CHAPTER- 1

INTRODUCTION AND BRIEF REVIEW
1.0 GENERAL INTRODUCTION

Sericiculture is an important agro-industry. It provides many people with gainful employment in the country. Northeastern region of India is the only place in the world, where all four commercially known varieties of silk are produced, i.e., Eri, Muga, Tasar, and Mulberry. Sericulture reflects one of the cultural traditions of the tribes. They have been practicing the tasar culture traditionally as a subsidiary cottage industry. Tasar yarn is a good material of warm clothing.

Although attempts were made to introduce Tasar culture on large scale during the turn of the 19th century, those remained largely without impact. The central silk board and the state governments have been making efforts for expansion of this industry.

Tasar silk is produced by the Antheraea mylitta, which is an endemic species. There are neither many institutes, who support the research and development of Tasar silk, nor are there sufficient literature available on this rare species. Present research has been undertaken to elucidate the process of maturation of eggs and its regulation by brain. The outcome of this study might help in constructing a practice manual for sericulture, involving Tasar silkworm, to get better yield.

1.1 Brief historical outline

Kopcc’s (1917) work on Lymantria moth revolutionized the field of insect endocrinology in the following years. But the demonstration of the role of brain in moulting in the bug, Rhodnius prolixus by Wigglesworth (1936) gave a boost to researches in this field. Endowed with the preliminary knowledge of this field of endocrinology several workers undertook the study of insect brain and the endocrine glands. Hanstrom (1938) identified large neurosecretory cells in the brain of
Rhodnius. Lyonet (1762) while working on the anatomy of Coccus coccus mentioned of CC for the first time. Johansson (1958) assumed that CC have two functions: (1) the storage and (2) production of a specific hormone. Müller (1928) made the first description of the insect CA in Blatta orientalis; however he concluded that the glands are nervous in character. Janet (1899) expressed the first doubts regarding the nervous character of the CA in the detailed anatomical study of the female ant, Lasius niger. From the historical point of view one might say that the field of insect endocrinology was founded in 1913, when Nabert after studying many insects of several orders, stated that the CA are glandular and exhibit periodic internal secretion. In 1918, on the basis of thorough histological investigation of several species of Lepidoptera, Ito concluded that the CA are indeed organ of internal secretion and that they function actively in the adult moths. The interrelationship between the neurosecretory cells of pars intercerebralis, CC and CA was established based on experimental evidence (Scharrer, 1952) and it was termed as intercerebralis-cardiacum-allatum system. Highnam and Hill (1969) collectively termed them as cerebral neuroendocrine system. Scharrer (1952) observed the role of CA and the cyclic activities in the neurosecretory cells of the brain in relation to the egg maturation.

1.2 Structure

1.2.1 The endocrine gland: Structure and general functions

The main endocrine axis in insects consists of the brain and associated head glands innervated by the brain (corpora allata and corpora cardiaca) and glands composed of lobulated cells with polymorphonuclei situated in the prothorax, the prothoracic gland. Clusters of neurosecretory cells in the brain produce a brain hormone, which
enters the corpora cardiaca, perhaps to get modified, and finally enters the hemolymph of the animal.

1.2.1.1 Brain and cerebral neuroendocrine system

The basic tenet of insect endocrinology is that the brain acts as an endocrine gland and is unquestionably involved in the control of other endocrine centers. This statement has been strengthened by numerous research findings at the levels of morphological and biochemical investigations. By employing varieties of surgical and staining techniques, it has been demonstrated that brain neurosecretory cell activity is positively correlated with the onset of egg maturation.

In insects many scientists have reported the presence of four pairs of groups of neurosecretory cells. Weyer (1935) reported two medial groups of neurosecretory cells in the brain of *Apis mellifera*. Williams (1948) identified two lateral groups of neurosecretory cells in *Platysamia*. In *Carausius morosus* Dupont-Raabe (1954) demonstrated the presence of third pair of group of neurosecretory cells in the tritocerebral region. Presence of the fourth pair in the optic lobe has been reported in *Calliphora erythrocephala* (Thomsen, 1965) and in *Orthetrum chrysis* (Tembhare and Thakare, 1976a, 1977).

The number of neurosecretory cells in an insect brain varies from insect to insect, and the staining reaction varies as function of the physiological state and developmental stage of the insect. By examining larval, pupal and adult stages of the *Cecropia* silkworm, a composite map of brain neurosecretory cells was made that revealed the presence of 8 large medial cell, 8 small medial A cells, 4 deep medial A cells, 4 posterior A cells, 10 lateral A cells, 4 lateral B cells and 4 medial B cells. The A and
B cells were identified on the basis of difference on their reactions to basic stains (Herman and Gilbert, 1966).

In due course of time neurosecretory cells (NSC) in the brain were classified. The classification of these cells on the basis of the staining peculiarities has been credited to Nayar (1955). He categorized the neurosecretory cells as A cells stained with chromalum hematoxylin and B cells with phloxine in *Iphita limbata*. The classification of these cells was latter on supported by Kopf (1957a, b), Johansson (1958), who recognized two more types, such as C and D cells in *Oncopeltus fasciatus* by using Chrome Hematoxylin Phloxine & Aldehyde Fuchsin stains, extended this classification further. The classification of the neurosecretory cells proposed by previous workers is followed although the neurosecretory cells may differ from species to species.

Neurosecretory cells are characterized by the presence of secretory material detectable histologically as chromophilic. The neurosecretory cells contain granules of about 1000-1500 A\(^2\) in diameter or 2000-3000 A\(^5\) depending on the cell, species and perhaps physiological state (Scharrer, 1963, 1968; Smith and Smith, 1966). The neurosecretory substances are peptide in nature (Gilbert, 1964). There was lots of controversy as per the nature of neurosecretory materials (NSMs) in insects. Kobayashi and Kirimura (1958) suggested the lipoidal nature of NSM in the brain of *Bombyx mori*, while Kirimura *et al.* (1962) suggested NSM to be cholesterol. Sloper (1957) demonstrated the presence of cystine rich protein in the form of NSM in the NSC of Cockroach. In various insects NSM has been demonstrated to be mucopolysaccharide-proteinaceous nature (Scharrer and Scharrer, 1954a, b; Arvy and Gabe, 1962; Ganguly and Basu, 1962; Novak, 1966; Hinks, 1971; Thakare and Tembhare, 1975; Tembhare and Thakare, 1977).
After synthesis and packaging, the active material passes via neurosecretory axons to the corpora cardiaca and thereafter it is released into the hemolymph following alteration (Normann and Duve, 1969). The axons of the neurosecretory cells of one group form a single axonal bundle. The medial and lateral neurosecretory cells give rise to the medial and lateral neurosecretory pathway. The medial neurosecretory pathway crosses each other inside the brain, while the lateral neurosecretory pathway runs independently. The medial and lateral neurosecretory pathways emerge out in the form of nerves named nervi corpori cardiaci I and II, respectively. Dupont-Raabe (1956) reported the presence of nervi corpori cardiaci III, which is originated from the neurosecretory cells of the tritocerebrum (Ventral neurosecretory cells).

The primary stimuli for the synthesis and release of the neurosecretory substances are environmental factors, such as photoperiod, temperature, nutrition, etc. These factors stimulate sensory neurons, which then pass information to the central nervous system, where integration takes place. Siva Prasad and Murali Mohan (1998) demonstrated morphological changes in CNS of *Bombyx mori* during metamorphosis. Shanavas *et al.* (2004) demonstrated the developmental and hormonal regulation of actin and tubulin in the central nervous system of silkworm, *Bombyx mori* during postembryonic development. Arif *et al.* (2002) studied the juvenile hormone stimulated protein phosphorylation in the CNS of *Bombyx mori*. Krishnan and Chaudhuri (2002) described the malate dehydrogenase activity during the development of final instars of *Bombyx mori*. Nagaraju (2000) described the recent advances in molecular genetics in *Bombyx mori*. Mahendran *et al.* (2006) studied the genetic variability and phylogenetic relationship among the different ecoraces of *Antheraea mylitta*. 
1.2.1.2 Corpora cardiaca (CC)

Earlier experiments have demonstrated that the corpora cardiaca act as neurohaemal organs and received the brain hormone (Gilbert, 1964). Most of the work in recent years has been devoted to studying the micromorphology of these structures and their function in the regulation of physiological events. Corpus Cardiacum (CC) has been demonstrated to be the neurohaemal organ for NSM produced by the NSCs. Lyonet (1762) described CC for the first time attached to the brain on the ventral side in Cossus cossus. De Léma (1933, 1934) demonstrated for the first time that the corpora cardiaca are the principal storage and releasing organs for NSM.

The histology of the corpora cardiaca shows that they are externally ensheathed with a connective tissue layer and internally composed of nervous as well as glandular structure. The cerebral neurosecretory products are transported along the neurosecretory axons contained within the cardiaca nerves. A large number of axonal fibres and some glial cells constitute the main body of the corpora cardiaca, some secretory cells are found either grouped together in a particular region or distributed throughout the stroma of the gland.

The glial cells, the thin invaginations of the basement membrane, the branched neurosecretory axons loaded with neurosecretory materials, the numerous endings, and the occurrence of release sites are the characteristics of neurohaemal organs.

The corpora cardiaca contain glandular chromophilic cells. The glandular cells of corpora cardiaca contain electron dense particles, the neurosecretory granules that are of the same size as the brain neurosecretory granules as seen in Carausius (Smith,
In the Coleoptera the body of corpora cardiaca is differentiated into medulla and cortex (Gundevia and Ramamurthy, 1972).

In the primitive group of insects (Ephemeroptera, Odonata) the CC are simple structures with undifferentiated nervous and glandular elements (Cazal, 1947, 1948; Arvy and Gabe, 1954a, b). But in Dictyoptera and Orthoptera there are well-differentiated nervous and glandular parts. The glandular parts represent the secretory cells (Highnam and Hill, 1969; Highnam and Goldsworthy, 1972). In Hydrophilus olivaceus it has been reported that the CC are differentiated into medulla and cortex, the medulla representing nervous part while the cortex the glandular part (Gundevia and Ramamurthy, 1972). In mosquito, the corpora cardiaca are totally nervous in nature, no secretory cells have been observed in them (Burgess and Rempel, 1966). In some Lepidoptera and Coleoptera, the corpora cardiaca have no neurohaemal part at all and the neurohaemal areas are located around the corpora allata (Kind, 1965; Panov and Bassurmanova, 1967; Srivastava et al., 1975). In some insect species, the corpora cardiaca are composed mostly of glandular cells and the wall of the aorta serves the neurohemal function. This has been observed in Heteroptera (Johansson, 1958; Singh et al., 1978), Diptera (Normann, 1965) and Dermaptera (Awasthi, 1975, 1976).

The cerebral neurosecretory products are transported along the neurosecretory axons contained within the corpora cardiaca nerves. Innervation of corpora cardiaca with the brain differs from one species to another. In primitive insects like Ephemeroptera odonta, a single pair of nerve innervates the corpora cardiaca but innervation of corpora cardiaca by two or three pairs of nerves seems to be common feature. In Diptera, corpora cardiaca are innervated by recurrent nerve (Normann, 1965;
Thomson, 1969; Bhargava, 1970). In cockroaches and some other insects, corpora cardiaca are innervated by a large number of nerves that originate both in the brain and in the ventral ganglion (Adiyodi and Adiyodi, 1974).

In many insects, corpora cardiaca are completely fused together and form a single gland. In some, they are partially fused and in some other cases they are separated from one another. Many workers suggested the production of intrinsic hormone by secretory cells of the corpora cardiaca. The functional significance of this hormone in the intermediary metabolism has also been pointed out.

1.2.1.3 Corpora allata

The cellular structure of corpora allata (CA) is highly variable. Nabert (1913) after studying many insects belonging to several Orders, stated that the CA are glandular and that they exhibit periodic internal secretions. On the basis of a thorough histological investigation of several species of Lepidoptera, Ito (1918) concluded that the CA are indeed organs of glandular secretion, and that they function actively in the adult moths. In the Lepidoptera, the corpora allata are paired globular bodies, whereas in many other Orders of insects they are fused into a single median mass beneath the aorta. In the Diptera the CA contribute to the structure of the ring gland.

The CA contain many neurosecretory neurons that most likely originate in the brain and communicate directly with the CA. These NSC axons ending within the CA have their cell bodies residing within the brain and the axons traverse the CC before reaching the CA.

The endocrine nature of Corpus allatum was first proposed in *Blatta orientalis* (Müller, 1928) but its functional status has been attributed by Wigglesworth (1936) in
*Rhodnius prolixus* and later by Engelmann (1959, 1965, 1968, 1970). Wigglesworth (1964, 1970), Highnam and Hill (1969), and Doane (1973). Since the time of Lyonet (1762) the CA have been regarded as nervous structure. The CA was so named by Janet (1899), who cast doubt on its nervous character. The detailed study by Nabert (1913) showed clearly that it was indeed a glandular organ and he suggested that it might be an endocrine gland.

The interrelation between the NSCs of pars intercerebralis, corpus cardiacum (CC) and CA has been established by experimental evidence (Scharrer, 1952). As a result of recent studies, the NSCs, CC and CA have been collectively termed as the cerebral neuroendocrine system (Highnam and Hill, 1969). The structure and function of the neuroendocrine system have been extensively studied and reviewed by many scientists. The most notable workers in this field of neuroendocrine system are: Thomsen (1943); Scharrer and Scharrer (1954a, b); Dupont-Raabe (1956); Nayar (1956a); Kobayashi (1957); Pflugfelder (1958); Van der Kloot (1960); Ewen (1962); Johnson (1963); Scharrer (1963, 1964); De Wilde (1964); Gilbert (1964); Novak (1964, 1966, 1975); Wigglesworth (1964, 1970); Highnam (1965, 1967); Gabe (1966); Highnam and Mordue (1970); Miller (1975); Marks and Holman (1976); and Tembhare and Thakare (1977).

### 1.3 Reproductive system

Usually the ovaries are composite structures, consisting of a variable number of tubular ovarioles in which oogenesis takes place. The number of ovarioles may vary greatly. One paired ovarioles is present in some Hemiptera, while single ovariole occurs in several aphid families. The termite queen has more than 2000 ovarioles in each ovary.
The ovaries of the insect are grouped into two types based on the nourishment supplied to the developing eggs, panostic and meriostic type. In panostic type of ovary the follicular epithelium is the only nutritive tissue that surrounds each oocyte. In meriostic type of ovary nurse cells are associated with follicular cells, which are also called trophocytes. On the basis of arrangement of the nurse cells the meriostic ovary is further divided into polytrophic and teleotrophic.

Polytrophic ovary, in which anterior part contains oogonia, primary oocyte, and nurse cells, is present in endopterygotes (Lepidoptera, Coleoptera, Diptera and Hymenoptera) (Snodgросс, 1935). In polytrophic type nutritive cell alternating with the oocyte are enveloped in their follicles. Both trophic elements take part in vitellogenesis. This phenomenon is found in Lepidoptera, Hymenoptera and Diptera. The number of nurse cells varies with the species. Teleotrophic ovarioles, in which the trophocytes remain concentrated in the germarium, are present in Hemiptera.

1.4 Vitellogenesis

Vitellogenesis in insect is studied by known techniques and has been reviewed by number of workers (Dedner, 1915; Bonhag, 1958; Nath, 1960, De Wilde, 1964; Telfer, 1965; Engelmann, 1970; Raabe, 1984; Kerkut and Gilbert, 1985). Since the pioneering work of Williams (1940) on the female reproductive system in the moth *Las ac ombid* sp., large number of workers have studied extensively the structural organisation of polytrophic ovaries and the process of oogenesis and vitellogenesis in various species of Lepidoptera (Telfer, 1960; Cruickshank, 1964; King and Agarwal, 1965; Ohtsuki, 1965; Miya and Kurihara, 1966; Tedder and Calcote, 1967; Stanley and Vaughan, 1968; Telfer and Anderson, 1968; Pollack and Telfer, 1969; Cummings and King, 1969; Anderson and Telfer, 1970; Ramamurty, 1970; Anderson, 1971;

Latest contribution in this field of study is by Dallai et al. (1985); De Bianchi et al. (1985); Watane and Thakare (1987); Dumbre et al. (1990); Sato and Yamashita (1991); Gaur and Meherotra (1993); Arisawa and Hijime (1990); Yokoyama et al. (1993); Thyagaraja et al. (1993); Pan et al. (1994); Chaudhuri et al. (1994); Yano et al. (1994,1998); Adamczyk et al. (1996); Vajre (1996); Raikhel et al. (2002) studied on the molecular biology of vitellogenesis in mosquito. In Drosophila, Lynn et al. (2003) studied molecular basis of the hormonal control of molting and metamorphosis. The genetic and environmental correlation between body size and egg production has been studied (Robertson, 2004).

*Antheraea mylitta* is a semi-domesticated species. The larval period passes outdoors. Many physical factors, like temperature and humidity play an important role in the development of larvae. Heavy rains and short photoperiod disturb the larval development, which ultimately affect the fertility and fecundity. The ovipositional capacities vary in diapausing and non-diapausing crop.

The survey of literature reveals that histochemical and histological work has been carried out on the reproductive organs of tasar silk moth, *Antheraea mylitta* (Vajare, 1996). Chaudhuri et al. (1999, 2000, 2001) worked on biochemical studies of diapause termination of *Antheraea mylitta* D. and *Bombyx mori*. 
1.4.1 Neuroendocrine control of vitellogenesis

Ito (1918) suggested the endocrine nature of the corpora allata in *Bombyx mori* and observed the secretory activity during oogenesis. Weed-Pfeiffer (1945) concluded that a hormone from the corpus allatum is required for the normal functioning of the follicle cells.

The cells of the corpora allata exhibit cyclic secretory activity and that these cycles are correlated with their hormone effects (Kaiser, 1979; Engelmann, 1962; Scharrer and Von Hamack, 1958). However, it is still unknown whether they transform or transmit the hormone they receive from the neurosecretory cells.

Thomsen (1943) performed quantitative measurement of corpus allata in adult females of *Calliphora erythrocephala* and suggested that when the gland increases significantly in size, their endocrine activity markedly increase. Extirpation of the corpora allata in newly emerged females prevented more than 75% yolk formation in the ovarioles.

According to Wilkens (1969), in *Sarcophaga* the neurosecretory cells produce the gonadotropic hormone, while the juvenile hormone is involved in the regulation of vitellogenesis and protein synthesis.

Larsen and Bodenstein (1959), in an extensive study with *Culex pipens*, *Culex molestus*, and *Aedes aegypti*, gave the conclusion that the corpus allatum provides the hormone that activates the ovaries. It has been found that the secretion from CA plays an important part in the deposition of yolk in oocytes of *Calliphora*: but occasional females have been known to develop the eggs fully even when CA were removed (Thomsen, 1943). Possompes (1953) confirmed the latter findings after extirpation of
the CA in *Calliphora* larvae. Thomsen (1952) established that the source of the concerned hormone was the medial group of the NSCs in the brain. When these cells were excised the egg chambers failed to grow beyond 0.17 mm. Reimplanted NSC led to complete development. Clements (1956) confirmed the role of NSC in egg development in *Culex*. In these insects there was therefore good evidence that the NSCs in the brain are the chief source of the hormone necessary for the yolk formation. In *Rhodnius* when the brain was removed but the CA remain attached, there was no reduction in the egg production (Wigglesworth, 1963a, b). In the stick insects *Carausius* and *Clitumnus* eggs are produced in the absence of the medial NSC but in smaller numbers (Dupont-Raabe, 1952) and in *Oncopeltus fasciatus* the essential source of the yolk forming hormone was the CA; but this gland depends on the NSC for its full activity. In *Bombyx mori*, Bounhiol (1938) found that removal of the corpora allata in the last two larval stages does not interfere with the ovarian activity, but results in precocious adults with normal fecundity.

Scientists distinguished the factors that induce growth of the corpus allatum and those responsible for the regulation of its secretory activity. Those factors may be both humoral and nervous. Corpus allatum is innervated from the brain by Nervi corporis cardiaci and Nervi corporis allati. This innervation is partly reflectory and partly neurosecretory (Thomsen, 1952; Engelmann, 1957; Nayar, 1958). Second, the stomatogastric nervous system is connected with the gland via the hypocerebral ganglion providing autonomous innervation via the corpora cardiaca. Third, innervation takes place from the suboesophageal ganglion in *Thysanura* (Gabe, 1953a, b), and in *Leucophaea* (Engelmann, 1957) or via corpora cardica (De Wilde and De Boer, 1969).
There is evidence that in many species the activity of medial neurosecretory cells (MNSC) in the brain is responsible for the activity of the corpora allata. The neurosecretory material is stored in the corpora cardiaca (CC) or as in *Oncopeltus* in the aorta wall (Johansson, 1958). Engelmann (1957) with *Leucophaea* and Nayar (1958) with *Iphita* have shown that neurosecretory tracts from the protocerebrum pass through the corpora cardiaca and reach the corpora allata. Enlargement of the glands has been seen to follow the appearance of Gomori positive material along these tracts. Tembhare and Thakare (1976a, b) and Sakurai (1977) suggested that the neurosecretory material plays some role in the egg development. Further it has been demonstrated that the neurosecretory material migrates from the brain to corpora allata and stimulates the later to produce gonadotropic hormone. Schmüzi et al. (1997) described the neuroendocrine control of diapause hormone secretion in *Bombyx mori*.

Highnam (1962a, b) demonstrated that the activation of the corpora allata in *Schistocerca germanica* is mediated through the lateral neurosecretory complexes, each corpus allatum being under the independent control of the lateral neurosecretory cells (LNSC). Girardie (1970, 1975) submitted that in Locust, the corpora allata are directly stimulated and inhibited by the products of different neurosecretory cells. Thomsen (1952) reported that the lateral cells had only a limited influence on oocyte maturation in *Calliphora*. The protocerebral neurosecretory cells and the median neurosecretory cells are indispensable for oogenesis either by activating the corpora allata by stimulating protein synthesis, which is essential for yolk formation, or by producing gonadotropic hormone. But many scientists stated that the NSCs do not control egg maturation in a direct way. In some cases cauterization of the NSCs results in a lowered food intake that will results in a lower protein concentration in the
haemolymph and cessation of oocyte maturation. In *Leucophaea* and *Rhodnius*, the NSC does not activate the CA but the CA hormone seems to regulate protein metabolism associated with vitellogenesis (Engelmann, 1970). It has been amply demonstrated that NSCs are of considerable importance for oogenesis. This has been based on experiments conducted on Diptera, i.e., *Calliphora erythrocephala* (Thomsen and Thomsen, 1970) and *Sarcophaga bullata* (Wilkens, 1967, 1968, 1969).

A distinct correlation between oocyte maturation and amount of stainable material in the NSCs has been demonstrated in *Carausius* and *Clitumnus* (Dupont-Raabe, 1952), *Tenebrio* (Arvy and Gabe, 1953), and *Iphita* (Nayar, 1958). The amount of secretory granules in a NSC is used as a parameter of secretory activity of the cell. The granules in a NSC are related with the rate of production and transport. A cell completely filled with granules may be inactive, because release is low (Highnam, 1962a, b), or may in other cases, reflect a high degree of activity (Dupont-Raabe, 1952). A very active cell that releases the granules immediately after their synthesis will appear empty. A cell full of stainable neurosecretory materials may result from a lack of their release.

*In vivo* and *in vitro* investigations have shown that differentiation of vitellarium leads to cytoplasmic growth of the oocyte and previtellogenesis requires the presence of ecdysone. In *Tenebrio molitor*, cauterization of the pars intercerebralis caused a decrease in the size of the germarium and inhibited previtellogenesis (Mordue, 1965). In the same insect the role of brain neurohormone in the initial growth of oocytes has been examined (Laverdure, 1972).

The role of pars intercerebralis in controlling vitellogenesis has been suspected for a long time, because changes in the load of the neurosecretory cells had often been observed, related to reproduction and vitellogenesis. The first thorough investigation
into this matter was conducted by Highnam and Lusis (1962) and Highnam (1962a, b) on the locust, *Schistocerca gregaria*, in which vitellogenesis is cyclic. The parsintercerabralis contains a large number of neurosecretory cells that exhibit cyclic modifications. Heavy-load in cells corresponds to an inhibition of release, while a small load corresponds to an intense process of synthesis and release.

The release of neurosecretory hormone from the corpora cardiaca is the final phase of hemocerebral neurosecretion. The activity of the neurosecretory cells and the liberation of their product by the neurohaemal end organ is the final phase of activation. Continuous secretory activity may be observed in the perikarya, while at the same time the releasing function of the corpora cardiaca is intermitant and is influenced by sensory and electric stimulation. The system may also be induced to release its contents by electric stimulation of the central nervous system. This suggests that the release of neurosecretory hormone is under nervous control. Increase in the level of blood protein is followed by protein yolk formation in the ovaries.

Results of intensive studies suggest that for the development of ovary and for the growth and differentiation of oocyte, the cerebral complex together with the ring gland is necessary. It was thus realised that the ovary is dependent upon a complex system comprising of neurosecretory cells in the protocerebrum and suboesophageal ganglion, the corpus allatum and the corpus cardiacum. These components influence one another by nervous stimuli, by neurosecretion carried along nerve pathways, and by humoral factors in the circulating blood. These interactions were closely studied in Orthoptera, Diptera and Hemiptera (Ali, 1981; Adams, 1970; Sharma, 1994). It was revealed that brain coordinates different stimulations and carries out the process of the successive phase of reproduction. Apart from the nervous role, this organ acts
1.4.2 Environmental control of vitellogenesis

Reproduction is intimately linked with environmental, internal and nutritional factors. As already shown in the Lepidopterans, *Manduca sexta* and *Antheraea*, an endogenous circadian clock was observed to control the timing of the brain hormone secretion that precedes larval ecdisis in *Samia cynthia* (Fujishita and Ishizaka, 1981). The activities of cerebral neurosecretory cells and ovarian development are influenced by environmental factors, such as starvation (Highnam *et al.*, 1966; Panov, 1967), temperature (Highnam, 1958; Clarke, 1966) and photoperiod (De Wilde, 1965; Geldiay, 1970). These environmental factors influence the activity of neurosecretory cells of the pars intercerebralis by means of nervous stimuli (Novak, 1966). *Antheraea mylitta* undergoes pupal diapause for an extended period of about 200 - 210 days depending upon the environmental conditions. Chaudhuri *et al.* (2000) recently reported that application of vertebrate estrogen to diapausing pupae induced precocious adult emergence by advancing the reproductive maturation. The results of this study have a bearing on successful economical exploitation of sericulture practice. Robertson (2004) has studied genetic and environmental correlation between body size and egg production in *Drosophila melanogaster*. It was thus realized that
the ovary is dependent upon neurosecretory cells in the protocerebrum, suboesophageal ganglion, the corpus allatum and the corpus cardiacum.

A series of anatomical and pharmacological experiments were carried out by many scientists in *Antheraea mylitta* and different wild tasar silkworm (Yokoyama et al., 1993), for example neurosecretory cells of the brain (Khan et al., 1983), reproductive system (Vajare, 1996; Chaudhuri et al., 1994), emergence pattern in tropical tasar (Gaur and Meherotra, 1993), and steroid hormone effect in diapause regulatory mechanism (Chaudhuri et al., 2000).

1.5 Objectives

There is number of reports dealing with the morphology and anatomy of insect brain, ventral nerve cord and ventral ganglia but similar studies on the silkworm are lacking (Siva Prasad and Murali Mohan, 1998). The survey of literature on *Antheraea mylitta* D. also reveals that so far no work has been done on the cerebral neurosecretory system and the endocrine control of vitellogenesis. In view of the economic importance of the *Antheraea mylitta*, it is all the more essential to study in detail the morphological changes in the neuroendocrine system during development in relation to vitellogenesis. The present study is an attempt in this direction.