
Preface

Molluscs are unique for the presence of a protective external shell, defensive inking, distribution from the depth of 9,050 m to an altitude of 4,300 m, gamete diversity, the use of nurse eggs/embryos to accelerate the first few mitotic divisions in embryos, the occurrence of natural androgenesis, gigantism induced by elevated polyploidy, the complementary role of mitochondrial genome in sex determination by nuclear genes and the uptake of steroids from surrounding water. Not surprisingly, many books were authored or edited on one or other aspect of molluscs. This book represents perhaps the first attempt to comprehensively project the uniqueness of molluscs, covering almost all aspects of reproduction and development from aplacophorans to vampyromorphic cephalopods.

The book is organized in nine chapters. Considering their uniqueness, three chapters are devoted to shell and reproduction, shell and acidification, and aestivation. In view of its importance, regeneration is woven with the claimed asexual reproduction. Molluscan strategy is to carry shell(s) to escape from predators, limit energy expense on motility, and allocate the thus saved energy on reproductive output. Being proliferative breeders, molluscs inject a huge volume of fodder into the trophic dynamics, contribute 22 mt to the global food basket, colonize thermal vents and cold seeps by successfully engaging endosymbionts; whereas the adults move at 'a snail pace', their larvae embark on trans-Atlantic dispersal; they also serve as intermediary hosts to the dreadful disease causing schistosomes. For the first time, the second chapter attempts to relate shell thickness to reproductive output, and chirality to mating and insemination between dextrals and sinistrals. With increasing size/age, the allocation for shell growth is progressively diminished but with increasing reproductive output. At low temperatures and higher altitudes, energy cost of calcification of shell increases. The shell size, shape and thickness are phenotypic traits. Like other animals, the 2% shell-less molluscs depend on chemical defense; aplysiaids and cephalopods are known for inking and escape.

From the fairly long third chapter, it has become apparent that, the presence of shell in molluscs has afforded iteroparity and comparatively longer life span in prosobranchs and bivalves but its absence semelparity and short life span in opisthobranchs and cephalopods. Notably, >25%

of molluscs is hermaphrodites. In shell-less molluscs, gonochorism has facilitated faster growth and relatively larger body size in cephalopods but hermaphroditism small body size in opisthobranchs. Gastropods display great powers of regeneration inclusive of 'brain' and nervous system. The claimed asexual reproduction in the pteropod *Clio pyramidata* is more of regeneration involving multi-potent stem cells. The fifth chapter recognizes the occurrence of seasonal aestivation in snails and tidal aestivation in bivalves. For the first time, the effect of varying durations of aestivation on growth and reproduction in a freshwater snail and supratidal inhabitant bivalves are comprehensively described. For the first time, the scope for employing aestivating, schistosomus-infected snails as 'biological weapon' is also explored.

The sixth chapter commences with description of spawning induction and gamete preservation, indicates the presence of heterogamety in less than a dozen gastropods and bivalves, and reports the rare occurrence of androgenesis in bivalves; the induced triploid and tetraploid bivalves grow many times faster than their counterpart diploids, produce more and tastier meat with higher glycogen content and are available in markets during off season. The unique but perhaps 'vestigial' presence of Doubly Uniparental Inheritance (DUI) in bivalves and its possible causative complementary role of sperm mitochondrial genes in sex determination by nuclear genes is brought to light. Irrespective of sexuality in molluscs, sex is irrevocably determined by a few genes harbored on autosomes. Sex differentiation is solely accomplished by neurohormones. The genes responsible for biosynthesis of vertebrate-type steroid hormones are indicated to be missing in molluscan genome. Surprisingly, molluscs absorb and accumulate steroid hormones from surrounding waters. The ongoing debate on the role played by the steroid hormones in regulation of reproductive cycle is discussed. While tributyltin induces sex reversal from female to male in fishes, it only superimposes masculine traits on female neogastropods. Trematode parasites exploit many molluscs as intermediate host and partially or completely sterilize them.

Sex ratio represents the cumulative end product of sex determination and differentiation processes. In molluscs, sex ratio of 1♀ : 1♂ is maintained at population level. Among different families of a molluscan species, sex ratio varies from nearly all females to nearly all males. But the ratio remains constant between successive broods in a family. Hence, the ratio is more a family trait than that of species. The primary sex differentiation is determinate and not amenable to environmental influence. However, the secondary differentiation from male to female in protandrics is labile, protracted and amenable to environmental factors like food supply and temperature.

The eighth chapter highlights the effects of acidification on molluscan shell. Since the advent of industrial era, the oceans have absorbed 127 billion metric tons of CO₂ resulting in decreased pH, which renders the acquisition of calcium costlier. Consequently, the molluscan shells suffer from pitting, dissolution and loosening of the hinge to valve mechanism. However, with

abundant food supply, many molluscs do adapt and not suffer from shell dissolution.

This book is a comprehensive synthesis of over 907 publications carefully selected from widely scattered information from 249 journals and 87 other literature sources. The holistic and incisive analyses have led to harvest several new findings related to reproduction and development in molluscs and to project the uniqueness of mollusca. Hopefully, this book serves as a launching pad to further advance our knowledge on reproduction and development of molluscs.

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