SAMPLE FIRST EXAMINATION
ECOLOGY AND EVOLUTIONARY BIOLOGY, December 16, 1985

Session 1. Short factual questions. Answer 10 of the following 12 questions. One brief paragraph should be used to answer each question. (20%).

1. Diagram and briefly explain the theoretical responses of niche width shown by a population experiencing interspecific competition.

2. Describe the uses and assumptions of the logistic and exponential models of population growth.

3.What is a life table? What information is needed to construct it and what information can you get from it?

4.What is character displacement?

5.What does "optimum foraging theory" predict?

6.Define sexual selection and distinguish between it and other types of selection.

7.Explain the Lotka-Volterra model of predation and state its predictions.

8. Define inclusive fitness.

9.What does the Hardy-Weinberg model predict and what are its assumptions?

10. Distinguish among sympatric, allopatric and parapatric speciation.

11. Draw a simple energy flow diagram and label its key components,

12. Define and distinguish among paraphyly, polyphyly and monophyly.

Session II. Longer factual essays. Answer two of the four questions. (30%).

1. Give evidence, pro and con, for the concepts of gradualism and punctuate

2. Define and compare, with examples, characteristics of “r-selected" populations with those of “K-selected" populations. Evaluate each of these extremes in terms of succession, competition, predator-prey interactions and population density control. Mention the problems with the concept of "r and K selection".

3. Defend or refute the concept that interspecific competition
is a major factor in structuring communities.

4. A given pattern of variation is controlled by **two alleles,** a_1 and a_2. For every 100 offspring produced by a given number of a_1a_1 individuals, 200 offspring are produced by the same number a_1a_1 individuals and 50 offspring are produced by the same number of a_2a_2 individuals. Develop a hypothesis to explain this phenomenon, citing some known cases, and predict the ultimate gene frequencies.

Session III. Data analysis. Select one of two questions. (30%).

1. Ecologists have often accepted, sometimes without question, that morphological differences among species indicate ecological differences, and that differences between morphological characters and food size, or differences in qualities of related sympatric species, are evidence of resource partitioning. This viewpoint has recently been challenged by workers such as Wiens and Rotenberry (1980).

Bumblebees are generally thought to play a major role in the pollination of flowering plants in many North American plant communities. These colonial insects are particularly well adapted to the rigors of life in temperate and boreal climates. Unlike honeybees, bumblebees function at low temperatures and in cloudy, wet conditions. Bumblebee workers forage independently of other colony members; unlike honeybees, they are unable to recruit other workers to a food resource. Although bumblebee colonies exploit a wide range of flower species, each individual worker has access only to a relatively few flower plant species during its lifespan. Consequently, individual bees tend to specialize on one or a few flower types, while retaining the capacity to switch to others if necessary.

In a recent study, Harder (1985) presented data on the relationship between bumblebee morphology and flower use based on the analysis of bee behavior in an eastern Ontario old-field habitat. Figures 1, 4 and 5, and Table 1, include some data from this study.

a. Review the available data and discuss the relationship between morphology and foraging in bumblebees.

b. Discuss the possible ecological factors which are most likely to affect the correlation between morphology and feeding in northeastern North American bumblebees.

c. How do these date relate - if at all - to the interpretation of the seasonal flowering pattern and to the concept that bees and flowers have coevolved?

d. What sort% of observations or experiments could you suggest which might shed light on these questions?

TABLE 1. Characteristics of plant species visited by at least five bees (workers only) from 15 July–1 September 1981. *ruf*—*B. ruficinctus*, *gri*—*B. griseocollis*, *imp*—*B. impatiens*, *vag*—*B. vagans*, *fer*—*B. ferviduz*, *pen*—*B. pensylvanicus*.

Plant species	Bee species							Mean corolla depth (mm)	Inflorescence size*
	ruf	*gri*	*imp*	*ter*	*vag*	*fer*	*pen*		
	Frequency of use by species								
Daucus carota	8							0.0	>50.0
Melilotus alba	106	26	3		5	10		2.0	29.7
Spiraea alba	2	14	1	1				0.0	>50.0
Asclepias syriaca		13						2.3	52.8
Solidago canadensis	51	61	43		16	30	7	0.5	>100.0
Arctium minus		18	2		14		3	3.9	>30.0
Rubus strigosus			1	1	5		1	4.7	1.8
Solidago graminifolia	1	9	1			15	4	1.0	>100.0
Lycopus americanus	1	1	1		3	26		2.4	13.2
Prunella vulgaris					7	37	4	7.6†	4.4
Cirsium vulgare		1			3	17	10	6.2	53.0‡
Aster novae-angliae	1	1				15	19	3.6	>50.0
Vicia cracca						24		6.8	6.2
Oenothera biennis						10	1	8.8†	<5.0

* Mean number of florets that a bee could visit without flight.
† Corolla depth equals 1.2 times the glossa length of the shortest tongued bee visiting this plant.
‡ Mean number of florets probed by 45 bees.

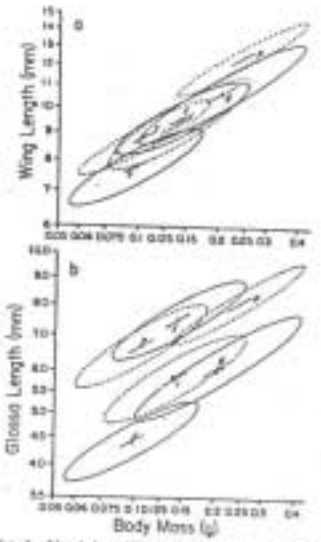

FIG. 3. Morphological characteristics of samples of 30 others of the six common species in the old field. Ellipses close 95% of the observations for each species and have ow the 95% confidence intervals for the respective means. st most abundant species (*B. ruficinctus* [r], *B. griseocoll*], and *B. fervidus* [f]) are illustrated by ——— ellipses, while – ellipses denote less common species (*B. impatiens* [i], vagans [v], and *B. pensylvanicus* [p]).

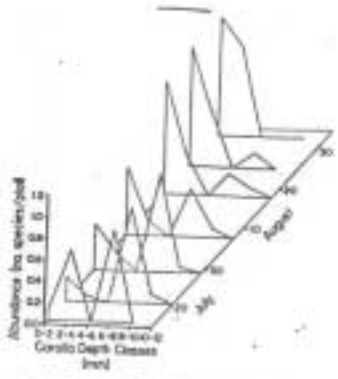

FIG. 4. Temporal dynamics of the availability of flowers of different depths in 2 × 2 m plots in the old field (see Fig. 3).

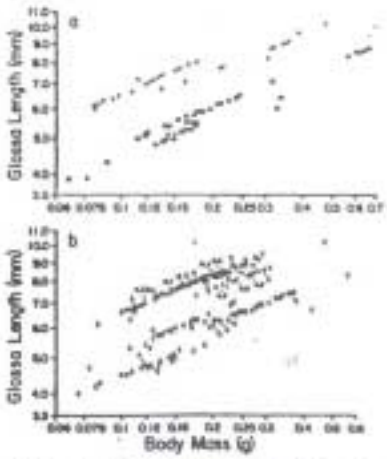

FIG. 5. Morphological characteristics of individual bees visiting (a) *Asclepias syriaca* [M] and *Vicia cracca* [V] on 7 and 14 July 1980 and (b) *Aster novae-angliae* [A], *Solidago canadensis* [C], *S. graminifolia* [G], *Rubus strigosus* [R] and *Cirsium vulgare* [T] on 28 August and 1 September 1981. Some letters represent several bees with the same characteristics that visited the same plant. In cases where several bees with the same characteristics visited different plants, one bee's flower choice marks the common morphological features within the main group of bees, while the choices of the remaining bees are indicated by a letter offset by a short line.

Session III. continued.

2. There is no set answer to the following question. Your analysis and approach is important here.

The following is a set of data on five taxa (and the characters which are distributed among them) are to be utilized in developing a hypothesis regarding their relationship.

a. Present their phyletic relationship in a explicit diagram.

b. Discuss this diagram in terms of the characters listed, analysing all characters as to their informative significance (i.e., homology, polarity, congruence, reversal, loss, etc.).

CHARACTER DISTRIBUTIONS

Taxa	A	B	C	D	E	F	G	H	I	J	K	L	M	N
I	1	0	0	0	1	0	1	1	1	1	a	b	d	a
II	0	1	0	0	1	0	1	1	1	1	b	b	d	c
III	0	0	1	0	0	1	1	1	1	0	c	c	d	c
IV	0	0	0	1	0	1	1	1	0	0	d	c	c	c
V	0	0	0	0	0	0	1	0	0	0	a	a	a	d

The zero character state represents the primitive condition. The one character state represents the advanced or derived condition. This applies to characters A - J.

Character K represents a character transformation series or homologous series in which the transformation is unipolar and a (little a) is primitive. Therefore, the series which reads a - b - c - d as derived from the ontogenetic series.

Character L represents a series in which a (little a) is primitive and b and c are independently derived from it.

Characters M and N have an ontogeny depicted as four stages. These stages, in sequence, are a - b - c - d. The letter entered for each taxon represents the adult condition.

a.

Session IV. Research proposal. (20%).

Choose one of the following topic areas for your research and carefully develop each of the following in your proposal:
a. What are the critical questions you are asking?
b. What field and/or lab methodologies would you use to examine the questions? What are your assumptions in using these techniques?
c. What sorts of data do you anticipate collecting?
d. How would you organize and analyze the data?

1. A given species of water beetle is dimorphic in winglength. In some populations, adults have large functional wings and are capable of flight whereas adults of others populations are wingless. Both adults and larvae occur in freshwater ponds and are predators on other aquatic invertebrates. In any large geographical area (e.g. the Upper Peninsula of Michigan or the Adirondacks), geographical variations with regard to this polymorphism occur among ponds of varying size, character, and distance apart. Design a project to evaluate this dimorphism and determine its ecological significance, if any.

3. Determine the evolutionary rates in any lineage of your choice (i.e., primates).

4. The sardine fishery was the backbone of the California fishing industry from the early part of the century until the late 1950s when this species virtually disappeared from California waters. This decline in the sardine population was accompanied by an increase in the abundance of anchovies. Both fish are planktivores. Large amounts of data on the catches of sardines per unit effort and the total fishing effort are available for the twenty years preceding the decline of the sardine. Both fish can be maintained in the lab for study and there is a plentiful fossil record documenting the related abundance of the fish.
Design a research project to determine the most probable causes for the decline of the sardine and the rise of the anchovy.

4. A researcher wishes to determine if two closely related sympatric species share their resources efficiently, or if they are in total competition with each other. Resources to be examined include food, habitat and time.

5. You are attempting a systematic revision of any group of your choice and at the hierarchical level of your choice. How would you go about accomplishing this task?