

operate uniquely at high latitudes. One striking pattern is a tendency of shallow-water genera to penetrate deep into the abyss, and a simultaneous tendency of the abyssal genera to emerge into shallow water. These two phenomena—polar submergence and polar emergence—remain clearly distinguishable from the standpoint of taxonomic perception of the genera involved. Contrary to the situation in tropical seas, the eye-bearing, shallow genera such as *Munna*, *Gnathia*, *Antarcturus*, *Cirolana*, *Serolis*, etc. descend along the antarctic continental slope into the abyss. Most often, the deep-sea species of these genera lack eyes or bear degenerate eyes. A scanning-microscope examination of *Serolis* eye structure has provided crucial data on the minute details of retinula and lens of antarctic species from different depths (mss. in preparation). The accompanying figure illustrates a shallow-water species with very prominent eyes and a deep-sea blind species (Fig. 1A and B). This predominantly antarctic genus, *Serolis*, was subject to a monographic study (Moreira and Menzies, submitted to the *Antarctic Research Series*).

Polar emergence is exhibited by several blind Aselote isopod genera such as *Macrostylis*, *Haploniscus*, *Desmosoma*, *Eurycope*, *Eugerdia*, *Munnopsis*, *Ilyarachna*, and *Storothyngura*, all exclusively deep-sea genera in middle and lower latitudes that emerge to moderate depths both in the Antarctic and in the high Arctic. A significant correlation is evident in the coincidence between the upper limits of these emerging abyssal genera in high latitudes and the start of the Abyssal Faunal Province, identified by a new method: the abyssal boundary determined on the basis of rate of faunal change showed tropical submergence or, in other words, polar emergence. The aspects of vertical faunal zonation in the Antarctic in comparison with other parts of the World Ocean are elucidated in a manuscript now in progress. A generic catalogue illustrating all isopod genera known within the Antarctic Convergence is being prepared with maps of distribution of antarctic species.

Data from the Scotia Sea offer evidence of a seasonal breeding cycle in the deep sea (George and Menzies, 1967). Further investigations of the breeding behavior of abyssal isopods provide new information confirming this cyclic reproductive activity in the physically uniform deep sea. The peak breeding period for abyssal isopods in both antarctic and North Atlantic deep-sea regions seems to be limited to four months of the year—July–November (George and Menzies, 1968).

References

- George, R. Y. and R. J. Menzies. 1967. Indication of cyclic reproductive activity in abyssal organisms. *Nature*, 215 (5103): 878.
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Antarctic and Subantarctic Brachiopods

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During the past year, I have been engaged in the concluding phases of my research on the brachiopods of the far South. My material consists of undescribed specimens from many earlier expeditions; however, the majority of the specimens were taken on cruises of USNS *Eltanin*. Some of my findings are summarized below.

At least 21 genera and 38 species are present in the material; two new genera are recognized. Ten new species are recognized in the genera *Compsothyris*, *Hispanirhynchia*(?), *Liothyrella*, *Eucalathis*, *Amphithyris*, *Dallina*, *Fallax*, and *Magellania*(?). Six other specimens which may represent new species have been described in *Compsothyris*, *Liothyrella*, and *Dyscolia*. Analysis of character variation in large samples has led to the placement of one genus and nine species in synonymy. This is the first time that *Amphithyris*, *Dallina*, *Fallax*, and *Dyscolia* have been reported from the far South. New subspecies have been described in *Neorhynchia*, *Liothyrella*, and *Gyrothyris*.

The majority of the Recent species and genera within the family Terebratulidae have been restudied. It has been concluded that the admittedly polyphyletic, but practical, genera *Terebratella* and *Magellania* should be retained in the broad sense. I also favor retaining the genera *Gyrothyris* and *Neothyris*.

The majority of antarctic brachiopod species show reduction in punctae density, shell thickness and spiculation, as well as coarsening of shell mosaic as compared with related taxa from farther north. These same changes are seen within the wide-ranging species *Liothyrella uva*. Similar trends as well as reduction in shell porosity are observed in deep-water species at various latitudes. These changes are believed to reflect the greater difficulty of maintaining and depositing calcite skeletons at locations with greater CaCO_3 solubility. The changes in punctae density lend support to Campbell's (1965) suggestion that Australian Permian terebratuline brachiopods with low punctae densities inhabited cool water.

Multivariate analyses suggest negative associations of foramen diameter, hinge-plate width, and beak height of the terebratulid shell with depth. I believe these associations reflect adaptations for stability in the varying current velocities at different depths.

Dissections of *Macandrevia vanhoffeni* reveal muscle arrangements quite different from those known in other genera in the same family. It is suggested that this genus be placed in a different family.

Within the Ross Sea, the greatest diversity of brachiopods occurs on the seaward edge of the shelf. This diversity is believed due to an ecotone effect caused by the junction of two different water masses at this location. Significant associations (using the chi-square test) between different brachiopod species occur in the Ross Sea only between *Crania lecontei*—*Compsothyris racovitzae* and *Magellania fragilis*—*Macandrevia vanhoffeni*. I believe these species occur together commonly only because of quite different feeding behavior.

My studies have clearly shown that brachiopods are a significant and abundant element of the marine benthos in the southern oceans. The large number of specimens available in this study has permitted close examination of species structure and its relationship to systematics in various brachiopod species.

Reference

- Campbell, K. S. W. 1965. Australian Permian terebratuloids. *Bureau of Mineral Resources. Geology and Geophysics Bulletin* no. 68. 113 p.

General Physiology of the Echinoderm Body Wall with Special Reference to Asteroids and Echinoids

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As earlier observations had suggested that the body wall of the antarctic sea star *Perknaster fuscus antarcticus* had much more protein than that of the temperate species *Pisaster ochraceus* and *Patiria miniata*, a study of the biochemistry of the body walls of antarctic and temperate-zone sea stars was initiated to determine whether this high protein level was characteristic of antarctic species or whether it was a peculiarity of only one of the species examined by chance. Conversely, it was desirable to sample other temperate sea stars to determine whether some might not have a high protein level in the body wall comparable to that in *Perknaster*. It was of interest also to determine the oxygen consumption rate for both temperate and antarctic sea stars as a measure of the metabolic activity of the body wall.

These objectives have been fulfilled in part. It was found that the high protein level (38.3% of the dry weight) of *Perknaster* was unusual among antarctic sea stars: in *Diplasterias brucei* it was found to be 29.7%; in *Cuenotaster involutus*, 31.1%; and in *Odontaster validus*, 21.7%. In the body wall of all of these sea stars, the lipid levels were found to be about

5% and the total carbohydrate about 1%. In the temperate sea stars, the protein level for the body wall varied from 9.7% of the dry weight in *Astropecten californicus* to 34.2% in *Dermasterias imbricata* and *Pycnopodia helianthoides*. In most of the other temperate sea stars, the values were closer to those in *Astropecten* than to *Dermasterias*—e.g., in *Pisaster ochraceus*, the common ochre star, 14.1%; *Pisaster giganteus*, 18.6%; *Pisaster brevispinus*, 13.5%; and *Patiria miniata*, the common sea bat, 12.8%. Only in *Orthasterias kohleri* do the values approximate those in *Dermasterias* and *Pycnopodia* (22.2%). In the body wall of most of these species, the lipid level per unit dry weight was much lower than in the antarctic stars—around 2%, reaching 4.3% in *Pycnopodia*. The carbohydrate level (in this case, glycogen-like material) was always less than 1%, and usually about half that amount.

Measurements of the oxygen consumption of these antarctic sea stars were planned for *Eltanin* Cruise 38, but the ship never reached the area of the continental shelf where the species are found, and none were caught.

The oxygen consumption of the body wall of the following six temperate sea stars was determined with Warburg respirometry: *Pisaster ochraceus*, *Patiria miniata*, *Pycnopodia helianthoides*, *Dermasterias imbricata*, *Orthasterias kohleri*, and *Astropecten californicus*. It ranged from 15 to 35 $\mu\text{l}/\text{gram wet weight}/\text{hour}$, the rate for *Pycnopodia* being the highest and that for *Patiria* and *Astropecten* the lowest. However, on the basis of protein level, *Astropecten* has the highest rate while *Dermasterias* has the lowest.

The possible reason for the low oxygen consumption in the high-protein body wall of *Dermasterias* may be a result of much inert protein, possibly connective tissue. The construction of the body wall in *Dermasterias* was therefore studied histologically and compared with that of *Patiria*. Preliminary examination of the material indicates that *Dermasterias* has much more connective tissue in the body wall than *Patiria*.

Oxygen consumption compared for *Patiria* (low protein) and *Dermasterias* (high protein) on the basis of DNA level of the body wall proved to be quite similar, much more so than on the basis of protein level. If DNA is taken to measure the cell content of the tissue, this finding suggests that the oxygen consumption of the body wall is related to the number of cells present, not the protein, much of which is extracellular in the high-protein type of body wall.

It is conjectured that, on the basis of protein level, the body wall of a sea star like *Perknaster* with high protein level would probably have a lower oxygen consumption than a star like *Odontaster* with considerably lower protein level, but that on the basis of DNA level, they would be similar.