1. INTRODUCTION
The concept of neurosecretion is a special third system that correlates within the body of the metazoan animals and this has been extensively studied by several researchers (Scharrer and Scharrer, 1937; Scharrer, 1952, 1959, 1966; Bern, 1966; Gabe, 1966; Knowles and Bern, 1966). Neurosecretory material (NSM) are specific stainable secretory products that are present in versatile neurons and are characterized as proteinaceous products, otherwise known as neurohormones. Furthermore, the active principle within the granules remains associated with an inactive protein carrier (neurophysin) that exhibits specific staining and ultrastructural characteristics. Dispatch of neurosecretion is furnished through axoplasmic flow to the nerve endings, wherefrom the neurohormone is either released directly and thereafter diffused into the blood stream, surrounding tissue or crosses the cell membrane in granular form and awaits escape from the carrier substance until it reaches the extracellular fluid (ECF). Extensive ultrastructural studies of neurons through electron microscopy have now broadened the concept of neurosecretion to include all secretory products of nervous origin that enter the blood stream and thus considered to be as hormones.

The hexapodan neurosecretory (NS) system [Brain, Corpora cardiaca (CC), Corpora allata (CA)] has been extensively investigated ever since they were discovered (reviewed by Wigglesworth, 1964; Bern and Hagadron, 1965; Doane, 1973; Maddrell, 1974). It was Imms (1957), who described the insect brain as the dorsal ganglionic centre of the head and bears three fold divisions (in the adult) to be designated as proto-, deuto- and tritocerebrum respectively. Just behind the brain a pair of neurohaemal organ, the CC are found to lie over the oesophagus and each of the CC is joined with dorso-medially situated hypocerebral ganglion. Besides these, the CC remain connected anteriorly with the protocerebrum by nervi corpori cardiaci (NCC) and posteriorly by nervi corpori allati (NCA). The corpora allata are paired, spherical, non-neural, glandular bodies placed behind the CC. However, such typical anatomical relationship undergoes modifications in varying degree as and when various orders
of pterygote insects are referred to.

In the recent years the knowledge concerning cytomorphic distinction, distribution of NS cell as well as their role in the control of events throughout the life cycle of insects have acquired tremendous momentum. In hexapods, the protocerebral NS cells are usually situated at the pars intercerebralis (PIC) on both sides of the middle line in the dorsal and aboral parts of dorsal cellular cortex. Hanström (1940) observed that the axons of both median cell groups form two nerves which in their intracerebral course cross each other and on leaving the rear of the brain constitute the nervi corporis cardiaci interni (NCC I) while axons of the lateral cells take a direct course to the rear of the brain and form the nervi corporis cardiaci externi (NCC II). Changes in the morphological characteristics of the perikaryons of origin (NS cells) are dependent on their number and size, state of secretion and the quantity of product contained by the cytoplasm. The general form of the NS cells in the PIC is usually unipolar and/or pyriform. These cells may assume polyhedral form following reciprocal cell pressure but always bear prominent axon hillock regions. Nuclei are generally spherical with fine chromatin particles and may possess one or more fairly large nucleoli in most cases. Cytoplasmic vacuoles of variable dimensions are often encountered in the PIC neurosecretory neurons despite containing secretory inclusions. The quantity of secretory product may undergo fluctuation in accordance with different stages of the secretory cycle. Nevertheless, configuration or texture of these elaborations within the perikaryons depends mostly on the quanta contained by the cells observed under light microscope.

On the basis of staining behaviour, Thomsen (1954a, b) report two types of NS cells in the PIC of C. erythrocephala, B. junceus and S. speciosus. First type contains granules that stain intense blue and the other phloxinophilic (red) with Gomori CAH-technique. Nayar (1955a) in Iphita limbata and De Lerma (1956) in Hydrous piceus made similar observations. Ganguly and Banerjee (1960) in
M. *grandis* categorised (A-, B-, C- and D-) types of NS neurons according to the descending order of their sizes. However, Highnam (1961) categorised 4 types of NS neurons in the PIC region of *S. gregaria* on the basis of their size difference as well as staining reactions. Nanda (1966), in his works on *P. americana* and *O. velox* has also described 4 types (A-, B-, C- and D-) of Gomori-positive NS cell which are classified according to their staining affinities, size, nuclear organization, nature of cytoplasmic inclusions and presence and absence of vacuolations. Such morphometric variation and stainability are considered to be the sole criteria for NS cells classification (Barde and Tonapi, 1977). Apart from these diagnostic features, Singh et al. (1977a, b) stressed upon the shape of the NS cells and accordingly they have distinguished two types (A- and B-) of brain cells in the larvae of *Antheraea mylitta*. In their studies on a lepidopteran insects *Amsacta collaris*, Singh and Awasthi (1981) have also distinguished three (A-, B- and C-) principal types of cells on the basis of their staining properties.

Variation in the distribution pattern of NS cell within the brain of insects has been extensively studied. And therefore, reports made by Ganguly and Banerjee (1960), Nanda (1966), Naskar and Nanda (1975) and Singh and Awasthi (1981) on *M. grandis*, *P. americana*, *C. megacheppalla* and *A. collaris* respectively are worth mentioning. Ganguly and Banerjee (1960) described only A-type cell in the middle group, C-type cell in the lateral and cellular aggregation (made up of both B- and C-type cells) in the optic lobe of the brain. Other workers, however, noted distribution of A-cell in the PIC chiefly, lateralis partly, and in the tritocerebrum rarely, along with unrestricted distribution of B-cells in almost all the regions of the brain. In contrast, Ramade (1969) has also identified NS cells at the medial as well as anterior dorsal surface of the brain of *M. domestica*. Later, Adams (1976) has attempted to classify this median NS cells as well as their quantitative distribution in the brain of the same species.
A detailed analysis of the function of NS cells of *Locusta migratoria*, fed continuously throughout their growth, has been made by Clarke and Langley (1962). Strikingly no change either in the amount of NSM of the median NS cells, in their axons (NCC), or in CC during post embryonic development or at different times during the inter-moult period has been recorded by them. But NSM appear to be produced continuously throughout growth. In *Calliphora erythrocephala*, M. Thomsen (1965) described median NS cells that display definite cyclic changes as and when the size of the nuclei and content of the cells are taken into account. Furthermore, it has been attributed that the cytological changes depend upon the age of the fly, the diet given and are correlated with ovarian development. In their studies on the saturniid moth *Hyalophora cecropia*, Herman and Gilbert (1965) identified a good number of NS cells in the brain which provide histological evidence of secretory activity. Previous to this finding, Ewen (1962) recorded A-cells of PIC, either in groups or individually, which show periods of activity that can be correlated with the stages of development in *Adelphocoris*. He further pointed out that enhanced activity of A-cells and hyperactive condition of CA during pre-oviposition period of the adult female are indicative of the gonadotropic function of the latter. Thomsen and Lea (1968), studied cyclical changes in the medial NS cells of *Calliphora erythrocephala* under various experimental conditions. They concluded that the activity of the NS cells is being regulated by CA on the basis of nutritional level. Later, Beattie (1971) implicated cytoplasmic abundance with the functional efficacy of NS cells in *P. americana*. Naskar (1978), however, maintained that the fluctuation in the amount of secretory inclusions coupled with the appearance of vacuolations readily indicate cycle of secretion in the PIC of *C. megacephala*.

Considerable information are available to show that the NSM from the cells of insects brain travel along the axons and reach the specialised neurohaemal organ from where NSM are released into the blood stream. While studying the internal structures of insects,
Lyonet (1772) [cited by Pflugfelder, 1952] came across some unknown glands for the first time and designated these structures as ganglia. Later, Pflugfelder (1936, 1937) made further investigation on these glands and introduced the term 'corpora cardiaca' (CC), made up of nervous and osmiophilic cells that have secretory or excretory functions. Hanström (1939, 1942), however, stated that ontogenetically the paired CC may be considered as ganglia, because they develop as invaginations of the stomodaeum in the neighbourhood of hypocerebral ganglion and later move close to the wall of the aorta to which they become intimately connected. Nevertheless, secretory nature of these organs has also been claimed by him. Later, Cazal (1948) advocated the syncytial nature of the gland despite being composed of nervous and secretive cells. In his studies on CC of L. migratoria, Nayar (1954), too, reiterated the syncytial characteristics of the gland and observed nuclei of two different sizes besides containing cytoplasmic inclusions (spheroid bodies) of 0.6 μm in diameter in an average.

Scharrer and Scharrer (1954) reported that in many species of insects, axons running from the brain to the CC stain positively with common NS stains. They have further shown that when the NS pathway between the brain and the CC of Leucophaea maderae is severed, the secretory material accumulates proximal to the cut region and disappears largely from the corpora cardiaca. Furthermore, the axons from the NCC I reach not only to the CC but sometimes extend up to CA in most of the pterygote insects. M. Thomsen (1954a, b), in his studies on C. erythrocephala, reported that the axons of the NS cells of hymenoptera diverge within the CC and undergo ramification between the cells. Secretory granules, however, remain stored in the swellings of the axons. Nayar (1956) has shown that the cells of the CC of Iphita limbata bear secretory products which appear to be of different nature from the already known extrinsic NSM. Willey and Chapman (1960) also confirmed such contention and opined that both nervous and chromophil elements are equally responsible for NS function. Light microscopic studies
of Ganguly and Banerjee (1960) reveal the existence of only B-type cells in the CC of *Macroceroea grandis*. They have located deep blue granular clumps at the outer periphery of the gland despite their presence in the NCC. Later Highnam (1961) described two distinct regions of CC in *S. gregaria* - one for storage of NSM from the brain and other glandular zone. Similar situation has been described by Ewen (1962) in case of *Adelphocoris*. Then B. Scharrer (1964) reported two classes of intrinsic elements, parenchymal and interstitial cells in the CC of *Leucophaea maderae*. The dual character of CC, viz., that of storage as well as release centre, for the extrinsic NS substances and of an endocrine organ in their own right, has been established beyond doubt. Electron microscopic studies by Scharrer (1963) and Scharrer and Jones (1963) further elicit that the CC in the cockroach, *Leucophaea* possess numerous profiles of cellular processes and three types of cell bodies like neurons, glia like interstitial elements and intrinsic parenchymal cells of neuroglial character. In another study, Normann (1965), opined that the CC of *G. erythrocephala* are comprised of extrinsic and intrinsic axons, NS cells, glia cells and outer cellular layer - the stroma. Nanda (1966), in his works on *P. americana*, reiterated the syncytial nature of the gland which is predominantly composed of connective tissues and a few tracheal cells besides containing intrinsic and extrinsic elements. In their observations, Unnithan et al. (1971), stated that the CC in *Oncopeitus fasciatus* are composed of two types of parenchymal secretory cells, with electron dense granules measuring 1300-3000Å and 1000-2000Å in diameter respectively. The CC also contain interstitial cells and some axons of extrinsic origin with or without granules. In his review, Rowell (1976), however, stated that the essential elements of the CC are the intrinsic glandular cells. Later, Awasthi (1977) identified three types of granules in the CC of a house cricket, *G. sigillatus* and maintained that the nature of these granules appears to be both aminergic and peptidergic as and when the size, shape and opacity of the contents are taken into consideration. Indeed, the glandular criterion of the said neural organ further has been advocated by
him on the basis of the presence of two types of intrinsic cells intensely endowed with mitochondria as well as free ribosomes. Jhonson and Bowers (1963) have reported the storage-release mechanism of the CC with respect to the activation of the target organ. Bhargava (1970), in his works on *Lithocerus indicum*, suggested that there may be a probable chemical change in the NSM during its sojourn in the corpus cardiacum proper. Awasthi (1972b) presented a detailed description of the CC-CA complex in a dipteran fly, *Sacrophaga ruficornis* and reported the occurrence of AF-stainable materials of cerebral origin in addition to other materials exclusively elaborated by the corpora cardiaca. He further noticed the presence of a fair amount of NSM in the aorta and reiterated that the NSM is partly stored and released from CC and partly from the aorta. In case of aphid (*Megoura viciae*), "direct delivery" of neurohormones from the CC to the target organs through long axonal processes has been emphasised by Steel (1977) to subscribe the neurosecretory innervation.

The first comprehensive studies on the histological structures of CA in *Melanoplus differentialis* have been made by Mendes (1948) and according to him four types of cells are available on the basis of their location, nuclear morphology and cytoplasmic abundance within the gland concerned. Nayar (1956), however, described this gland in *Iphita limbata* in another context and attributed its syncytial nature despite possessing dimorphic nuclei located at the peripheral (large nuclei) and central (small nuclei) regions. Later, Bielenin (1963) recognised a massive CA of *L. pomeranicum* that is made up of large mass of cells possessing ill-defined cell boundaries. Ganguly and Banerjee (1960) and Ganguly and Nanda (1965) also advocated the syncytial characteristics of the glands in question and emphasised distinct orientation of the nuclei and cytoplasmic vacuoles within the glands of *M. grandis* and *P. americana* respectively. Similar studies have also been made by Burges and Rampel (1966) in adult female mosquito *Aedes aegypti* and asserted special importance to the cytoplasmic condition with respect to possession of vacuoles.
Extension of the NCC - axons charged with NSM within the CA has been observed by several investigators (Arvy and Gabe, 1952a,b, 1953a,b, 1954; Arvy et al., 1953; Schultz, 1960; B. Scharrer, 1961, 1964; E. Scharrer, 1962; Khan and Fraser, 1962; Saini, 1966; Awas-thi, 1972a, 1973). Besides these, Tombes and Smith (1970) reported that the CA of Hypera postica also maintain relationship with the suboesophageal ganglion through nerves originated from the latter.

The ultrastructural analysis of the corpus allatum of Oncopeltus fasciatus (Unnithan et al., 1971) reveals that some of the electron dense granules at the peripheral region of the gland display similar identity with those staining with performic acid - Victoria blue (PAVB) stain.

As regards the types of hormones elaborated by CA, Kim (1973) inferred that atleast two kinds of hormones are released from the CA of Dendrolimus spectabilis: (1) Juvenile hormone - secretion occurs unimpeded till last instar which, however, mediated through both neural and neuroendocrine stimuli as established previously by experimental evidence (Engelmann, 1965; Highnam, 1967). Later, Judy (1974) suggested that the brain uses certain pathways which inhibit the function of the CA, while other neural or neuroendocrine stimuli are capable of relieving such inhibition which eventually leads to the release of hormone. (2) Gonadotropic hormone is secreted in the late pupal to adult stage by receiving the brain stimulation.

In any case, CA are particularly viewed as the main source of JH for a long time and the recent demonstration of JH synthesis by isolated CA in a definite medium (Judy et al., 1972 - cited by Judy, 1974) seems rather conclusive in this context. Gwadz and Spielman (1973), while assessing the role of CA, have established that interruption in the normal development of ovarian follicles in Aedes aegypti by decapitation or allatectomy could be corrected by either reimplantation of CA or administration of synthetic analogues of juvenile hormone.
Thus, it appears that the insect NS unit is comprised of several components like pars intercerebralis NS cells, CC and CA and the relative importance of a particular component seems to vary in different insects (Wigglesworth, 1964). To elicit such functional interdependence, the NS system of insects possibly provides a link between the nervous and endocrine systems for coordination (Highnam, 1962a).

Studies on the reproductive biology are indispensable since in course of reproduction many invertebrates undergo profound changes in anatomy, physiology and behaviour. In any case, impact of environmental cues on the reproductive activities are to be considered seriously, especially when involvement of reprophysiology is adhered to. This has its bearing in the context of proper control and management of reproduction of certain species, be it harmful or beneficial. Among invertebrates, insects are chosen as tool to have an insight for the reproductive physiology. Such studies may be of great help in tracing the physiological phylogeny of reproduction and also their relation between somatic growth and asexual and sexual reproduction.

The reproductive organs of the male insects usually consist of a pair of testes, vas deferens, seminal vesicles and accessory glands (conglobate and mushroom-shaped glands). The testes are paired elongated structures, composed of small distinct 'globules' resembling a bunch of grapes (Raichoudhury and Mitra, 1941) in contrast with the earlier observations (Miall and Deny, 1886) where atrophy of the testis in adult roach, _P. orientalis_ has been reported. Snodgrass (1937) in _B. orientalis_ described the structure of testes in final nymph which consists of a mass of rounded numerous sacs. Vas deferens are paired, narrow tubes, one from each testis run posteriorly beneath the cercal nerves and then change course to enter to the ejaculatory duct (Cornwell, 1968). Seminal vesicle is the swollen part which arise from the surface of the ejaculatory duct and remains
connected with the terminal end of the vas deferens. In *B. germanica*,
the seminal vesicles consist of two small oval sacs at the anterior
end of the ejaculatory duct, whereas in *Blatta* and *Periplaneta* they
consist of two groups of numerous small sacs on the ventral surface
of the duct (Cornwell, 1968).

Gupta (1946); Adiyodi and Adiyodi (1974) described conglobate
(phallic) gland (CG) as large, compact, pyriform structure appearing
at the anterior end of the ejaculatory duct of *P. americana*. This
gland may vary in form in different species. In *Blatta* it is an
elongated sac which tapers posteriorly and ends in a duct on the
left phallomere; in *Periplaneta* it is subdivided into several lobes
and in *Blattella* it consists of a mass of coiled tubules (Cornwell,
1968). It is noteworthy that the CG enlarges and reduces at pre
and post mating phase respectively (Jaiswal and Naidu, 1976).

Mushroom-shaped gland (MSG) is a complex organ and the gland
displays morphological variation in different groups of insect (Khalifa,
1950; Callahan and Cascio, 1963; Roth, 1967; Odhiambo, 1969; Louis
and Kumar, 1971; Adiyodi and Adiyodi, 1974). MSG is composed
of sets of tubular glands or utricles. Some earlier studies reported
the existence of two types of tubules in male *Blattaria* sp. (Roth,
1967). Louis and Kumar (1971) distinguished three types of tubules
in MSG of *P. americana*. Previous to this information, Jurecka (1950)
[cited by Richards, 1963], however, mentioned 6 types of tubules in
*Blatta orientalis*. Later, Vijayalekshmi and Adiyodi (1973) observed
five types of tubules in *P. americana* on the basis of morphology
and solubility properties of their secretion in water.

Available literatures reveal fragmentary information on the histo­
logical profile of the testis in insects in general and dictyoptera
in particular. It was Snodgrass (1935) who reported the follicular
composition of the testis and each follicle is essentially made up
of a thin epithelium resting on a basement membrane in majority
of the insects; in some cases the epithelium may consist of two
layer of cells. Later, Jaiswal and Naidu (1972) described for the first time of the histological profiles of P. americana and reiterated the observations of Snodgrass (1935) to implicate the follicular characteristics of the testis and opined that these follicles may be of different sizes and shapes. Ambika and Prabhu (1978) advocated that the spermatogenic cells within the follicles of D. cingulatus may remain either segregated or in cluster and these elements display four distinct categories viz. spermatogonia, spermatocytes, spermatids and sperms. Previous to this observation, Raichowdhury and Mitra (1941) have contended least difference between the testicular follicles of adult and young stages. But later, Amerson and Hays (1967) opined that in the last nymphal stage of cockroach, the testicular follicles display heterogeneous picture where in some of the follicles may contain typical zones of maturation while others contain fully mature sperm. Almost similar observations have been made on the testis of adult roach which normally contain an abundant of mature sperm despite registering reduced quanta of spermatogonial cells (Cornwell, 1968).

From the literature it appears that the male accessory glands of insect play an important role in the formation of semen and spermatophore and in some cases also contains active substances affecting female reproductive physiology. The CG is one of such male accessory glands in P. americana. Appearance of this gland is first encountered in the last phase of early instar nymph. According to Jaiswal and Naidu (1976), the gland in question is composed of several lobes of glandular cells of different shapes and sizes, surfaced by a thin membranous layer. Indeed, the interspaces between the phallic lobes are filled with fluid. Detailed observations, as per their account, reveal the secretory nature of the gland due to the possession of several secretory cells all around the lobe leaving some space in the middle. The secretory cells do have large size and are endowed with small nuclei at the centre (Jaiswal and Naidu, 1976).
MSG has been considered as another component of the male accessory glands in *P. americana*. This gland is very much conspicuous and composed of heterogeneous sets of tubular glands as and when their morphological structure, cytological profile and nature of secretion are referred to. In their comprehensive account, Adiyodi and Adiyodi (1974) stated that each tubular gland bears secretory epithelium that rests on thin basement membrane and surfaced externally by a layer of muscles. The nuclei of the epithelium are roughly oval with irregular outlines and occupy more or less central position. In so far as, the biochemical profiles of the gland are concerned, it is asserted that there is a close similarity with the conglobate gland. Again in view of Vijayalekshmi and Adiyodi (1973), some discrepancies in the light of containing biochemical constituents are in existence. According to their contention, MSG is found richer in many constituents than CG; some of the components like plasmalogen are more abundant in CG than MSG. They have at last concluded that the similarity in biochemical constitution between MSG and CG is particularly striking in view of the differences in their morphology and histology.

Faculty of reproduction in its totality is under endogenous as well as exogenous regulation. The former is accomplished under hormonal control, mediated through neuroendocrine regulation and the latter involves environmental factors as temperature (Thorson, 1946; Galtsoff, 1964; Pearse, 1965), salinity changes (Panikkar and Aiyar, 1939; Giøse, 1959a), physical shock (Young, 1945), changes in light intensity (Segal, 1970), lunar or tidal phases, chemical exudates from opposite sex of the same species (Giøse, 1959b) etc. [cited by Adiyodi and Adiyodi, 1977]. It is all the more important for the timing of the reproductive period which is otherwise monitored through environmental conditions favourable for successful reproduction. Indeed, reproductive periods are usually timed in such a way that the developing larvae or young obtain the most favourable environmental conditions for growth and survival. Likewise, a knowledge of the biochemical composition of an organism proves to be
a solid ground for the understanding of its physiology. Biochemical analysis of the different organs yields interesting data on the exchange and movements of chemical substances between the various systems throughout the course of an annual reproductive cycle (Nair, 1971; Nair and Saraswathy, 1971; Pillay and Nair, 1973; George and Nair, 1975) [cited by Adiyodi and Adiyodi, 1977].

Endocrine control of reproduction in female insects has been established by several investigators (Nayar, 1957, 1958, 1964; Doane, 1962; Highnam, 1963; Engelmann, 1964 [cited by Novák, 1975]; Deoras and Bhaskaran, 1967) through interesting experimentations. In any event, the ovarian development is controlled synergistically by the brain neurohormone (allatotrophic) as well as juvenile hormone (Thomsen, 1952; Johansson, 1958a, b; Highnam, 1962a, b; Highnam and Lusis, 1962; Engelmann, 1968). Elegant experimentations (Ittycheriah and Nayar, 1967) sometimes give details for the ovarian development through various operations like sensitisation of ovary by ecdysone for vitellogenesis in the adult, influence of inhibiting factor from the ovary to facilitate oviposition following vitellogenesis and the like. Overall survey reveals that the ovarian maturation encompassing synthesis of yolk and oocyte growth is indispensable due to the factors elaborated from CA which otherwise is controlled by the brain NS cells (Prabhu et al., 1967; Jalaja et al., 1976).

Hormonal influence on the maturation of male reproductive organs of insects has been studied by several workers (Williams and Kambysellis, 1969; Takeuchi, 1969; Yagi et al., 1969; Kambysellis and Williams, 1971; Nowock, 1971, 1972, 1973; Takeda, 1972; Dumser and Davey, 1974, 1975a, b; Ambika and Prabhu, 1978). In their observations, Schmidt and Williams (1953) stressed upon the role of ecdysone on the spermatogenesis of the late post embryonic stages of H. cecropia and S. cynthia. In doing so the permeability of macromolecular factor is indispensable (Williams and Kambysellis, 1969) for the right maturation of the testis. In the same year, Yagi et al. (1969) opined the importance of ecdysterone in vitro
studies of spermatogenesis of *Chilo suppressalis*. Later Takeda (1972), however, emphasised that in *M. flavescens* the transformation of spermatocytes into spermatids could only be made after addition of ecdysterone *in vitro*. In *P. americana*, development of testis has been reported by Blaine and Dixon (1970) who opined that neither prothoracic glands nor NS cells affect the development of testes though corpora allata maintaining the testes in juvenile stage by retarding their development. Subsequently, Ambika and Prabhu (1978) in *D. cingulatus* attributed rather a contrasting feature where JHA induced transformation of spermatocytes into spermatids as well as sperms. They further reported that, when early 4th instar testis is implanted into the newly moulted adult male or female, spermatids and sperms develop; but if the implantation is made in allatectomized female, the differentiation of spermatocytes to spermatids and then to sperms is inhibited. Accordingly, it is inferred that JHA stimulates spermatogenesis and the influence of CA hormone is direct.

Cautery of the median NS cells of *C. erythrocephala* (Thomsen, 1952), *O. fasciatus* (Johansson, 1958b), *L. migratoria migratorides* (Mc Caffery and Highnam, 1975) inactivates the CA and prevents their normal increase in size, suggesting that some form of allatotropic factor is produced by the cerebral NS cells. However, reimplantation of brain tissues or injections of CC extracts restores normal CA activity. Thus it is believed that brain NS cells have a trophic effect on the CA in a number of insects (Mc Caffery and Highnam, 1975). In *M. sanguinipes* both median NS cells and CA are essential to oocyte maturation (Gillott and Elliott, 1976). The failure of the oocytes of allatectomized females to sequester protein was attributed to the removal of a gonadotropin which stimulates the follicle cells to become patent (Elliott and Gillott, 1976). In contrast, the failure of vitellogenesis in median NS cell-cauterized females was interpreted to indicate that the availability of yolk precursors not the uptake mechanism had been affected. In addition, allatectomy or median NS cell cautery has been shown to alter the development of the fat body (Gillott and Elliott, 1976) and prevent
the normal accumulation of protein in the haemolymph (Elliott and Gillott, 1976). In his electrocautery studies, Bradley (1976) also suggested that a factor produced in the PIC would be required for maturation of a normal number of oocytes in *Acheta domesticus*. Furthermore, deprivation of median NS cells stalls the protein digestion (Strangways-Dixon, 1959, 1961), checks the metabolism of carbohydrates, enzymes and proteases in *P. americana* (Round, 1968). Interesting result with regard to water metabolism, has been documented by many authors (Nunez, 1956; Gersch, 1964; Maddrell, 1966; Wigglesworth, 1970; Mordue, 1971) with respect to the role of median NS cells. In their observations, it is concluded that median NS cells of the brain apart from NS cell complements located in other different ganglia of ventral nervous system contain diuretic and antidiuretic factors. Cautery of NS cells of the brain provokes retention of water and consequent dilution of haemolymph (Highnam et al., 1965). Removal of NS cells of the brain causes 20 percent reduction of the normal O₂ consumption and diminishes nutrition uptake (Larsen, 1970).

In *M. sanguinipes*, a significant increase in the wet weight of the fat body follows ovariectomy (Gillott and Elliott, 1976). However, Elliott and Gillott (1977) demonstrated that there was an increase of protein content of the haemolymph following ovariectomy in the same species. The accumulation of large amount of protein in the fat body and haemolymph of ovariectomized female, *M. sanguinipes* suggested that most yolk protein is of extraovarian in origin. Thus ovariectomy apparently has no immediate effect on protein synthesis (Elliott and Gillott, 1978). In viviparous cockroach, *Diploptera punctata* ovariectomy either in nymphs or young adults depressed the rate of JH synthesis by the CA. Thus the normal cycle of JH synthesis by CA in newly emerged mated females requires the presence of ovaries (Stay and Tobe, 1978). 10-day old adult, *Acheta domestica* females obtained from ovariectomized last larval instar displayed dramatically less PAF-positive brain NSM than did sham-operated control (Bradley and Simpson, 1981). They also noted that the
decrease in detectable NSM in ovariectomized animals could be related to decrease titers of JH or ecdysterone. Similar observations were reported for the paramedial NS cell of the suboesophageal ganglion of the cricket, Telogryllus commodus (Durnberger et al., 1978) and for the brain median NS cell of Musca domestica (Adams, 1976). In T. commodus ovariectomy immediately after adult ecdysis resulted in a decreased amount of PAF-positive material and an increased rate of incorporation of \(^{35}\)S cysteine in the suboesophageal ganglion of Day 10, suggesting that the rate of synthesis and release of NSM is greater following ovariectomy. The opposite was reported for S. gregaria where ovariectomy led to a precocious accumulation of PAF-stainable material in the PIC, the NCC I and the CC (Highnam, 1962a). The CA of Leucophaea maderae females display an impressive characteristic to respond to alteration of the internal milieu resulting from ovariectomy. In contrast, male castrates of Leucophaea maderae do not differ significantly from normal controls as to the volume and cytoplasmic content of their CA. This difference between the sexes in response to castration is undoubtedly related to the absence of a corpus allatum-gonad axis in male Leucophaea (Scharrer and Von Harnack, 1960, 1961).

Fragmentary information on the hormonal control of insect accessory glands is available since most studies have been concerned mainly with the primary reproductive organs. However, juvenile hormone appears to be involved in the differentiation and secretory activity of many of these glands (De Wilde and De Loof, 1973; Adiyodi and Adiyodi, 1975). The first demonstration on the control of accessory gland function by juvenile hormone was in R. prolixus (Wigglesworth, 1936) and this has been confirmed in other species including M. differentialis (Pfeiffer, 1936), female C. erythrocephala (Thomsen, 1952) and male S. gregaria (Loher, 1960; Highnam, 1962a; Cantacuzène, 1967). Szopa (1981a, b) showed that secretory activity of the accessory glands in adult female S. gregaria is under the control of juvenile hormone. Adiyodi and Adiyodi (1975) reported that the accessory glands in male P. americana become active under the
influence of juvenile hormone.

Because of the paucity of experimental data, the function of the accessory gland in male insects is least understood. The ARGs of male insects produce a number of proteins concerned with protection of gametes and their eventual transfer to the female (Guthrie and Tindall, 1968; Barker and Davey, 1981). In their studies on male P. americana, Jaiswal and Naidu (1976), reported the prime role of the secretions of CG in connection with fixing of the spermatothecae firmly in their right place i.e. within the female genital chamber so that the spermatozoa could migrate directly into the opening of the spermatheca. They further subscribed the idea that the spermatothecae were formed by the elaboration of both utriculi breviore and utriculi majores in the ejaculatory duct.

Effects of extirpation of female ARGs are studied in few insects (Leoplod and Degrugillier, 1973; Degrugillier and Leoplod, 1976; Degrugillier and Grosz, 1981). Recent studies have shown that secretions from the accessory glands of some diptera are important in sperm penetration of the egg during oviposition. Leoplod and Degrugillier (1973) showed that ARG ablated female Musca domestica are less than 1 percent fertile and in subsequent study (Degrugillier and Leoplod, 1976), it has been demonstrated that in glandless females spermatozoa are unable to penetrate the cap secretion that covers the micropyle. Rossignol et al. (1977) suggested that secretion from these glands would have a similar function in Aedes aegypti. Degrugillier and Grosz (1981) reported that the effects of female ARG removal on egg hatchability and sperm penetration of eggs in three dipteran species and also noted that the removal of ARGs altered the ovipositional behaviour.

It was Pflugfelder (1939) who first studied the effects of JH on the endocrine system of Dixippus where compensatory reduction in the size of CA occurred. Similar observations have been reported by Doane (1961) in Drosophila sp. and Ozeki (1961) in earwig
Anisolabis sp. Experimentation with crude CA extract and JH as such or its analogues reveals interesting findings. Nayar (1962) while working on Periplaneta americana has reported that injection of natural JH extracts completely inhibits release of NSM coupled with inactivity of the corpora allata despite initial enlargement. In their studies on the effects of two JHAs - farnesyl - methyl-ether (FME) and ZR-777 on the neuroendocrine system, Jacob and Prabhu (1979) noted functional derangement of the embryonic NS cells (clumping of NSM), prothoracic glands and CA (cellular enlargement) of Dysdercus cingulatus. Abou Halawa (1981) reported inhibitory effects of juvenoids on the development and differentiation of the neuroendocrine system of S. crassipalpis. Recently, Awasthi (1984) has shown that the JHA treatment to the last instar larvae of Philosamia ricini indicates a number of morphological abnormalities. Several other data in respect to effects of various JHAs on the pupal metamorphosis (Geyer et al., 1968a, b) on the epidermis and cuticle of Tenebrio molitor (Zlotkin and Levinson, 1969), on the ovarian development and oxygen consumption in allatectomized adult female Pyrrhocorrrhis (Slama, 1965), on the production of intermediates unable to reproduce or supernumerary nymphs in Dysdercus cingulatus (Babu and Slama, 1971) are there. The precise action of JHAs on the neuroendocrine system has not yet been established (Gordon and Burford, 1984). Unequivocally, Akai et al. (1971), however, found that the administration of JHA to the 5th instar larvae of B. mori increased the duration of the feeding instar and elevated RNA and fibroin synthesis. This has an implication for the production of weighty cocoons to increase the silk yield which otherwise involved in the process of neuroendocrine regulation. In their observations, Pener et al. (1972) studied the effects of JHA on the NS cells of the PIC and CA on the mating behaviour and colour change in adult L. migratoria. Metwally and Gelbic (1974) have reported that in the larvae Spodoptera littoralis juvenoid induces defective and degenerate sperm production. Yagi and Kuramochi (1976) in S. litura too, observed inhibition of spermatogenesis. Inhibitory effects on spermatogenesis induced by JH have been noticed...
in B. mori, both in vivo (Takeuchi, 1969) and in vitro (Yagi and Fukushima, 1975).

Considerable evidences now prove that phosphatases play important role in the physiological activities of the animals (Bautz and Lanot, 1976, 1981; Sujak, 1977; Nanda and Goswami, 1978; Tarafdar, 1988). Their role in insect development especially in relation to nutrition and egg maturation has been well established (Ludwig et al., 1962; Raychaudhuri and Butz, 1965a, b; Nath and Butler, 1971; Dhand and Rastogi, 1975). It was Moog (1946), who has hypothesized that acid phosphatase (AcP) plays an important role in sperm nourishment. In this context, Raychaudhuri and Butz (1965a, b) suggested that the production of sperm is accelerated with the peak activity of the AcP in contrast with the observation of Lambermont (1960) in Aedes aegypti reported a steady decline of AcP activity. Rousell (1971) reported that in M. domestica an increase in alkaline phosphatase (AIP) during the 1st week of adult life, which later followed by a steady decline until the 4th week. Earlier, Rockstein (1956), however, found a steady decline of AcP and AIP activity with advancing age.

Depending upon the species, allatectomy has a variety of effects on protein concentration of the haemolymph. Highnam et al. (1963) in Schistocerca and Adiyodi and Nayar (1966) in P. americana have reported that haemolymph protein level is enhanced following allatectomy. Vanderberg (1963) presented evidence to show that CA were involved in synthesis of protein as well as RNA. In contrast, Thomas and Nation (1966) have shown the fall of haemolymph protein concentration in P. americana female after allatectomization and they have also noted depressed protein synthesis from labelled amino acids in allatectomized females. Similar observations were made by several investigators (Pfeiffer, 1945; L' Hélias, 1953; Wigglesworth, 1954a; Engelmann and Penney, 1966; Pratt and Davey, 1972a). However, Pfeiffer (1945); L' Hélias (1953), Wigglesworth (1954a) and Thomas and Nation (1966) have opined that allatectomy does not interfere
with at least certain aspects of protein synthesis and metabolism. But after ovariectomy, the haemolymph volume and protein (Highnam, 1962b; Hill, 1962; Thomas and Nation, 1966; Strong, 1967; Mjeni and Morrison, 1973) as well as lipid concentration (Lee and Goldsworthy, 1976) are dramatically increased. Strong (1967) has reported that the changes in blood volume and protein concentration are, however, prevented if ovariectomized locusts are also allatectomized. According to Mwangi and Goldsworthy (1980), the concentration of total protein of the haemolymph in ovariectomized locusts was significantly higher than that of the control, but the haemolymph total protein concentrations in allatectomized and allatectomized-ovariectomized locusts were significantly lower.
The justification of the present investigation holds water as, notwithstanding the exhausted researches of the previous investigators concerning neuroendocrine identity of the cephalic nervous system, its relationship with the gonads as well as ARGs in other insect species, there still remains some lacunae in certain fields which deserve further probe. Accordingly, the following alternatives may arise:

1) Whether structure, nature and orientation of NS cell groups in the PIC region of P. americana are in conformity with the conventional method of staining or not?

2) Whether pars intercerebralis NS cells could be considered as a suitable region to feature the response brought about by several experimentations or not?

3) Whether or not extracerebral neuronal (CC) and non-neural (CA) endocrine glands register salient changes in the event of physiological stress like extirpation or treatment with analogues (JHA)?

4) Whether the anatomy and histology of the male reproductive system of the species under study has been probed thoroughly or not?

5) Whether electro-cauterization of the pars intercerebralis NS region provides evidence for ascertaining histologic changes in the adjoining NS cells of the brain, CC - CA complex, testis and ARGs or not?

6) Whether bilateral allatectomization renders correlated changes in the functioning of the cephalic NS system, testicular spermatogenetic cycle as well as in the rhythm of the accessory male reproductive glands or not?
7] Does testectomization cause stressful conditions to the ARGs and brain neurosecretory system?

8] Whether ablation of male ARGs reveal drastic changes in the pars intercerebralis NS cells, CC-CA complex and spermato-genetic cycle of the testis or not?

9] Whether exogenous application of JHA induces alterations in secretory cycle of the brain NS cells, storage and secretory properties of the corpora cardiaca, functional status of the corpus allatum, transformative abilities of the testicular follicles and histologic changes in the ARGs or not?

10] Whether removal of corpora allata tells upon reprometabolic dependent biochemical constituents (especially general protein and several metabolic enzymes) of the haemolymph or not?

11] Do these probes render any significant data for the maintenance of male reproductive system in P. americana in the light of neurohormonal mediation or not?