval with 95% certainty. The *t*-value is the Student's *t*- value when the degree of freedom is infinity. (At infinity, the Student's *t*-value is also refer to as Z-value). The critical values of the Student's *t* distribution are provided.

Find the appropriate *t* in the table and calculate SE and the 95 % confidence interval for your estimate of population size. Enter the numbers you obtain in the table in the answer sheet. Round your value to the nearest hundredth (two decimal places) during your calculations and record your values in the answer sheet.

Critical Values of the Student's *t* Distribution

Degree of freedom	$\alpha = p = P(t > t_{critical})$			
	0.1	0.05	0.01	0.001
1	6.31	12.71	63.66	636.62
2	2.92	4.30	9.93	31.60
3	2.35	3.18	5.84	12.92
4	2.13	2.78	4.60	8.61
5	2.02	2.57	4.03	6.87
6	1.94	2.45	3.71	5.96
7	1.89	2.37	3.50	5.41
8	1.86	2.31	3.36	5.04
9	1.83	2.26	3.25	4.78
10	1.81	2.23	3.17	4.59
11	1.80	2.20	3.11	4.44
12	1.78	2.18	3.06	4.32
13	1.77	2.16	3.01	4.22
14	1.76	2.14	2.98	4.14
15	1.75	2.13	2.95	4.07
16	1.75	2.12	2.92	4.02
17	1.74	2.11	2.90	3.97
18	1.73	2.10	2.88	3.92
19	1.73	2.09	2.86	3.88
20	1.72	2.09	2.85	3.85
21	1.72	2.08	2.83	3.82
22	1.72	2.07	2.82	3.79
23	1.71	2.07	2.82	3.77
24	1.71	2.06	2.80	3.75
25	1.71	2.06	2.79	3.73
26	1.71	2.06	2.78	3.71
27	1.70	2.05	2.77	3.69
28	1.70	2.05	2.76	3.67
29	1.70	2.05	2.76	3.66
30	1.70	2.04	2.75	3.65
40	1.68	2.02	2.70	3.55
60	1.67	2.00	2.66	3.46
120	1.66	1.98	2.62	3.37
∞	1.65	1.96	2.58	3.29

TASK III. (14 points) Interspecific interaction

Materials	Quantity
1. Two species model board (30 × 32 cm)	1
2. Transparent quadrat board (30 × 30 cm)	1
3. Electronic calculator	1

Introduction

Spiral shellfishes and clams live in the same habitat. In order to know whether there is an interaction between these two species, we examine the distribution of each species in that habitat.

Q9. (2 points) Using the given quadrat board, observe whether the spiral shellfish and the clam are absent and/or present in each quadrat. Write the number of quadrats you have observed in the box in the answer sheet.

Q10. (2 points) The significance of the species' distributions measured in this habitat can be examined by using the Chi-square (χ^2) test. The null hypothesis for the χ^2 test in this situation is that the distribution of each species:

A. is nonrandom.

B. is independent of each other.

C. shows a mutually negative influence.

D. shows a mutually positive influence.

E. is influenced by a third species.

Put a checkmark (√) in the appropriate box in the answer sheet.

Q11. (4 points) To perform the χ^2 test, first determine the expected counts for each observational class. For example, the expected counts of quadrats where both species are present is calculated by multiplying the number of quadrats where one species is present with the number of quadrats where the other species is present divided by the total number of quadrats. Compute the other expected counts similarly to the nearest tenths (one decimal place) and fill the table in the answer sheet.

Q12. (2 points) Using the function below, calculate the χ^2 value for this data set. Record your value to the nearest hundredth (two decimal places) in the answer sheet.

$$\chi 2 = \sum \frac{(\text{observed count} - \text{expected count})^2}{\text{expected count}}$$

Q13. (1 point) In order to evaluate the Chi-square value (χ^2), the degree of freedom for the data set must be determined (*df*). What is the degree of freedom for this data set? Record the value in the answer sheet.

Q14. (2 points) Decide whether to reject or not reject the null hypothesis using the significance level (probability, p) of 0.05. In the given χ^2 table, locate the degree of freedom in the appropriate column. Compare your calculated χ^2 test statistic to the tabular χ^2 value to make your decision. Put a checkmark (√) in the appropriate box in the answer sheet.

Q15. (1 point) Considering the spatial pattern of the distribution, what kind of interactionis likely to be taking place between the two species? Choose **all** possible options and put a checkmark (√) in the appropriate box in the answer sheet.

A. No interaction

B. Commensalism

C. Competition

D. Parasitism

E. Exclusion

Chi-square Table

Degree of freedom	Probability, p				
	0.99	0.95	0.05	0.01	0.001
1	0.000	0.004	3.84	6.64	10.83
2	0.020	0.103	5.99	9.21	13.82
3	0.115	0.352	7.82	11.35	16.27
4	0.297	0.711	9.49	13.28	18.47
5	0.554	1.145	11.07	15.09	20.52
6	0.872	1.635	12.59	16.81	22.46
7	1.239	2.167	14.07	18.48	24.32
8	1.646	2.733	15.51	20.09	26.13
9	2.088	3.325	16.92	21.67	27.88
10	2.558	3.940	18.31	23.21	29.59
11	3.05	4.58	19.68	24.73	31.26
12	3.57	5.23	21.03	26.22	32.91
13	4.11	5.89	22.36	27.69	34.53
14	4.66	6.57	23.69	29.14	36.12
15	5.23	7.26	25.00	30.58	37.70
16	5.81	7.96	26.30	32.00	39.25
17	6.41	8.67	27.59	33.41	40.79
18	7.02	9.39	28.87	34.81	42.31
19	7.63	10.12	30.14	36.19	43.82
20	8.26	10.85	31.41	37.57	45.32
21	8.90	11.59	32.67	38.93	46.80
22	9.54	12.34	33.92	40.29	48.27
23	10.20	13.09	35.17	41.64	49.73
24	10.86	13.85	36.42	42.98	51.18
25	11.52	14.61	37.65	44.31	52.62
26	12.20	15.38	38.89	45.64	54.05
27	12.88	16.15	40.11	46.96	55.48
28	13.57	16.93	41.34	48.28	56.89
29	14.26	17.71	42.56	49.59	58.30
30	14.95	18.49	43.77	50.89	59.70

TASK IV. (13 points) Prey choice model

	Quantity
Materials	
1. Prey model board (22 × 24 cm)	2
2. Electronic calculator	1

Introduction

A foraging animal encounters various types of prey items. Each type of prey can be characterized by its energy content (E), the time required to search for that prey (searching time, Ts), and the time required to capture and consume it (handling time, Th). Therefore, we can measure prey profitability by the function E/(Ts+Th). In this situation, according to optimality theory, natural selection would favor behaviors that maximize an animal's net energy intake per amount of foraging time.

The behavioral options for a forager are whether to accept or to reject an item of a given prey type when it is encountered. Assume that there are two kinds of prey item, Type 1 and Type 2. Let the profitability be higher for Type 1 — that is, $E_1/(Ts_1+Th_1) > E_2/(Ts_2+Th_2)$. Thus, Type 1 items should always be accepted. Prey profitability is density-dependant. That is, profitability of a prey species changes if the prey species becomes less abundant.

On the boards for Site I and Site II, there are three prey items for gulls:

Prey A: Spiral shellfish 

Prey B: Clam 

Prey C: Razor clam 

Q16. (2 points) For Site I, record the density of each of the prey species A, B, C (number of individuals per m^2, assuming that each quadrat is 1m x 1m). Calculate searching time (Ts) for each of the prey species, where the species-specific searching time at density = 1 has been provided. Ts= (1/density)·*a* (sec). The value '*a*' is a species-specific constant. Calculate the values to nearest hundredth (two decimal places).

Prey species	Ts (sec) when the prey density is 1
Prey A	**10**
Prey B	**15**
Prey C	**5**

Q17. (2 points) After capturing a prey item, gulls fly high and drop the item to break its shell. The forager repeats the behavior if the shell does not break. The table below indicates the drop height and the average number of drops required at that height to break the prey's shell. For each prey type, indicate with a checkmark (√), in the answer sheet, the optimal drop height that gulls should choose, if they are optimal foragers.

	Height of drop (m)	Average number of drops required to break shell
Prey A	2	60
	3	40
	5	20
	10	8
	15	7

	Height of drop (m)	Average number of drops required to break shell
Prey B	2	60
	3	20
	5	7
	10	5
	15	4

	Height of drop (m)	Average number of drops required to break shell
Prey C	2	30
	3	10
	5	8
	10	5
	15	4

Q18. (2 points) Gulls fly one meter up or down in 0.5 seconds. Given the optimal drop height for each prey species, calculate the handling time (Th) for each prey item. Record the number in the box in the answer sheet.

Q19. (3 points) The table below lists the average energy gain from eating an individual of each prey species (kilojoules (KJ) per prey). Calculate the profitability of each prey species at Site I to the nearest hundredth (two decimal places), and record the number in the box in the answer sheet.

Prey species	Energy (KJ per prey)
Prey A	7
Prey B	25
Prey C	5

Q20. (2 points) Of the following choices, what would be the optimal decision for the gulls at site I? Put a checkmark (√) in the most appropriate box in the answer sheet.

A. Eat all of prey A.

B. Eat all of prey B.

C. Eat all of prey C.

D. Eat prey A at first and then switch to prey B.

E. Eat prey B at first and then switch to prey C.

Q21. (2 points) A gull finds an item of prey C in Site II. The gull can, however, decide not to take this item and fly to Site I where it can search for prey B. Given that Site I requires 50 seconds of flying time from Site II, what should the gull do in order to maximize the profitability of the next prey item, if it is an optimal forager? Distribution of the prey items in Site II has been provided to you. Put a checkmark (√) in the most appropriate box in the answer sheet.

A. The gull will eat the prey C in Site II.

B. The gull will move to Site I to search for prey B.

C. The gull will search for prey B in Site II.

D. The gull will move to site I to search for prey C.

E. The gull will search for prey A in Site II.

PRACTICAL TEST 4
Answer Key

ECOLOGY

Total Points: 51

Duration: 90 minutes

TASK I. (16 points)

Q1. (4 points)

Species	Population size	Density (number of individuals/m^2)
Starfish 	15	0.31
Razor clam 	20	0.41
Sea slater 	**15**	0.31
Sea urchin 	13	0.27
Fiddler crab 	**13**	0.27
Octopus 	10	0.20
Oyster 	14	0.29
Mudskipper 	11	0.22
Sea anemone 	**13**	0.27

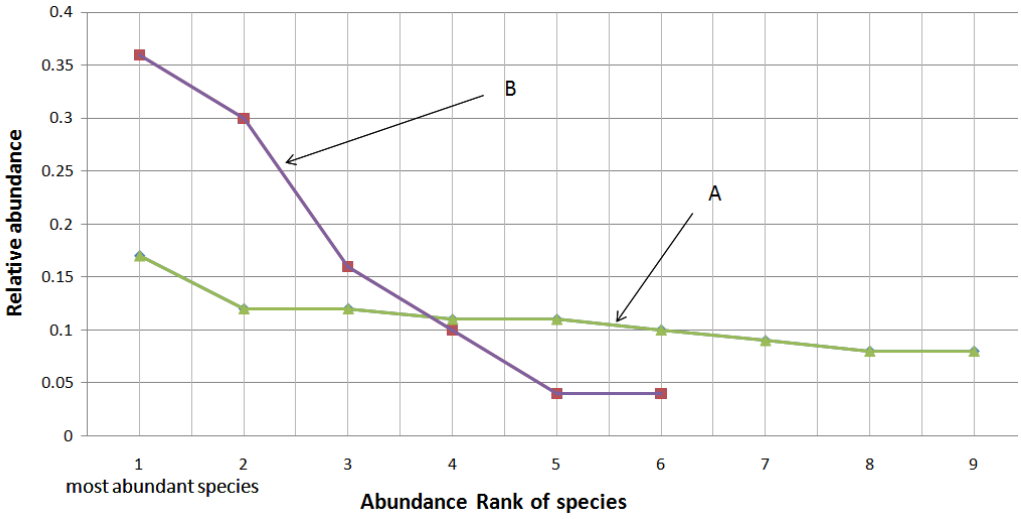
1. One point will be subtracted for any error in rounding value and error in decimal place.
2. In case of calculation error for any value, one point is subtracted for each error.

Q2. (2 points)

Community A			Community B		
Species	Population size	Proportion of relative abundance	Species	Population size	Proportion of relative abundance
Starfish	**13**	0.12	Fiddler crab	**2**	0.04
Razor clam	**18**	0.17	Barnacle	**18**	0.36
Sea slater	**13**	0.12	Sea anemone	**15**	0.30
Sea urchin	**12**	0.11	Sea cucumber	**2**	0.04
Fiddler crab	**11**	0.10	Hermit crab	**5**	0.10
Gastropod	**8**	0.08	Gastropod	**8**	0.16
Oyster	**12**	0.11			
Mudskipper	**9**	0.09			
Sea anemone	**10**	0.09			
Total	**106**		Total	**50**	

1. 0.5 point is subtracted for any error in rounding value and error in decimal place.
2. In case of calculation error for any value, 0.5 point is subtracted for each error.

Q3. (4 points)



1. Full points will be given for marks on the appropriate curve, and appropriate titles and scales for the X-axis and the Y-axis.
2. For incorrect marks or no marks and scales, 2 points are subtracted.

Q4. (4 points)

Species diversity index of community A (H'_A)	Species diversity index of community B (H'_B)
2.15	1.51

1. Full points will be given for values between 2.10 – 2.19 for community A and 1.50-1.59 for community B.

Q5. (1 point)

A	B	C	D
√		√	

Q6. (1 point)

A	B	C	D
			√

TASK II. (8 points)

Q7. (4 points)

Number of individuals captured during the second sampling	Participant's Value
Number of marked individuals recaptured	Participant's Value
Estimate of the population size	Use of the Excel Table

1. 1 point will be given if the participant wrote the first and second answers.
2. 0.5 point is subtracted if the participant did not round off the numbers.

3. 0.5 point is subtracted if the participant did not record one decimal place or recorded more decimal places.

Q8. (4 points)

t-value	1.96
SE	Use of the Excel Table
Confidence interval of the estimated population size	Use of the Excel Table

1. Values found in Q.1 must be applied.
2. 0.5 point is subtracted if the participant did not round off the numbers.
3. 0.5 point is subtracted if the participant did not record one decimal place or recorded more decimal places.
4. It is OK if the confidence interval is written in the range (X~X') or in the form of Y±Y'.

TASK III. (14 points)

Q9. (2 points)

Observed count		Spiral shellfish 	
		Present	Absent
Clam 	Present	15	12
	Absent	6	16

1. 1 point is subtracted if the participant wrote one wrong answer.

Q10. (2 points)

A	B	C	D	E
	√			

1. Plural choice is null.

Q11. (4 points)

Expected count		Spiral shellfish	
		Present	Absent
Clam	Present	11.6	15.4
	Absent	9.4	12.6

1. 1 point is subtracted for each wrong answer.
2. 0.5 point is subtracted if the participant did not round off the numbers.
3. 0.5 point is subtracted if the participant did not record one decimal place or recorded more decimal places.
4.
5. Use the excel table for the evalution when the observation counts are wrong (full point in the case of exact calculation).

Q12. (2 points)

χ^2	3.96

1. Use the excel table for the evaluation when the answers of Q9 and Q11 are wrong (full point in the case of exact calculation).

Q13. (1 point)

Degree of freedom (*df)*	1

Q14. (2 points)

	Fail to reject	Reject
Null hypothesis		√

If Q12 < 3.84, "fail to reject" is a correct answer.

Q15. (1 point)

A	B	C	D	E
	√		√	

1. 1 point is obtained if the participant chose only B or D.
2. If answer of Q14 is "fail to reject", correct answer is "A"

TASK IV. (13 points)

Q16. (2 points)

Prey species	Density (number of individuals/m^2)	Ts (sec) when the prey density is 1	Ts (sec) at the Site I
Prey A	1.00	**10**	10
Prey B	0.75	**15**	20
Prey C	0.50	**5**	10

1. 0.5 point is subtracted if the participant did not round off the numbers.
2. 0.5 point is subtracted if the participant did not record one decimal place or recorded more decimal places.
3. 1 point is subtracted if the participant wrote one wrong answer.

Q17. (2 points)

	Height of drop (m)	Average number of drops required to break shell	Optimal height for handling
Prey A	2	60	
	3	40	
	5	20	
	10	8	√

	15	7	

Prey B	Height of drop (m)	Average number of drops required to break shell	Optimal height for handling
	2	60	
	3	20	
	5	7	√
	10	5	
	15	4	

Prey C	Height of drop (m)	Average number of drops required to break shell	Optimal height for handling
	2	30	
	3	10	√
	5	8	
	10	5	
	15	4	

Q18. (2 points)

Prey species	Handling time per prey (sec)
Prey A	80
Prey B	35
Prey C	30

1. 1 point is subtracted if the participant wrote one wrong answer.

Q19. (3 points)

Prey species	Energy (KJ per prey)	Prey profitability
Prey A	**7**	0.08
Prey B	**25**	0.45
Prey C	**5**	0.13

1. 1 point is subtracted if the participant wrote one wrong answer.
2. 0.5 point is subtracted if the participant did not round off the numbers.
3. 0.5 point is subtracted if the participant did not record one decimal place or recorded more decimal places.
4. Use the excel table for the evaluation using answers of Q16 and Q18 (full point in the case of exact calculation).

Q20. (2 points)

A	B	C	D	E
				√

Q21. (2 points)

A	B	C	D	E
	√			

Plural choice is null.