Comparative Paleoecology of Fossils and Fossil Assemblages

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McKerrow (1978)
Comparative Analysis of Individual Ecology

McKerrow (1978)
Theoretical Ecospace

Bush et al. (2007)

http://www.paleo.pan.pl/people/Bitner/Pictures/Bitner-brachiopod.jpg

Bambach (1983)
Constraints on Ecospace Use

- Total Modes of Life: 216
- Observed: 92 (43%)

- Why aren’t 100% of possible modes found?
  - Evolution hasn’t had time to find them?
  - Some modes unlikely due to evolutionary constraints (e.g., impossible? inefficient?)

- 98 modes are unlikely (45%)

Bambach, Bush & Erwin (2007)
Constraints on Ecospace Use

1. Either the animal or the food should be mobile so that they meet

2. The animal and the food should occur in the same tier (unless one of them travels)

3. Motility can be limited by the physical properties of the surrounding medium

Bambach, Bush & Erwin (2007)
Taxonomic vs. Ecologic Diversification

- Globally & locally, taxa & ecologic lifestyles seem to have radiated together
- Which one was the causative agent?
- Analysis of local scale:
  Tuesday, 9:15—Were Local Ecological Interactions Linked to Secular Trends In Alpha Diversity In Level-Bottom Marine Communities?

Comparative Analysis of Assemblages: Ecological Ordination

McKerrow (1978)
Types of gradients

1. Species distributions—one gradient

2. Species distributions—two gradients

3. Ternary gradient

Species are not aligned along a gradient

Bush and Daley (2008)
Example: Yorktown Formation

- Pliocene, shallow water
- Preserves a transition from a rubbly/sandy substrate to a muddy one

Daley (1999), Bush and Daley (2008)
NMDS of Yorktown Fm.

Bush and Daley (2008)
NMDS of Yorktown Fm.

1. Muddy bottom, low disturbance
   - Yoldia laevis
   - Parvilucina multilineatus

2. Rubbly bottom, low disturbance
   - Cyclocardia granulata
   - Crepidula costata

3. Muddy bottom, disturbed
   - Mulinia congesta

4. Rubbly, disturbed
   - Chama congesta

Infauna → Epifauna

Bush and Daley (2008)
Gradients through Time
(Millions of years)

- How did extinctions, originations, migrations, and environmental changes affect gradient structure (i.e., the ways in which species assembled)?

Holland and Patzkowsky (2007)
Gradients through Time
(Hundreds of millions of years)

• Many changes through time in how organisms related to the environment (tiering, motility, etc.)

• Were there changes in how environmental parameters controlled species distributions?

• i.e., Did organisms form similar taxonomic/ecologic gradients in response to similar environmental gradients?

Bush et al. (2007)
Gradient Analysis: CZ modes of life

Onshore-Offshore Gradient

Bush and Daley (2008)
Gradient Analysis: CZ modes of life

Hiering Gradient

Surficial, attached, facult. motile, suspension

Surficial, attached, nonmotile, suspension

Shallow, unattached, facult. motile, suspension

Deep, unattached, facult. motile, suspension

Surficial  →  Shallow Infaunal  →  Deep Infaunal

Bush and Daley (2008)
Gradient Analysis: PZ modes of life

Bush and Daley (2008)
Gradient Analysis: PZ modes of life

Bush and Daley (2008)
Gradient Analysis: PZ modes of life

Bush and Daley (2008)
Gradient Analysis: PZ modes of life

Bush and Daley (2008)
Why does the PZ appear more random than the CZ? Three possibilities:

1. Fossil assemblages were more randomly structured with respect to ecology in the Paleozoic.

2. The environmental parameters that structured Paleozoic fossil assemblages were more randomly distributed in space.
   - Habitats dominated by different modes of life were themselves not organized along regular gradients.

3. Linear gradients are more prevalent onshore, and these habitats were more intensively sampled in the Cenozoic data set.
Deleted Slides
Quantitative Changes in Ecospace Use

Bush, Bambach, & Daley (2007)
Raup’s Theoretical Morphospace for Spiral Growth
Yorktown Formation

Transition from the Rushmere Member (sandy-shelly) to the Morgart’s Beach Member (muddy)
NMDS of Yorktown Fm.

Bush and Daley (2008)
NMDS of Yorktown Fm.

Sample Richness (30 specimens)

Bush and Daley (2008)
Ordination based on ecologic guilds

- Similar to ordination based on species abundances
- Main gradient: infauna-dominated to epifauna-dominated assemblages

Bush and Daley (2008)
Gradient Analysis: CZ vs. PZ based on relative abundances of modes of life

Bush and Daley (2008), Stainbrook (1942)
PZ modes of life randomized

Bush and Daley (2008)
PZ modes of life randomized

Bush and Daley (2008)