Introduction
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The nervous and endocrine system coordinate the activities of the various organs and the tissues in the body that the animals function as individuals. Majority of the neurones with glandular activity, are known to be necessary for the transmission of transient impulses, with their highly localised production of chemicals such as neurohumors which are rapidly destroyed. All neurones transmitting in this manner are, in effect, gland cells secreting their chemical mediators into the synaptic cleft regions. Neurones have similar properties throughout the animal kingdom, although their morphology and arrangement may vary. Cytological display of neuronal secretory activity is indication of vigorous biosynthetic activity which is said to be associated with the formation of exoplasmic protein (see Hagadorn, 1967; Highnam and Hill, 1978).

The way in which nervous system operates may differ considerably between animals, depending on the number of neurones involved and the individual shape, size and spatial arrangement of the component. Upto fifty percent of the nervous system is composed of non-exitable satellite glial cells which are packed between and around the neurones. They are supposed to transport neurosecretory substances (Lubet, 1955a; Umiji, 1969), provide physical support for neurones and can modify action
of nerve cells as well as acting as a barrier or reservoir for ions, metabolites and transmitters (see Leak and Walker, 1980). The arrangement of neurones into ganglia allows an increase in number of synaptic contact for any particular cell and thus increases the integrative capacity of a given number of neurones.

Amongst invertebrates, molluscs show great variability in their nervous system ranging from primitive arrangement in chitons to the complex mass of fused ganglia forming the 'brain' of Cephalopods. Most of the effector organs used for pharmacological or physiological experiments with molluscs are somatic muscles, involved in movements of some parts of the body wall or foot; visceral muscles responsible for the movements of feeding apparatus; gut, reproductive tract and other viscera; and cardiac muscles of heart (Huddart, 1975). Among lamellibranchs different types of adductor muscles, heart muscles and gill ciliary activity have been studied from the pharmacological point of view (see Bayne, 1976a). Evidence for the occurrence of a wide variety of neurotransmitters in different tissues of lamellibranchs including the nerve ganglia has been discussed from the functional point of view by Leak and Walker (1980).

In all major animal groups studied so far there occurs among the more 'conventional' neurones, other nerve cells
remarkably of different appearance; the neurosecretory cells (NSCs). The NSCs, in addition of displaying the cytological feature common to all neurones, generally show prominent indication of glandular activity. With the light microscope they are characterised by the presence of abundant secretory materials in their perikarya. This material is seen also in the axons which oftenly end blindly adjuscant to muscular spaces rather than innervating their target structures directly. These blindly ending terminals serve a storage release function and in the more advanced groups of animals such as crustaceans such compact structures are termed as neurohemal organ by Knowles and Carlisle (1956). The structures like corpus cardiacum of insects, the sinus glands of crustaceans, and the pars nervosa of vertebrates are well known neurohemal organs. The neurosecretory chemicals take time to build an effective concentration, and consequently must have a longer biological life than the chemicals of ordinary neurones, before they are eventually destroyed or excreted. Rothballer (1957) remarked that the brain, as a primary receptor and integrator of wide variety of internal or external sensory inputs, is faced with the problem of influencing activities with more diverse time courses; from phasic muscle twitches to the ionic, growth and reproductive sequences. In order to achieve these sequences, it is not surprising that the nervous system should use hormonal outputs as well as conventional
innervation where appropriate. The NSCs, with their combination of neuronal and glandular capabilities are perfectly suited to translate a neuronal input into the hormonal output best suited to a long term process. In this capacity the NSCs may produce hormones, which act directly upon the peripheral target or it may exert its effect indirectly by influencing the activity of other, non-neural, endocrine organs. In this later case, the NSCs again may act via the production of blood-born hormone. Knowles and Bern (1966) stated that the significance of NSCs as connecting link between nervous and endocrine systems and neurosecretory neurones "participate either directly or indirectly in endocrine control and form all or part of endocrine organ". Hormones are consequently well suited to exert their effects over extended period of time, and the endocrine system control long-term process within the body, such as the coordinated growth of organs or the maintenance of appropriate metabolite concentrations in the blood and tissues.

The secretion of proteins or peptides is an integral process in the function of many neurones, especially NSCs, peptidergic neurones, and adrenergic neurones. These cells are thus fused with the necessity of maintaining an adequate supply of the secretory product despite fluctuations in secretory demand. In theory, this could be accomplished either by having a sufficiently large pool of the product to meet maximum demand levels and allow this pool to fluctuate
with secretory activity or alternatively, specific regulatory mechanisms might modulate either the synthesis or catabolism of the secretory product in accordance with secretory rate. However, present data are not sufficient to establish the general validity of either of these alternatives. While many NSCs do exhibit fluctuation in their content of secretory material with changes in secretory state, the lack of biosynthetic studies on these preparations does not allow a clear distinction to be made between the alternatives listed above (see Berry and Arch, 1981).

The significance of differential staining affinities of neurones within the nervous system of both vertebrates and invertebrates was first appreciated by the Scharrers (see review by Gabe, 1966). Their staining differences were used as the basis for first description of NSCs and to give original definition of neurosecretion (Scharrer, 1977). The dangers of attributing neurosecretory function to a neuron on histological grounds have been pointed out on numerous occasions (Bern, 1966; Bern and Knowles, 1966) and number of authors suggested vigorous criteria, including morphological and biochemical evidence, to be satisfied before ascribing neurosecretory function to a cell (see Berlind, 1977). Historically, neurosecretory cells were recognised by a number of specific histochemical techniques, including light microscopic stain such as chrome-haemotoxylin-phloxin, paraldehyde fuchsin and azan (see review by Rowell, 1976).
Light microscopic staining has been used extensively with paraaldehyde fuchsin and chrome-haematoxylin-phloxin in molluscs (Simpson et al., 1966; Gabe, 1966) and insects (see Raabe et al., 1974; Rowell, 1976; Panov, 1980).

In the less highly organised invertebrates like the members of Coelenterata, Turbellaria, Platyhelminthes, Nemertia and Nematoda NSCs have also been identified. In Echinodermata radial nerves have been shown to possess polypeptide hormone (Chaet, 1966). In Annelida groups of scattered NSCs are found in the brain or supraoesophageal ganglia and in the ganglia of ventral nerve chord in both polychaetes and oligocheates (Gabe, 1966). In hirudineans NSCs are found in the brain and chromaffin cells in segmental ganglia (see review by Nagabhushanam and Kulkarni, 1983). Neurones with histological characteristics of NSCs occur in almost all ganglia of the nervous system in gastropods and lamellibranchs (see Highnam and Hill, 1978). Amongst arthropods, highly organised invertebrate animals, insect endocrine system has four major components—groups of neurosecretory cells in the brain, the corpora cardiaca, corpora allata and the thoracic gland or their equivalent. Structures homologous with thoracic glands, are formed in some insects. The crustacean endocrine system cannot be categorised so easily as that in the insects. There is a pair of Y-organs in the head, in males a pair of androgenic glands, and three major neurohemal organs like the sinus glands, the post-commissural organs and the pericardial
organs. Many of the NSCs are within the optic ganglia, congregated as specialized structures called X-organs.

The phylum Mollusca is a large group of living animals with anatomies that are similar as a result of their common evolution. The phylum Mollusca includes a seemingly infinite variety of forms in their evolution. This phylum also comprises animals like gastropods and lamellibranchs of high degree of edibility and of commercial importance (see Mondadori, 1982). Many authorities believe that the phylum Mollusca comprises more than 1,00,000 species, only arthropoda includes more than this, making the Mollusca one of the largest and most important phyla.

In Mollusca, interactions with the environment are handled by the nervous system (including the sense organs) and the muscular system (the muscles that making the foot and those that attach the animal to its shell). Both systems, of course, have been of different forms in different group of animals. Basically there are two extreme types of neural organization (with many intermediate forms). The chord system, in which the neural tree tapers and branches in smooth lines; and the ganglion system, which is characterised by knots of nerve cells called ganglia, bound together by nervous tissue consisting of slender elongations of the cells. Methods
of reproduction and dispersion of species relates to its survival. Sexual dichotomy is not as clearly defined among the molluscs as it is in many other animals. Some groups are dioecious (that is, the individuals are entirely male or female), while others are hermaphroditic (that is, individuals bear combine characteristics of both sexes). Hermaphroditism in molluscs is usually of the type in which the gametes of different sexes do not mature at the same time, and there is evidence of existence, in most species, of mechanisms to inhibit self impregnation, so that reproduction requires two partners. This means that the individual heredities will be combined and different characteristics can be acquired more easily. It is evident that even hermaphroditism is more advantageous than dioecious, because at least hermaphroditic animal can always meet with any other animal of the same species and thus has a much higher chance of ensuring successful impregnation. Whether male or female, dioecious or hermaphrodite, each animal is provided with a reproductive organ (gonad) to produce gametes. Males and females of gonochoristic bivalve molluscs are very similar in gross anatomy of their reproductive systems. Usually the gonads are paired and located near or adjacent to the digestive gland. Often the two gonads are so close together that the paired condition is difficult to detect (for example freshwater Unionidae). The reproductive system of functional hermaphrodites is only marginally more complex than that of gonochoristic
bivalves. In one kind of fertilization both eggs and sperms are released into the water and fertilization takes place there. This is called external fertilization. This results in an enormous waste of germ cells, and this phylum has, over the course of evolution, developed several mechanisms for internal fertilization. There are two main types of larvae. The larval form thought to be more primitive is the trochophore and often the trochophore will develop while still within the egg into second larval stage called veliger. In lamellibranchs there is a veliger stage of development. Some freshwater species have a special larval form called, glochidium which is parasitic in gill or other parts of fish or salamandor.

The freshwater molluscan fauna, using the classification of Vokes (1980), has represented primarily three superfamilies - the Unionaceae, Corbiculaceae and Dressinaceae. Historically, physiological ecology of freshwater bivalves is based on taxonomy with notes on habitat, community composition, abundance and distribution. Modern physiological ecology of freshwater clams has more recently involved field and laboratory studies on the basis of life cycles, growth, reproduction, population dynamics and energetics (Burky, 1983).

The physiological ecology and energy metabolism during reproduction in lamellibranch molluscs have been studied by
Bayne (1976a) stated that the physiological ecology of bivalves can give an insight on the adaptation of animal to function in its particular environment and such study also provides knowledge with the natural conditions which are normally experienced by the animal. One of the aspects like respiration, is considered for understanding the physiological adaptation of a species, since many features of aerobic metabolism can be studied directly by measurement of oxygen consumption by intact animals. In general, as with many species, the rate of respiration has been found to vary with change in virtually any environmental variable. In this respect many workers have given emphasis to the relation between respiration and size of the animal, level of ration, effect of temperature and salinity, exposure to air, oxygen tension and seasonal variations. Temperature and seasonal pattern in respiration during reproduction are somehow important (see Bayne, 1976a; Burky, 1983).

The subject of thermal compensation in poikilotherms, including bivalve molluscs has been reviewed by several investigators (Prosser, 1955; Fry, 1958; Prosser and Brown, 1961; Segal, 1961; Vernberg, 1962; Kinne, 1964, 1970; Vernberg and Vernberg, 1972; Newell, 1973). In the light of many varied effects of environmental changes on respiratory rate, it is not surprising to find a regular seasonal pattern in the rate of respiration by some species. Correlation between seasonal pattern of
respiration and the cycle of gametogenesis, storage and utilization of nutrient reserves has been worked out by few investigators (Bruce, 1926; Krüger, 1960; Bayne and Thompson, 1970, Widdows and Bayne, 1971; Bayne, 1973). Indian bivalve molluscs have also received some attention to study their respiratory rates in relation to changes in environmental conditions (Nagabhushanam, 1966 on Martesia striata, Rao and Kutty, 1968 on Donax faba; Deshmukh, 1972 on Meretrix meretrix; Mane, 1975 on Katelysia opima; Mane and Talikhedkar, 1976 on Donax cuneatus; Dhamne and Mane, 1976 on Paphia laterisulca). Most of the workers from India and abroad have worked out some aspects of respiration on exclusively marine species. However, there are some reports on freshwater bivalves also (Jadhav and Lomte, 1985). Most of these deal directly with responses to temperature, anaerobiosis and drying under controlled laboratory conditions. The reviews provide valuable but limited estimates because of the state of growth, reproduction or life cycle are often ignored or are not known. Comprehensive studies on life cycle and habitat characteristics are seldom coupled with respiratory physiology. The studies of Burky and Burky (1976) on Pisidium walkeri, Hornbach (1980) and Hornbach et al. (1983) on Sphaerium striatinum and Way et al. (1981), Alexander (1982), Alexander and Burky (1982) on Musculium lacustrea, and Buchwalder (1983) on Musculium partumeium provide this type of information. Several reports are available on respiratory physiology of freshwater bivalves
from India and abroad (Salanki and Lukacsovics, 1967 and Zs-Nagy, 1974 on *Anodonta cygnea*; Nagabhushanam and Lomte, 1970 and Lomte and Nagabhushanam, 1971 on *Perreysia corrugata* and McMohan, 1979 on *Corbicula fluminea*).

Changes in biochemical constituents are pronounced in invertebrates which are cyclic in reproduction, since a great amount of energy must be channelised to the gonad during reproduction. This is reflected in the deposition or depletion of the nutrients with the advent or departure of the reproductive period (Lambert and Dehnel, 1974). The aspect of energy metabolism and reproduction has been reported for a number of species of bivalves due to their commercial importance and edibility value. But the relative influence of gonad development on the distribution and storage of biochemical constituents in different body parts has been examined in only a few cases. Giese (1969), Gabbott (1975, 1976), Bayne (1976a) and De Zwaan (1983) have reviewed much of the work on biochemical changes, particularly the carbohydrates. A review of lipids in marine invertebrates including bivalves is given by Giese (1966), Lawrence (1976) and Voogt (1983). Seasonal variations in biochemical composition of *Mytilus edulis* in British Waters have been reported by Daniell (1920, 1921, 1922), Williams (1969) and Bayne and Thomoson (1970). Seasonal changes in biochemical composition have also been reported for *Pinctada mortensi* (Ashikaga, 1948; Tanaka and Hatano, 1952), *Teredo pedicellata* (Lane et al., 1952; Greenfield, 1953),
Pecten jacobeus (Lopez-Benito, 1955), Donax vittatus, Abra alba, Chlamys septemradiata and Nucula sulcata (Ansell 1972, 1974 a,b), Mytilus edulis (De Zwaan and Zaande, 1972; Gabbott and Bayne, 1973; Darrow and Edwards, 1975), Argopecten (=Aequopecten) irradians (Estabrooks, 1973) and Pecten maximus (Comely, 1974). Ansell et al. (1964) determined seasonal changes in biochemical composition of adductor muscle, mantle, siphon, visceral mass (gonad), digestive gland and foot in Mercenaria mercenaria. Bayne and Thompson (1970) determined the biochemical composition of mantle, gonad (germinal) and non-mantle (somatic) tissues of Mytilus edulis. In Mytilus edulis the mantle tissue serves as a site of storage of nutrients and gamete production. From India relatively few investigators such as Durve and Bal (1961) on Crassostrea gryphoides, Nagabhushanam (1961) on Martesia striata, Nagabhushanam and Mane (1975 a, 1978) on Katelysia opima and Mytilus viridis, Bidarkar (1975) on Crassostrea cucullata, Dhamne (1975) on Paphia laterisulca have reported changes in the biochemical composition correlating with annual reproductive cycle of bivalves. Seasonal changes in biochemical composition of different body parts of few species have been reported by Nagabhushanam and Mane (1975 a) on Katelysia opima and Mane and Nagabhushanam (1975) on Mytilus viridis. Freshwater bivalves from Indian rivers have received little attention in the field of biochemical energetics during reproduction. Few workers reported seasonal
variations in the whole body of few freshwater species (Lomte, 1968 on *Perreysia corrugata*; Lohgaonkar, 1974 on *Lamellidens corrianus*; Khatib, 1975 on *Indonaia caeruleus*; Godbole 1977 on *Indonaia caeruleus*; Jadhav, 1980 on *Lamellidens corrianus*).

Considerable data exist on reproduction in bivalve molluscs. Much of the work has been reviewed exclusively on marine species (see Bayne, 1976a; Giese and Pearse, 1979) and very brief description of reproduction in freshwater species is given by Purchon (1977) and Mackie (1984). Several environmental factors have been shown to control the reproductive cycle. Gametogenesis begins shortly after the growth and maturation of the gonad. Maturation of the gametes is under the control of several environmental factors, for example, temperature, lunar periodicity, depth of water, mechanical factors, food abundance and availability, light intensity, and endogenous factors, for example, genetic and hormonal controls. Of all the external controls, temperature probably is one of the most important. Maturation of gametes is regulated by annual temperature fluctuations or a threshold temperature. For some species the act of spawning is initiated when the temperature exceeds a critical level characteristic of species (Sastry, 1979; Andrews, 1979). Some species like oysters respond to a particular change in ambient temperature, either to the local, seasonal maximum or minimum.
Few workers supported that there are different physiological races of oysters, each with its threshold spawning temperature at different latitude and depth (Loosanoff and Engle, 1942; Stauber, 1950; Korringa, 1957; Loosanoff, 1960; Galtsoff, 1964). Giese (1959) suggested that temperature appears to act indirectly by optimising the physiological development of adults. For many species lunar periodicity in spawning has also been documented (Korringa, 1947; Thorson, 1950; Galtsoff, 1964). Much of the literature shows close relationship between the gonad and digestive systems, revealing importance of food abundance and availability in maturation of the gonad, because gonadal tissue innervates the digestive gland in several species of mytilids, corbiculids and unionids. This aspect of food abundance and availability, and gonad growth has been reviewed by Sastry (1979) and Mackie (1984). Numerous other factors have been reported to affect spawning (see Giese and Pearse, 1979; Mackie, 1984). Amongst endogenous factors, neurosecretory control of spawning is well known in Mollusca. Gametogenic cycle have been linked to neurosecretory cycle in *Mytilus edulis* and *Mytilus galloprovincialis* (Lubet, 1959), *Crassostrea virginica* (Nagabhushanam, 1963), *Dreissina polymorpha* (Antheunisse, 1963), *Katelysia opima* (Nagabhushanam and Mane, 1973) and *Aequipecten irradians* (Blake, 1972; Sastry, 1975, 1979). Hormonal control of spawning has also been reported in bivalves. Oysters sperms
contain "diantilin" that cause increase in ventilation of
mantle cavity by increasing the size of ostial pores, relaxing
adductors, and accelerating the rate of ciliary beat (Nelson
and Allison, 1940). Its secretion occurs prior to egg
spawning (Nelson, 1936). Substances in testicular tissues
are reported to induce spawning in female Mytilus
californianus (Young, 1942, 1946) and Tridacna (Wada, 1954).

Apart from endogenous regulation in maturation and
spawning in bivalve molluscs, as shown by the above workers,
the data on such regulation in growth and metabolism, and
several aspects of physiology are scanty. The work carried
out by Lubet (1966) on Mytilus edulis and on Perna perna
by Umiji (1969) stated that removal of cerebral ganglia has
little or no effect on shell or body growth, or on glycogen
metabolism and storage. However, ablation of cerebral
ganglion does result in disorders of lipid metabolism,
particularly a reduction in lipid accumulation (Lubet, 1965).
Visceral ganglion removal does result in alterations in
filtration and feeding rates of the animals, weakening of
muscle tonus, and loss of reserves in Mytilus edulis
(Altman, 1959; Lubet, 1965, 1966), Crassostrea virginica
(Nagabhushanam, 1964), Aequipecten irradians (Blake, 1972), and
Katelysia opima (Nagabhushanam and Mane, 1973).

Though considerable data is accumulating on several
aspects of exogenous and endogenous regulation in reproduction
and energy metabolism in bivalve molluscs, the data appears to be restricted exclusively and especially for dioecious marine species. Very little work on involvement of neurosecretion in reproduction and energy metabolism is reported in case of freshwater species (Kulkarni, 1987). To extend the knowledge in this field, the present work has been undertaken on the freshwater species using the bivalve, *Lamellidens marginalis* (Lamark). This species is abundantly distributed along the banks of river in India. Along the banks of the Godavari river at Paithan near Aurangabad this species occurs throughout the year abundantly and hence it is used in the present study.