Preface

Gametes development and their final fusion during fertilization assume center stage in the reproductive biology of animals. In Crustacea, gamete production and the several modes of fertilization are accomplished, by evolving different sexual systems, together with elaborate mating behaviors. Crustaceans express unique ways of sex determination that form the bases for sexuality, meaning acquisition of different sex characteristics, which are normally developed in both sexes. Nevertheless, significant numbers of crustacean species exhibit dual sexuality by which production of both gametes rests with a single individual. In accordance with the display of many sexual systems, the mechanistic modes of sex determination are likewise highly diverse. Furthermore, genetic and environmental determinants could bring about changes in the gender of many crustaceans. Despite variability in sex determination pattern, sex differentiation in malacostracan crustaceans is under the control of a male hormone, secreted by the androgenic gland, an equivalent of which has never been reported in any other invertebrate. Apart from many modes of sexual reproduction in crustaceans, there are instances where certain primitive crustaceans practice asexual reproduction by means of parthenogenesis.

Inasmuch as the mechanism of fertilization shows variability among different species, the crustaceans have evolved a variety of fully operational sperm-delivery systems that protect the sperm's viability as well as their safe transfer on to the female. Concomitant with the development of diversified sexual systems and sperm transfer mechanisms, the origin of different mating systems and the associated male–female behaviors play pivotal roles in successful fertilization in Crustacea. Besides, many coral reef-inhabiting caridean shrimps, living in symbiotic relationship with other marine invertebrates such as sponges, have reached the pinnacle of complexity in sexuality and peculiar mating behaviors, resulting in communal living and establishing advanced social systems, such as eusociality. The elaborate mating systems, as occurring in several crustaceans, provide illustrative examples for sexual selection among males, with respect to acquiring dominance over other members of the same sex as well as in attracting females for mating. Similarly, mate selection by the females has also evolved among some decapod species. Thus, crustaceans have been used as model systems to investigate current issues related to sexual selection such as sexual conflict, mate choice, sperm limitation, and sperm allocation. Undoubtedly, evolution of complex sexual systems and the associated physiological and

behavioral adaptations has reference to crustacean species diversity in aquatic as well as terrestrial environments.

Crustacean reproductive endocrinology is at the crossroads of its potential application to the development of aquaculture of commercially significant species such as shrimps, lobsters, crayfish, and crabs. In this respect, gamete biology has attracted utmost attention to control egg production in captivity. There is a spurt of research activities on the control mechanisms in yolk formation in an attempt to augment egg production by manipulating endocrine systems in the aquaculture-important species. A simple eyestalk extirpation in a grass shrimp resulted in accelerated ovarian activity and the discovery of a gonad inhibitory hormone in the eyestalk ganglia of crustaceans. As a result, the idea of eyestalk ablation to induce oocyte maturation and spawning found universal acceptance for the hatchery production of commercially important crustacean species. Further work revealed the existence of many proximate endocrine factors to counteract the inhibitory eyestalk hormones, besides promoting gonadal maturation. Equally interesting is the crustacean spermatology. Most crustacean spermatozoa are aflagellate and nonmotile. There is also incredible diversity of sizes and shapes among the spermatozoa, even within a single genus, providing important phylogenetic clues. The secondary loss of motility in crustacean sperm and their subsequent encasement within spermatophores, in which form sperm are transported to females, could be viewed as a novelty in the evolution of fertilization mechanisms among marine invertebrates.

Crustaceans originated about 500 million years ago during Precambrian period and have since then undergone dynamic species radiation occupying diverse niches in aquatic ecosystems, as well as a few species venturing into terrestrial environment. Both morphological and recent molecular data have uncovered the phylogenetic closeness existing between Crustacea and Insecta, placing them under a separate clad Pancrustacea within Arthropoda. Obviously, many important reproductive processes show similarity between crustaceans and insects. Furthermore, crustaceans have emerged as the most important, economically useful invertebrate, by virtue of their aquaculture potentials in augmenting production of seafood in both developing and developed countries. However, no comprehensive treatment of crustacean reproductive biology is currently available. Information is scattered only in research papers and reviews and book chapters. Hence, a book on crustacean reproductive biology is not only timely but also useful to students of crustacean and invertebrate biology, researchers, and aqua culturists all over the globe.

My interest in the reproductive biology of crustaceans began when studying the role of fat body in cockroach vitellogenesis during my postdoctoral research in the University of Madras. With inspiration derived from Prof. Michael Locke, Case Western Reserve University, Cleveland, Ohio, who was then the Sir C.V. Raman visiting professor in our University, I switched from my doctoral study on millipede fat body to insect reproduction. When I started my research career as Lecturer in the Zoological Laboratory, Madras University, located right

in front of the world-famous Marina Beach, my attention shifted to a host of marine invertebrates, which were available to me, as experimental model animals. One such animal was the mole crab, *Emerita asiatica*, and I just stumbled on it. At this time, Academic Press, New York, published the first volume of a multivolume treatise on marine invertebrate reproduction in the year 1974. Professors A.C. Giese and J.S. Pearse meticulously delineated the scope and content of marine invertebrate reproduction in their introductory chapter. There was no looking back for me from that point. I began my work on crustacean reproduction, using *Emerita* as the model organism, and my students investigated crustacean reproduction on a comparative basis by selecting a wide variety of crustaceans that abound on the Madras (now Chennai) Coast. As we progressed in this endeavor for over three decades, the idea of writing a monograph on crustacean reproduction blossomed in my mind.

Essentially, this book gives a comprehensive understanding on the basic phenomena governing reproductive processes in crustaceans. It is fondly hoped that this book will serve the need for students in crustacean biology, invertebrate reproduction, and comparative reproductive endocrinologists. Biology teachers will find this book useful in teaching comparative reproduction and endocrinology. And for aquaculturists, this book will serve as a manual to obtain information on aspects of reproduction in the edible crustacean species. Over and above all, this book will serve as a framework from which continued research on crustacean reproduction will proceed.

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