Question 5

Intent of Question

The primary goals of this question are to evaluate a student's ability to: (1) identify the treatments in a biological experiment; (2) present a completely randomized *design* to address the research question of interest; (3) describe the benefit of limiting sources of variability; and (4) describe the limitations to the scope of inference for the biologist.

Solution

Part (a):

The three different growth-enhancing nutrients (A, B, and C) and two different salinity levels (low and high) yield a total of $3 \times 2 = 6$ different treatment combinations for this experiment.

Treatment Combination	Nutrient	Salinity Level
1	A	Low
2	A	High
3	B	Low
4	B	High
5	C	Low
6	C	High

Part (b):

Since 10 tiger shrimps have already been randomly placed into each of 12 similar tanks in a controlled environment, we must randomly assign the treatment combinations to the tanks. Each treatment combination will be randomly assigned to 2 of the 12 tanks. One way to do this is to generate a random number for each tank. The treatment combinations are then assigned by sorting the random numbers from smallest to largest.

Treatment Combination	Nutrient	Salinity Level	Tanks with
1	A	Low	Smallest and second smallest random numbers
2	A	High	Third and fourth smallest random numbers
3	B	Low	Fifth and sixth smallest random numbers
4	B	High	Seventh and eighth smallest random numbers
5	C	Low	Ninth and tenth smallest random numbers
6	C	High	Next to largest and largest random numbers

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Question 5 (continued)

After three weeks the weight gain (after – before) is computed for each tank, and the treatments are compared using appropriate averages.

Part (c):

Using only tiger shrimp will reduce a source of variation in the experimental units, the tanks of shrimp in this experiment. By eliminating this possible source of variation, type of shrimp, we are better able to isolate the variability due to the factors of interest to us (nutrient and salinity level). This will make it easier to identify any treatment effects that may be present.

Part (d):

Using only tiger shrimp will limit the scope of inference for the biologist. Ideally, the biologist would like to identify the treatment combination that leads to the most growth for all shrimp. However, the biologist will only be able to identify the best treatment combination for tiger shrimp because other types of shrimp may respond differently to the treatments.

Scoring

Part (a) is scored as essentially correct (E) or incorrect (I). Parts (b), (c), and (d) are scored as essentially correct (E), partially correct (P), or incorrect (I).

Part (a) is essentially correct (E) if all six treatments are correctly listed. This may be done in a 2 x 3 table or tree diagram but must clearly indicate the six treatments. A correct but incomplete listing of treatments in part (a) can be recovered in part (b) if the six treatments are clearly stated.

Listing the factors (nutrients A, B, C and salinity high, low) is incorrect and cannot be recovered in part (b).

Part (b) is essentially correct (E) if:

- each treatment combination is randomly assigned to 2 of the 12 tanks
  AND
- a correct procedure for randomization is described (so that two knowledgeable statistics users would use the same method to assign treatments to the tanks).

Part (b) is partially correct (P) if only one of these components is present. For example,

- Each treatment is randomly assigned to 2 of the 12 tanks, but the method of randomization is not fully described (i.e., just say randomly assign each treatment to 2 of the 12 tanks).
  OR
- A correct procedure for randomization of the treatments to the tanks is described, but each treatment does not necessarily appear twice.

Part (b) is incorrect (I) if there is no randomization or randomization of treatments is applied to the shrimps only (not the tanks).

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Question 5 (continued)

Notes:

- If the randomization has been correctly applied to the tanks, additionally randomizing the shrimps or treatments will be regarded as extraneous.
- Because the stem indicates shrimp growth is to be compared, students are not required to identify a response variable in part (b) as was done in the model solution.

Part (c) is essentially correct (E) if

- the statistical advantage of reduced variability is identified
  AND
- an appropriate explanation that relates reduced variability to increasing the likelihood of determining differences among treatments is clearly provided.

Part (c) is partially correct (P) if only one of the two components is correct.

Part (c) is incorrect (I) if neither of the two components is present.

Notes:

- In this completely randomized design, confounding is not possible. Therefore a reference to confounding or lurking variables always incurs a penalty.

Part (d) is essentially correct (E) if

- the statistical disadvantage of limited scope of inference is identified
  AND
- an explanation that different species of shrimp may respond differently to treatments is provided.

(If the different responses to the treatments by other species of shrimp have been established in part (c), then it need not be repeated in part (d).)

Part (d) is partially correct (P) if only one of the two parts of the essentially correct response is provided.

Part (d) is incorrect (I) if neither of the two parts of the essentially correct response is provided,

4 Complete Response

3 Substantial Response

2 Developing Response

1 Minimal Response

If a response is between two scores (for example, 2½ points) use a holistic approach to determine whether to score up or down depending on the strength of the response and communication. The strength of the responses in parts (b) and (c) may be most important in making this choice.

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5A1

5. A biologist is interested in studying the effect of growth-enhancing nutrients and different salinity (salt) levels in water on the growth of shrimps. The biologist has ordered a large shipment of young tiger shrimps from a supply house for use in the study. The experiment is to be conducted in a laboratory where 10 tiger shrimps are placed randomly into each of 12 similar tanks in a controlled environment. The biologist is planning to use 3 different growth-enhancing nutrients (A, B, and C) and two different salinity levels (low and high).

(a) List the treatments that the biologist plans to use in this experiment.

n	nutrients	salinity level
1	A	low
2	A	high
3	B	low
4	B	high
5	C	low
6	C	high

(b) Using the treatments listed in part (a), describe a completely randomized design that will allow the biologist to compare the shrimps' growth after 3 weeks.

Assign each tank a number from 1 to 12 so that one number corresponds to each tank. Then, for each tank roll a die and assign the appropriate numbered treatment from part (a) to that tank. Roll again if a treatment is rolled which has already been assigned twice. This design randomly assigns treatments to tanks, which each treatment being assigned to two tanks.

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5A2

(c) Give one statistical advantage to having only tiger shrimps in the experiment. Explain why this is an advantage.

Since tiger shrimp will vary less in their characteristics than shrimp in general, by using only one type of shrimp we are able to reduce the variability of our subjects. This will then reduce variability in treatment effectiveness due to varying species, allowing us to determine more clearly the effectiveness of each treatment.

(d) Give one statistical disadvantage to having only tiger shrimps in the experiment. Explain why this is a disadvantage.

Since we use only tiger fish, we may not generalize the results of our study to any other types of shrimp, as they could respond differently to the treatments. So, this study is not useful if we are interested in the effects of the treatments on shrimp other than tiger shrimps.

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5B1

5. A biologist is interested in studying the effect of growth-enhancing nutrients and different salinity (salt) levels in water on the growth of shrimps. The biologist has ordered a large shipment of young tiger shrimps from a supply house for use in the study. The experiment is to be conducted in a laboratory where 10 tiger shrimps are placed randomly into each of 12 similar tanks in a controlled environment. The biologist is planning to use 3 different growth-enhancing nutrients (A, B, and C) and two different salinity levels (low and high).

(a) List the treatments that the biologist plans to use in this experiment.

where (growth enhancing nutrient, salinity level) he plans to use, (A, low) (A, high) (B, low) (B, high) (C, low) (C, high)

(b) Using the treatments listed in part (a), describe a completely randomized design that will allow the biologist to compare the shrimps' growth after 3 weeks.

By assigning each of the treatments a different number from one to six the biologist can use a die to randomly assign the treatments to different tanks. Because there are six treatments and 12 tanks he will want to use each treatment in 2 tanks, so for each tank the biologist should roll the die and assign the indicated treatment to the tank, unless he has already assigned that treatment to 2 tanks in which case he should roll again until he rolls a number of a treatment which has not already been assigned twice.

After randomly assigning 10 tiger shrimp to each tank, the biologist should measure the size/weight of the shrimps before starting the experiment, and then he can measure their growth after 3 weeks in there perspective tanks.

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5B2

(c) Give one statistical advantage to having only tiger shrimps in the experiment. Explain why this is an advantage.

Because tiger shrimp are more similar to other tiger shrimp than to other types of shrimp, using only tiger will create less variability based on the type of shrimp for the biologist, therefore he may have a smaller standard error for his experiment with not that many shrimp

(d) Give one statistical disadvantage to having only tiger shrimps in the experiment. Explain why this is a disadvantage.

Tiger shrimp may differ from other types of shrimp, so the results of an experiment only containing tiger shrimp cannot be extended to other types of shrimp.

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5C1

5. A biologist is interested in studying the effect of growth-enhancing nutrients and different salinity (salt) levels in water on the growth of shrimps. The biologist has ordered a large shipment of young tiger shrimps from a supply house for use in the study. The experiment is to be conducted in a laboratory where 10 tiger shrimps are placed randomly into each of 12 similar tanks in a controlled environment. The biologist is planning to use 3 different growth-enhancing nutrients (A, B, and C) and two different salinity levels (low and high).

(a) List the treatments that the biologist plans to use in this experiment.

- Nutrient A / low salinity
- nutrient A / high salinity
- nutrient B / low salinity
- Nutrient B / high salinity
- nutrient C / low salinity
- nutrient C / high salinity

(b) Using the treatments listed in part (a), describe a completely randomized design that will allow the biologist to compare the shrimps' growth after 3 weeks.

each tank will be assigned a number one-six. A die will be rolled for each shrimp, placing it into the cores pording tank until it is full, in which case it will be rolled again. Each tank should be kept in the same conditions (amount of light, temperature) so as to reduce the effect of lurking variables. After 3 weeks, growth should be recorded for each tank and compared by both type of nutrient and by the amount of salinity. This will allow for comparisons to be made two ways.

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(c) Give one statistical advantage to having only tiger shrimps in the experiment. Explain why this is an advantage.

One statistical advantage to having only tiger shrimp is that their amount and rate of growth should be relatively the same. Also, they should be effected by the nutrients and salinity the same as the other tiger shrimp in the tanks This will decrease the effect of varying variables on the experiment allowing for more precise conclusions to be drawn

(d) Give one statistical disadvantage to having only tiger shrimps in the experiment. Explain why this is a disadvantage.

A disadvantage is that the experiment can only help to explain the effects on tiger shrimp. Because different kinds of shrimp may be effected differently, this experiment cannot be generalized to all shrimp, only tiger shrimp.

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AP® STATISTICS
2006 SCORING COMMENTARY

Question 5

Overview

The primary goals of this question were to evaluate a student's ability to: (1) identify the treatments in a biological experiment; (2) present a *completely randomized design* to address the research question of interest; (3) describe the benefit of limiting sources of variability; and (4) describe the limitations to the scope of inference for the biologist.

Sample: 5A
Score: 4

In part (a) a table is used to clearly present all six treatments. The treatment numbers used in part (a) are referred to in part (b) when a die is rolled to assign treatments to tanks randomly. The process of the random assignment is clearly described, and care has been taken to ensure that exactly two tanks are assigned to each treatment. In part (c) the essay states that by using only tiger shrimp, the variability among shrimp is less than would be present if all shrimp were included in the study. The advantage of reduced variation is nicely given as "allowing us to determine more clearly the effectiveness of each treatment." The disadvantage of having only tiger shrimp and why it is a disadvantage is succinctly stated in part (d): "we may not generalize the results of our study to any other types of shrimp, as they could respond differently to the treatments." Strong communication is present in each part. This essay earned a score of 4.

Sample: 5B
Score: 3

Ordered pairs are used in part (a) to present the six treatment combinations for this experiment. In part (b) treatments are randomly assigned to tanks using a die. The student explicitly states that "he should roll again until he rolls a number of a treatment which has not already been assigned twice," ensuring that each treatment is assigned to exactly two tanks. Although the response variable is not specifically stated as being the change in "size/weight" during the three weeks of the study, it is clearly indicated that measurements are to be made both at the study's beginning and end. In part (c) a reduction in variability is clearly presented as the advantage of having only tiger shrimp. The "smaller standard error" is a restatement of this reduced variation. The student does not discuss why the smaller variability is an advantage. In part (d) the disadvantage of a limited scope of inference is identified by noting the inability to generalize the study's conclusions to all types of shrimp. The fact that different species of shrimp may respond differently to the treatments is not given. This essay earned a score of 3.

Sample: 5C
Score: 2

The treatment combinations are listed in part (a). The shrimp are randomly assigned to tanks in part (b), and this was considered to be extraneous information. Treatments are not randomly assigned to tanks, and this random assignment of treatments to experimental units (tanks) is the critical randomization for this study. Although the student begins to describe the advantage of reduced variability in part (c), this is said to "decrease the effect of lurking variables." The use of lurking variable in this context is an inappropriate use of statistical terminology. "More precise conclusions" is not a sufficient explanation of why there is an advantage to using only tiger shrimp. In part (d) the student succinctly describes a limited scope of inference when using only tiger shrimp and explains that it is a disadvantage because "different kinds of shrimp may be effected [*sic*] differently." This essay earned a score of 2.

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