

PH.D. PROGRAM IN BIOLOGY
CITY UNIVERSITY OF NEW YORK
FIRST EXAMINATION ECOLOGY, EVOLUTIONARY BIOLOGY AND BEHAVIOR
FALL 1990

Session I. Short factual questions. Answer 10 of the following questions. One paragraph should be sufficient to answer each. Be sure to define, explain and give examples where possible.

1. What is canalization?
2. What is character displacement
3. What is parallel evolution?
4. What is inclusive fitness?
5. What is succession?
6. What is the compensation point (or depth)?
7. What is a log-normal distribution
8. Define carrying capacity.
9. What is a cladogram?
10. What is character congruence?
11. What is synapomorphy?
12. What is holotype?
13. What is an optimality model?
14. What is polyandry?
15. Distinguish between proximate and ultimate factors.
16. What are circannual clocks, and what types of behavior may be regulated by them?

1990 Exam

Session II. Longer factual essays. Answer two questions.

1. Define and compare phyletic, sympatric, allopatric and stasipatric speciation. For each of the above indicate the relative importance, examples and mechanisms involved.

2. Vegetative reproduction (cloning) is a prominent reproductive strategy in many animals (sponges, hydroids, anemones, corals) and plants (dandelions, blackberries, aspens, beeches). Discuss the ecological and evolutionary implications of cloning in terms of reproductive success, dispersion, resource utilization, defense against competitors, or predators. What are the disadvantages of cloning and what factors may limit its adaptation by other plants and animals?

3.. Describe the relationship between phylogeny and classification.

4. The term sex ratio refers to the proportion of males in a population. We can distinguish between four sex ratios: the primary sex ratio (sex ratio at conception), the secondary sex ratio (sex ratio at the end of parental care), tertiary sex ratio (sex ratio of newly independent nonbreeding animals) and quaternary sex ratio (sex ratio of older breeding individuals).

These various ratios are often, but not always, near equality (i.e. 50% 0:50, or 0.5).

Discuss the influence of selection and/or mating system on each of these ratios. Include examples from organisms exhibiting primary and quaternary ratios of 0.5, and organisms in which one or more of these ratios deviates from 0.5.

1990 Exam Session III
Session III. Data analysis. Answer one question. (three choices)

1.

Acorn barnacles such as the North Atlantic species *Semibalanus balanoides* are common intertidal, filter-feeding animals occurring -primarily in the mid-to upper intertidal where they live attached permanently to rocks. Heat, desiccation and winter ice limit barnacles in the upper intertidal, whereas predators are more abundant in the mid-to lower zone (where feeding conditions are most favorable for barnacles). Where barnacle larvae settle in large numbers, growth of barnacles may result in crushing and overgrowth among neighbors. In a recent paper (Ecol. v. 70, 1989), Pertness studied the density-dependent dynamics of *Semibalanus* on shores in Narragansett Bay (RI)

Recruitment (larval settlement) usually occurs in February. Fig. 1 shows temperature and density data at three tidal heights. Density stress on barnacles is shown in Figs. 2 & 3. Fig. 4 shows summer growth patterns. Fig. 5 illustrates survivorship of barnacles which have already survived (i.e. survivorship in the second year). Fig. 6 shows the results of manipulations of recruit density on survivorship to September for recruit densities low (< 3 recruits per cm^2), medium (5-10 per cm^2) and high >10 per cm^2). At medium and high recruit densities all barnacles exhibited crowded morphologies and covered 100% of available space by June. Figures 7 and 8 show barnacle tissue temperatures and rock surface temperatures Fig. 3 compares barnacle tissue and rock temperatures On rocks with solitary, and crowded barnacles; this figure also illustrates the effect of shading or embedding barnacles temperature.

Discuss the role of intertidal position and barnacles density on barnacle population dynamics.

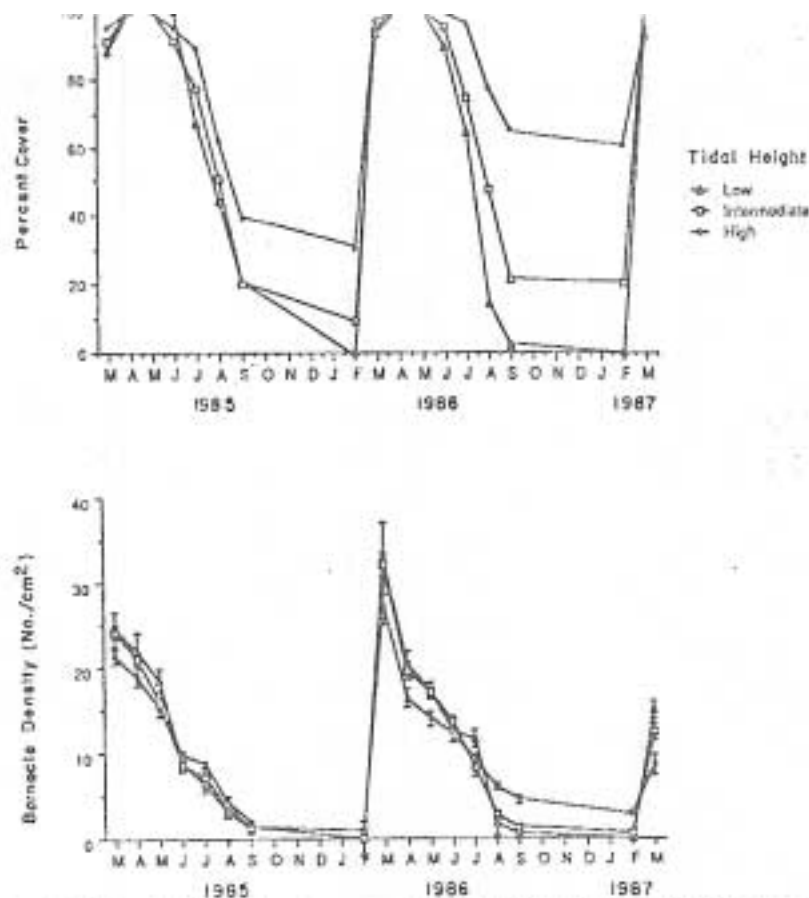


FIG. 1. *Semibalanus balanoides* density and percent cover on boulder surfaces at the study site from March 1985 to March 1987. Data are from 10-15 100-cm² permanent quadrats at low, intermediate, and high tidal heights. Standard-error bars are visible only when they exceed the size of the symbols.

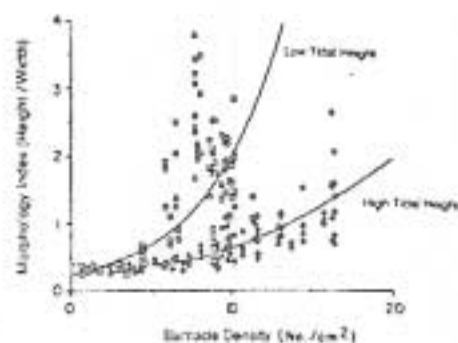


FIG. 3. The influence of density on *Semibalanus balanoides* morphology (first height/basal diameter) at low and high tidal heights. Data are from a survey taken in June 1985.

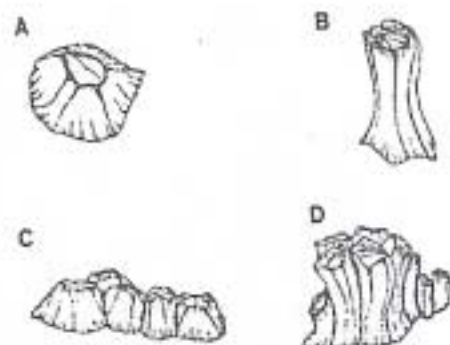


FIG. 2. Line drawings of density-induced morphological variation in *Semibalanus balanoides* at the study site. (A) typical solitary morphology, (B) elongated morphology of individuals in dense aggregations, (C) morphology of aggregations at high tidal heights where individuals are as tall as they are wide, and (D) morphology of aggregations at low tidal heights where individuals are 2-6 times as tall as they are wide.

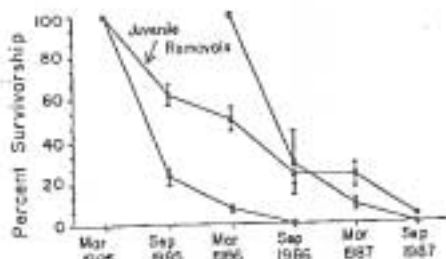


FIG. 5. Survivorship of 1-yr-old *Semibalanus balanoides* at the study site in 1985 and 1986 (mean \pm SE) at intermediate and high tidal heights (pooled). Data are presented for unmanipulated quadrats in 1985 ($n = 28$) and 1986 ($n = 28$), and for quadrats where recruits were removed beginning in the spring of 1985 ($n = 11$).

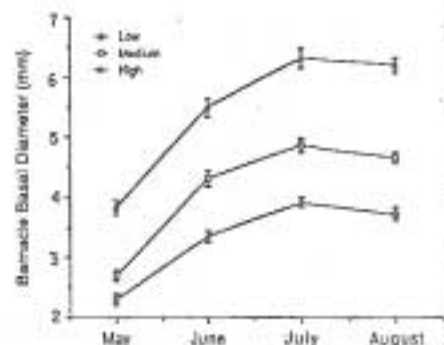


FIG. 4. Mean basal diameter (\pm SE) of solitary *Semibalanus balanoides* at low, intermediate, and high tidal heights in 1986. Each point represents 20-30 randomly chosen individuals.

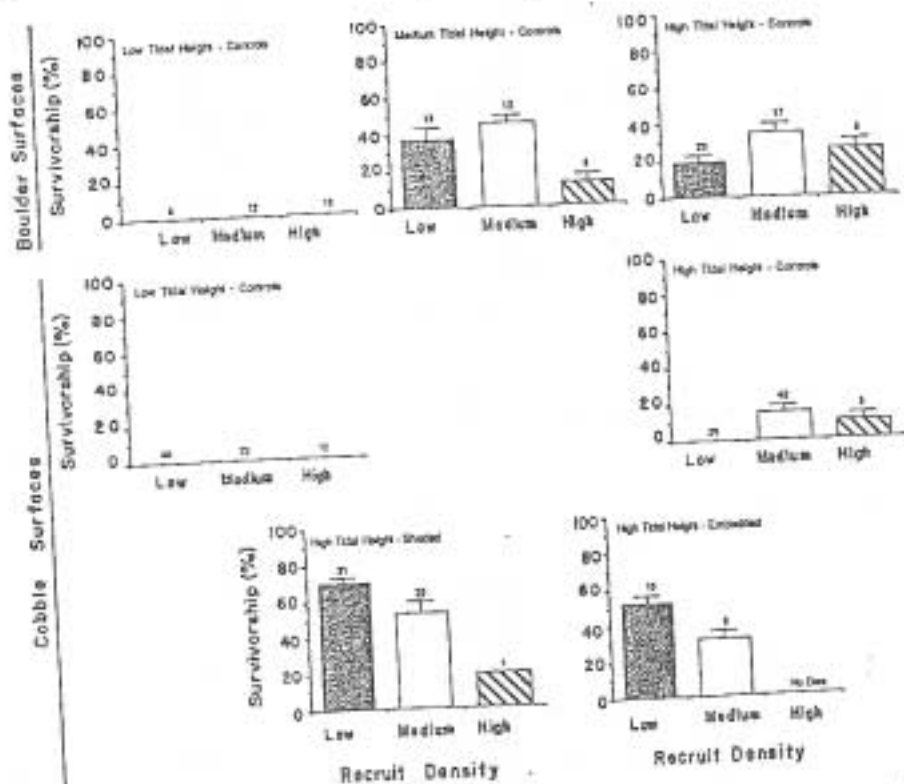


FIG. 6. Survivorship of *Semibalanus balanoides* in the recruitment-density manipulation experiment as of September. Density treatments were: low = <1 recruits/cm², medium = 4-10 recruits/cm², and high = >11 recruits/cm². Sample sizes are given for each treatment above standard-error bars. Data from boulder surfaces are from 1987. Cobble data from 1986 and 1987 are pooled. Corals represent the pooled data from unmanipulated and predation-removal areas, which did not differ significantly ($P > .10$, ANOVA). Some cobbles at the high tidal height were shaded and some were embedded in the sand substratum.

Ques 2, Session III

The evolution of patterns of behavior cannot be understood fully without dissecting out the nature of individual and geographical variation of natural populations. Our knowledge of antipredator behavior is especially devoid of this kind of information, with a few exceptions. The antipredator repertoire of the adult two-lined salamander, Eurycea bislineata is understood more fully than that of any other salamander. These salamanders exhibit defensive postures when attacked by predators such as blue jays or shrews that are repulsed by salamander skin secretions. In posturing, the salamander presents its most distasteful part, the tail, to the predator. Garter snakes are not repulsed by the skin secretions and salamanders do not posture to these predators. Therefore, the use of appropriate antipredator responses to each predator can be important to survival.

Two-lined salamanders respond differently to specific cues from snake predators. They remain immobile when touched by any part of a garter snake's head or body. However, when touched by a flicking tongue, a salamander often runs away. Individuals that distinguish between a potential attack (tongue-flick stimulus) and simply a nearby predator (head-body touch) and that exhibit the species-typical response gain a survival advantage. More salamanders displaying the species typical response survived encounters (87%) than those exhibiting alternative, species atypical, behavior (31%).

Data presented below attempt to determine if individual salamanders respond differently or if they are limited to one response path when they are touched by garter snake tongue-flicks. Responses from two different populations were studied; the Haganan area, with the highest density of garter snakes, and the Shokan area, with fewer snakes. Because salamanders frequently autotomize (break off) tails when attacked, the relationship between response and the distance run and speed for salamanders is considered for salamanders with and without tails.

What can be determined concerning alternative patterns of antipredator behavior from the data below?

Table I. Number of individuals from each locality exhibiting the run, jump and immobile response to garter snake tongue-flicks over five trials when tested at 18°C

Population	Response	Trial number				
		1	2	3	4	5
Hagaman (<i>N</i> = 100)	Run	69	43	39	30	16
	Jump	10	17	18	6	17
	Immobile	21	40	43	64	67
Shokan (<i>N</i> = 40)	Run	17	13	9	8	3
	Jump	1	5	4	1	3
	Immobile	22	22	27	31	34

Table II. Number of salamanders responding consistently to tongue-flick stimuli over five trials

Locality	<i>N</i>	Run	Jump	Immobile	Mixed
Hagaman	100	20	2	28	50
Shokan	40	2	0	26	12

Table III. Running speed and distance of salamanders as related to locality, first response and presence of tail

Locality	Tail	Response	<i>N</i>	Mean speed cm/s (st)	Mean distance cm (st)
Hagaman	Yes	Run	46	0.36 (0.07)	0.98 (0.07)
		Jump	7	0.31 (0.03)	0.62 (0.12)
		Immobile	16	0.31 (0.02)	0.87 (0.13)
	No	Run	15	0.24 (0.04)	0.55 (0.08)
		Jump	3	0.23 (0.08)	0.99 (0.37)
		Immobile	4	0.17 (0.05)	0.26 (0.10)
Shokan	Yes	Run	5	0.53 (0.03)	1.74 (0.12)
		Jump	0	—	—
		Immobile	13	0.42 (0.02)	1.58 (0.11)
	No	Run	8	0.26 (0.04)	1.04 (0.17)
		Jump	1	0.15	0.22
		Immobile	8	0.27 (0.03)	1.00 (0.12)

Question 3, Session III 1990

You are trying to construct a phylogeny for a group of insects.

Illustrations are given for the antennae and phallus of the males of 7 species and an outgroup, these structures having been determined to contain information of some phylogenetic interest. Information for additional characters is provided in the following listing. Prepare a data matrix based on this information and derive a cladogram based on these data.

outgroup: labium reaching onto abdomen

setae on dorsum simple

scale-like setae absent (no code)

antennalis: labium reaching onto abdomen

setae on dorsum scale-like

scale-like setae on clavus and part of corium

apicalis: labium reaching onto abdomen

setae on dorsum scale-like

scale-like setae on clavus and part of corium

callicrates: labium reaching onto prosternum

setae on dorsum scale-like

scale-like setae on entire clavus and corium

cardini: labium reaching onto prosternum

setae on dorsum scale-like

scale-like setae on entire clavus and corium

manleyi: labium reaching onto abdomen

setae on dorsum scale-like

scale-like setae on entire clavus and corium

pallidipes: labium reaching onto abdomen

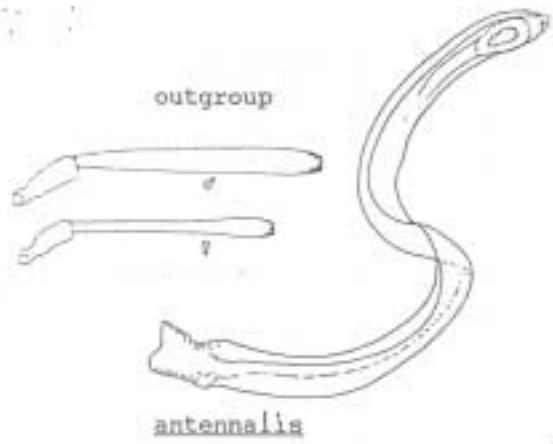
setae on dorsum scale-like

scale-like setae on entire clavus and corium

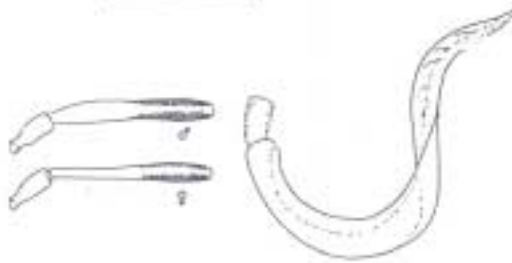
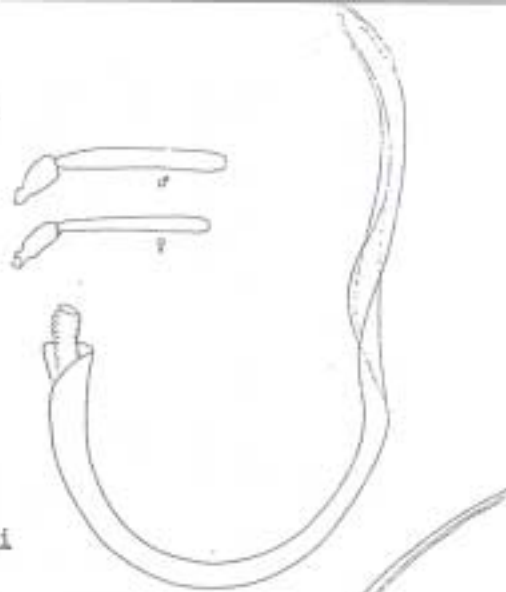
usingeri: labium reaching onto abdomen

setae on dorsum scale-like

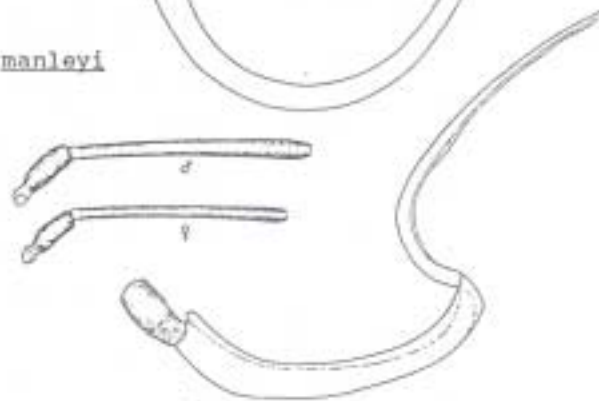
scale-like setae on entire clavus and corium



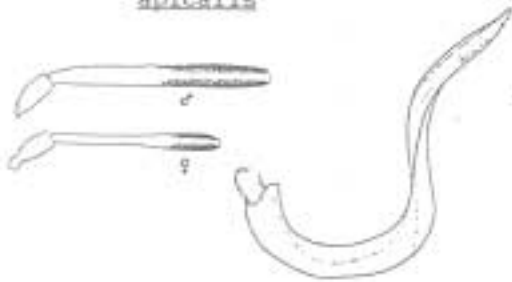
cardini



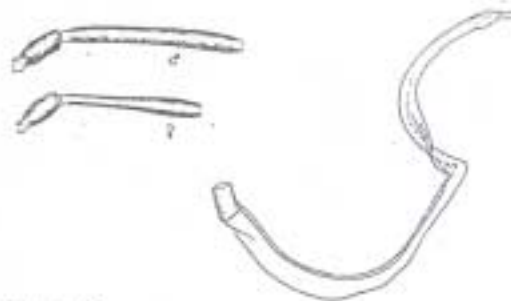
manleyi



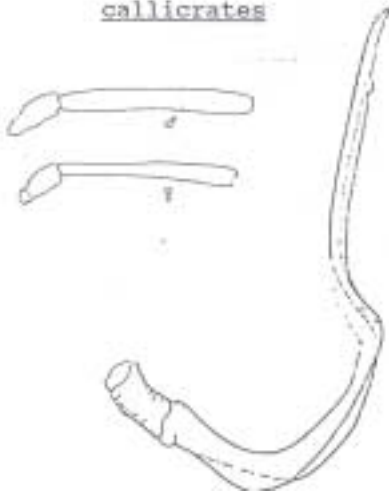
apicalis



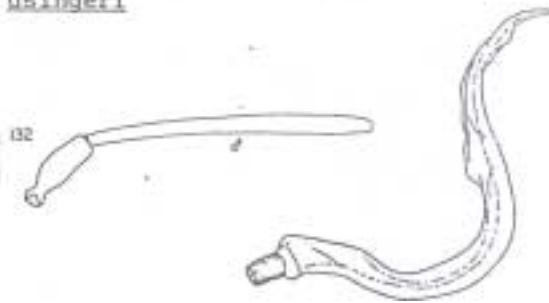
pallidipes



callicrates



usingeri



Session IV. Research Proposal 1990.

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 that 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 sort of data do you anticipate collecting?
- d) How would you organize and analyze the data?

1. Design a research project to test if a taxon is of hybrid origin.
2. Design a research program. to evaluate the effects of nutrient discharge by upstate farms on phytoplankton production in the lower Hudson estuary.
3. Suppose that you wanted to understand why species X is present in a particular habitat and species Y, closely related to X, is absent. Design an experiment that would increase your understanding of this situation.
4. You have had the good fortune to discover a hitherto unknown species of chimpanzee-like animal in Cuba. Design a research project, based upon this discovery, that will reveal its significance for our understanding of the evolution and history of higher primates. Consider the new species to be represented by a osculation of 100 living individuals; or if you prefer by fossils, including 100 complete skeletons taken from a small deposit, containing no additional and no other bones.