

- 124—Gastric pouches. 0 = absent, 1 = left, 2 = right.
- 125—Pyloric ceca. 0 = absent, 1 = present.
- 126—Hood. 0 = present, 1 = fused, 2 = absent.
- 127—Mouth scales. 0 = absent, 1 = present.
- 128—Shape of mouth opening. 0 = round, 1 = triangular, 2 = vertical slit, 3 = horizontal slit.
- 129—Lateral expansion of mouth. 0 = not expanded, 1 = expanded.

#### CHARACTERS 130–132:

##### RADULAR CARTILAGES

Data derived from Sasaki (1998) and Guralnick and Smith (1999). Numbers in parentheses refer to Sasaki's original character numbers.

- 130—Posterior cartilage (54). 0 = present, 1 = absent.
- 131—Anterolateral cartilage (55). 0 = present, 1 = absent.
- 132—Median cartilage (56). 0 = present, 1 = absent.

#### CHARACTERS 133–134:

##### RESPIRATORY SYSTEM

- 133—Pneumostome. 0 = absent, 1 = present.
- 134—Gill filament shape (Lindberg and Ponder 2001). 0 = round, 1 = elongate-triangular.

#### APPENDIX 3: LIST OF ADDITIONAL CHARACTERS AND STATES USED IN THE MORPHOLOGICAL DATA SET

##### CHARACTERS 118–122: NEURAL

- 118—Cephalic tentacle epithelium characterized by ensheathing sensory cells (Künz and Haszprunar 2001). 0 = absent, 1 = present.
- 119—Muscular hydrostat system (Kier 1988). 0 = absent, 1 = present.
- 120—Giant nerve cells. 0 = absent, 1 = present.
- 121—Lateral nerve (Haszprunar 1988c). 0 = absent, 1 = present.
- 122—Cerebral ganglia. 0 = absent, 1 = present.

##### CHARACTERS 123–129:

##### ALIMENTARY SYSTEM

- 123—Position of gastric shield. 0 = dorsal, 1 = ventral.

##### CHARACTER 135: LARVAL

- 135—Velum. Ring = 0, lobed = 1.

##### CHARACTERS 136–143: MUSCULATURE

These characters are directly derived from Sasaki (1998). Sasaki's original character numbers are in parentheses.

- 136—Retractable mantle tentacles (2). 0 = absent, 1 5 present.
- 137—Dorsal protractor muscles of the odontophore (27). 0 = absent, 1 = present.
- 138—Anterior levator muscle of the odontophore (28). 0 = absent, 1 = present.
- 139—Posterior depressor muscle of odontophore (31). 0 = absent, 1 = present.
- 140—Postdorsal buccal tensor muscle (32). 0 = absent, 1 = present.

- 141—Retractor muscles of the subradular membranes (39). 0 = divided, 1 = fused.
- 142—Postmedian retractor muscles of the radular sac (41). 0 = absent, 1 = present.
- 143—Median tensor muscle of the radular sac (42). 0 = absent, 1 = present.

#### CHARACTERS 144–152: ELEMENTAL RADULAR COMPOSITION

Okoshi and Ishii (1996) measured the concentration of 17 elements in the radulae of 24 molluscan species; 10 of which represent family rank taxa used in our analysis. Although more sampling and study of radular elemental composition is needed, these preliminary data provide the first opportunity to explore and compare these characters across the Gastropoda. Moreover, current sampling is sufficient to rule out widespread convergence in taxa with similar feeding modes. For example, although patellogastropods and some vetigastropods and caenogastropods rasp rock surfaces for food, only patellogastropods show high concentrations of iron in their radular teeth. In contrast, some vetigastropods and the caenogastropod rock-rasping Littorinidae and carnivorous Nassariidae have higher concentrations of silicon than patellogastropods.

To determine whether elemental concentration carried phylogenetic signal, a  $17 \times 24$  matrix was constructed from the data and an *F*-test performed to estimate the statistical significance of the variance present in the matrix. Because the distribution of the variance in the data was statistically significant ( $p = 0.000$ ), Tukey's test (Hsu 1996) was used to identify those elements with statistically significant differences. Nine of the 17 elements were found to have statistically significant distributions: calcium, iron, magnesium, manganese, phosphorus, strontium, zinc, silicon, and copper. The elemental measurements were log transformed to reduce variance prior to gap coding, and the following character states were gap coded by graphing the distribution of values within each character and determining gaps or trend changes by eye. Obvious, isolated groupings and breaks in trends were recognized and assigned discrete character states.

- 144—Calcium (Ca). 0 = high, 1 = low.
- 145—Iron (Fe). 0 = high, 1 = low.
- 146—Magnesium (Mg). 0 = high, 1 = low.
- 147—Manganese (Mn). 0 = high, 1 = low, 2 = moderate.
- 148—Phosphorus (P). 0 = high, 1 = low.
- 149—Strontium (Sr). 0 = high, 1 = low.

- 150—Zinc (Zn). 0 = high, 1 = low, 2 = moderate.
- 151—Silicon (Si). 0 = high, 1 = low, 2 = moderate.
- 152—Copper (Cu). 0 = high, 1 = low, 2 = moderate.

#### CHARACTERS 153–166: DEVELOPMENTAL CELL LINEAGE TIMING

These character states represent the cell number of the developing embryo at which specific cell lineages originate. Complete character analysis is present in Lindberg and Guralnick (2003), and a discussion of character independence of cell lineage characters can be found in Guralnick and Lindberg (2002).

- 153—Median number of cells present at formation of  $1q^1$  cell lineage (4th division). 0: 16, 1: 21.
- 154—Median number of cells present at formation of  $1q^{11}$  cell lineage (5th division). 0: 24, 1: 28, 2: 32, 3: 38–40.
- 155—Median number of cells present at formation of  $1q^{12}$  cell lineage (6th division). 0: 44–54, 1: 68–99.
- 156—Median number of cells present at formation of  $1q^{121}$  cell lineage (6th division). 0: 36–49, 1: 55–72.
- 157—Median number of cells present at formation of  $1q^{22}$  cell lineage (5th division). 0: 32, 1: 44–49, and 2: 60.
- 158—Median number of cells present at formation of  $1q^{222}$  cell lineage (6th division). 0: 60, 1: 80, and 2: 123–132.
- 159—Median number of cells present at formation of  $2q$  cell lineage (4th division). 0: 16, 1: 12.
- 160—Median number of cells present at formation of  $2q^1$  cell lineage (5th division). 0: 32, 1: 24.
- 161—Median number of cells present at formation of  $2q^{11}$  cell lineage (6th division). 0: 60, 1: 50–52, 2: 44, 3: 41, 4: 37–38, 5: 32.
- 162—Median number of cells present at formation of  $3q$  cell lineage (5th division). 0: 20, 1: 23–24, and 2: 32.
- 163—Median number of cells present at formation of  $3q^1$  cell lineage (6th division). 0: 54, 1: 60–61, 2: 48, 3: 40–41, 4: 36.
- 164—Median number of cells present at formation of  $4Q$  cell lineage (6th division). 0: 85, 1: 63–64, 2: 48–49, 3: 42–44.

165—Median number of cells present at formation of 4d cell lineage (6th division). o: 64–73, 1: 41–48, and 2: 25–32.

166—Median number of cells present at formation of 4d<sup>1</sup> cell lineage (7th division). o: 90–130, 1: 39–49.