CHAPTER ONE

INTRODUCTION

The Chiroptera represents the second largest order of mammals in number of species and largest in overall abundance; excluding man and possibly rodents. They are also the most widely distributed land-based mammals. They are relatively inconspicuous only because they are active by night, hidden by day and wary of human contact. Their physiology of various organ systems, particularly from metabolic point of view has not received the attention rightly deserve from histochemists, biochemists and endocrinologists. Possibly these are the reasons they were not studied as vigorously as other mammals before the turn of the century.

Today our knowledge of Chiropetera has grown to sizable proportions. At present a voluminous data have accumulated on their evolution, karyology, taxonomy, zoogeography, migration, thermoregulation, audition, vision, olfaction and taste and biology of reproduction. Comparatively less attention was paid to the cutaneous glands and particularly true for the frontal gland in bats (Quay, 1970 a). Mainoya (1977) and Mainoya and Howell (1977) have reported on the histology of frontal sac gland in three species of Hipposiderid bats. Mainoya(1979) studied seasonal histological alterations in frontal sac gland of Persian leaf-nosed bat Triaenops persicus. Chandak and Nalavade (1980) and Chandak

et al. (1980 a) reported histological architecture of the frontal sac gland of Indian leaf-nosed bat, Hipposideros fulvus fulvus for the first time. Chandak (1981) reported occurence of frontal sac gland in Indian leaf-nosed bat Hipposideros speoris and gave detailed account on sex dimorphism, histology, seasonal variations in the histology, histochemical and biochemical variation in enzymes, lipids, mucosubstances and other metabolites and hormone dependency of the frontal sac gland. Therefore, it was thought desirable to study the histological variations and distribution of mucosubstances in the frontal sac gland. In the present investigation, the bats, H.fulvus fulvus were used since these are widely distributed in this region and possess frontal sac gland.

Histologically, the frontal sac glands are similar to the other skin glands having sebaceous and apocrine gland tubules. Comparatively much work has been done on skin glands of other mammals. There are several types of skin glands in mammals. These have been reported in 15 orders of mammals and classified into approximately 40 different types (Muller Schwarze, 1967). Some idea of the work done on these glands of the mammals will be obtained from the following brief review.

(I) Review of the literature on mammalian skin glands

The most of the skin glands have been studied for their histology, histochemistry, isolation of scent or pheromones, sex dimorphism, hormone dependency and functional physiological role played by the gland.

(A) Skin glands in Bats

A comparative account of diverse glandular areas in bats has been reviewed by Quay (1970 a). He reported that amongst 17 families of living chiropterans special glandular skin areas have been described in representative species of ten families only.

1) Frontal sac glands

Members of the family Hipposideridae and some of their relatives (Coelops and Anthrops) possess a peculiar median frontal sac behind leaf-nose (Quay, 1970 a). In those species where it occurs, the frontal sac gland varies in size from a prominent sac to inconspicuous papilla. This structure can apparently be everted at the will by the bat, may be adorned with special hair tuft centrally and skin lappets laterally and secrete a waxy or clean material. The account credits male with better developed frontal glandular organs than females, but at least in some species, Hipposideros langi and Coelops frithi, they are distinct in both sexes (Allen et al. 1917; Harrison, 1964).

Mainoya and Howell (1977) studied the histology of median frontal sac gland in three species of bats, H.commersoni, H. ruber and Triaenops persicus. They reported that in H.commersoni the gland was more prominent in males than in females and contained trilobed sebaceous gland associated with hair follicles and moderately enlarged saccular apocrine glands. The structure in H.ruber consisted entirely of coiled lobular type of apocrine gland in males. The females had only rudimentary gland without any sac. More complex glandular structure was found in T.persicus which consisted of superficial haired layer of sebaceous glands and saccular apocrine glands and deeper layer of enormously convoluted apocrine gland which was more active in males than females. Mainoya (1977) further studied the structure of frontal sac gland of H.ruber. The gland was found predominently of apocrine type with clumped apocrine cells at the periphery. Dark and light cells were observed in the apocrine tubules.

Among Indian bats Chandak and Nalavade (1980) and Chandak et al.(1980a) described predominantly apocrine type of frontal sac gland in male bat, H. fulvus fulvus, whereas the females had only rudimentary gland papilla without any sac. In males gland consisted mainly of apocrine sudoriferous glands.

The sac was lined by comparatively thin layer of skin containing sebaceous glands at the base of hairs. The lobules of the apocrine glands were abundant on ventral and lateral sides of the frontal sac. The apocrine gland tubules were lined by single layer of cuboidal epithelial cells. Chandak (1981) reported on histology of the frontal sac gland in H.speoris, wherein the gland consisted both of sebaceous and apocrine components. The frontal sac gland was found well developed in males, whereas the females possessed a rudimentary papilla and further showed that the glands exhibited seasonal alterations in histology during sex cycle of the bat and seasonal variations in various enzymes, mucosubstances and other metabolites.

Mainoya (1979) has reported on seasonal histological changes in the frontal sac gland of T.persicus, which can be very well corelated with the spermatogenic activity in tests indicating the possibility of androgenic control over the glands in males. The gonadal hormone dependency and the seasonal variations in the frontal sac gland of the bat, H.speoris have been indicated by Chandak (1981).

2) Facial glands :

Werner et al. (1950) reported on two types of glandular tissues in the face of the bat, Tadarida cynocephala viz. sebaceous and salivary. The former is found singly in association with small hairs and latter in clusters in association with larger hairs.

These are holocrine glands whose ducts open into the hair follicles. Dalquest and Werner (1954) studied the facial glands in 7 species of bats and reported that in members of the family Emballonuridae, Natalidae and Vespertilionidae possess sudoriferous glands in facial area. Bats belonging to the family Chilonycteridae have pairs of sebaceous glandular cells at the base of tiny hairs that are scattered over the chin leaf. In members of the phyllostomidae, the sebaceous cells are scattered over the leafnose, but in the members of the families Chilonycteridae, Phyllostomidae and Desmodontidae the sudoriferous glands are lacking in the facial area. Kulzer et al. (1985) studied skin glands in the face of the Egyption mouse tailed bat, Rhinopoma hardwickei. These glands consisted of holocrine, branched, alveolar sebaceous glands associated with hairs and sudoriferous apocrine sweat glands which are tubular and penetrate deeply into the subcutaneous tissue.

3) Gular gland

Gutierrez and Aoki (1973) studied the fine structure of gular glands of free tailed bat, Tadariada brasiliensis. The gular glands of this bat is a specialized sebaceous gland located in the skin of suprasternal region of adult males. This consists of aggregation of simple branched tubuloacinar gland units. Dapson et al. (1977) reported

gular glands in molossid bat, Molossus bondae, which consisted of both sebaceous and apocrine components. They further reported that the sebaceous secretion in both the bats contained fatty acids whereas the apocrine secretion from M. bondae exhibited PAS positive and sudonophilic reactions indicating the presence of carbohydrats and neutral lipids, perhaps glycolipids. Earlier Horst (1966) demonstrated PAS positive material in sebaceous cells of gular glands in M. rufus nigricans. The gular glands in species of Taphozous (Emballonuridae) show diversity. Some have well developed glands in adults of both sexes; others have only in males and rudimentary in females and some species entirely lack them (Dobson, 1873, 1878; Thomas, 1915, Brosset, 1962a, b; Rosevear, 1965; McKean and Price, 1967). In some species the gland is more active during breeding season (Brosset, 1962a).

4) Lip glands or Labial glands

The glands associated with integumentary side of the lips are skin glands. The dominant glandular component of this region is sebaceous in Vespertilionid and Phyllostomid bats (Werner and Dalquest, 1952; Dalguest et al., 1952; Dalguest and Werner, 1954) and sudoriferous in Emballonurids (Starck, 1958).

5) Pararhinal glands

Dapson et al. (1977) studied pararhynal glands of male big brown bat, Eptesicus fucus, which

consisted of sebaceous and apocrine portions. The former contained neutral lipids and cholesterol esters throughout. The apocrine portion contained saturated fatty acids, but tests for carbohydrates, proteins, phospholipids and cholesterol were negative.

6) Interdigital glands

Some bats possess special adhesive discs of thumb and soles. The adhesive discs of Thyroptera have been noted by many authors. Recently Wimsatt and Villa-R (1970) studied sudoriferous glands in adhesive discs on thumb and soles of the bat, Thyroptera tricolor.

7) Anal glands, para-anal glands & circum-anal glands

A median glandular pouch was described by Allen et al (??) just anterior to the anus in males of H. langi. Stubbe (1969) reported anal glands in bat, T. laticandata. The anal glands were sebaceous glands. The size of the gland varied in different species. Quay (1970b) studied histology of paired para-anal glandular organs of south Asian bat, Eonycteris spelaea. Each gland consisted of solid cords of cells budded from naked epidermis without association of hair follicles. Holocrine secretary activity and sebum like secretion was found in these glandular organs. Small circumanal rings of somewhat enlarged sebaceous and sudoriferous glands have been noted in few vespertilionids (Rauther, 1903; Schaffer, 1940).

8) Neck glandular skin patch

Mainoya and Howell (1979) examined histology of the neck glandular skin patch in 3 Pteropodid bat species, Eidolon helvum, Rousettus aegyptiacus and R. angolensis. In E.helvum the neck skin patch contains a large sebaceous gland complex, which is better developed and more active in males than in females. A comparable area in R. aegyptiacus contains rather non-specialized sebaceous gland alveoli in association with hair follicles and which are more active in male than in females in R.angolensis, in neither sex was the skin patch glandular. Hood and Smith (1984) described sexually dimorphic integumentary gland occuring in lower neck and upper chest, in the pteropodid bat, Macroglossus lagochilus. Histologically, the gland comprised of numerous hypertrophied tubular apocrine type glands which are restricted to males.

Besides above mentioned skin-glands some bat possess specialized skin glands. Scanty information is available on their structures. Allen et al. (1917) reported presence of dorsal glands in adult males of the bat, Lavia frons. Occurence of chin gland in bats have been reported in some Emballonurids (Brosset, 1962a). Starck (1958) reported chin gland and gular glands in Saccopteryx bilineats and these to be dominently sudoriferous although small sebaceous units are also present. Occurence

of modified glands of the usual sebaceous and sudoriferous categories have been reported in preputial area of bats (Rauther, 1903; Schaffer, 1940; Wimsatt and Kallen, 1952). A large glandular swelling between and infront of the eyes was noted by Miller (1907) in males of natalid bats. It was subsequently found in males of all members of Natalidae by Dalquest (1950), who named it 'natalid organ." It is apparently composed largely of glandular tubules probably of sudoriferous nature, of unknown function.

(B) Skin glands in other mammals

1) Preorbital glands and infraorbital glands

Pocock (1910) and Ansell (1969) gave an account of occurrence and gross morphology of the preorbital glands in wild-beest. Quay (1955) described histology and cytochemistry of preorbital pockets in Caribau rangifer. These glands were sebaceous and apocrine sudoriferous gland containing glycogen in apocrine glands. Quay and Muller-Schwarze (1970) described that preorbital sac in a deer Odocoileus hemionus columbianus is relatively non glandular and contains primarily sloughted epidermal cells and mucoid secretion. Mainoya (1976) demonstrated that the preorbital glands in wildbeest, Connochaets taurinus albojubatus consisted of holocrine sebaceous glands. Mainoya (1978) described both tubular apocrine and alveolar sebaceous glands in preorbital

glands of red duiker, Cephalophus natalensis. Barrette (1976) reported on well developed musculature for eversion of preorbital glands during scent making in muntjac, Manitiacus reevesi. Cohen and Gerneke (1976) reported that infraorbital glands in steenbok produced combined secretion of melanaceous branched alveolar sebaceous glands and enlarged apocrine sweat glands of unknown function.

2) Forehead gland

The forehead gland contains sebaceous and apocrine gland and undergo seasonal changes (Schumacher 1936). Recently Johnson and Leask (1977) reported that roe bucks, Caprelous caprelous have specialized skin on the forehead that produce secretion used in territorial marking. Atkeson and Marchinton(1982) studied forehead gland in white tailed deer, Odocoileus virginianus and showed presence of tubular apocrine sudoriferous glands. The glandular activity was very high in males during rut, which is consistent with the annual testosterone cycle.

3) Poll glands

Poll glands in camel (Leese, 1927, Purohit and Singh, 1958; Lee and Schmid - Nielsen, 1962) are enlarged tubulo-alveolar sudoriferous glands. Singh and Bharadwaj (1978) studied poll glands of Camelus dromedaris and reported that the glands are compound tubulo-alveolar modified sweat glands and glands increased with age. Their histochemical observations

revealed the presence of PAS positive mucopolysaccharides and alkaline phosphatase in the blebs of secretary cells.

4) Temporal glands

Africanl elephant, Loxodonta africana and Asiatic elephants, Elephas maximus possess temporal gland (Pockock, 1916). Scheneider (1956) and Fernando (1963) pointed out the gland is apocrime and tubulo-alveolar in both species of elephants. Short et al. (1967) showed lobular structure of temporal gland in African elephant, that produces a strong secretion-musth. Estes and Buss (1976) reported that the temporal glands are modified apocrine sweat glands and their secretory products contained acid mucopolysaccharides and lipids. Adam et al.(1978) also confirmed the apocrine nature of the temporal glands in African elephants.

5) Inguinal glands

In rabbit specialized apocrine glands occur in inguinal region (Buschke, 1933; Coujard, 1947; Montagna, 1950; Mykytowycz, 1966). Mykytowycz and Dudzinski (1966) consider that these glands serve mainly a sexual function and are androgen dependent. Androgen dependency of inguinal glands in rabbit was reported by Wales and Ebling (1971).

Inguinal glands in reedbuck, Redunca arundinum are blind hairless pockets (Claussen and Janguis, 1973). Their secretion is visible distinctly and of pungent odour. Recently Mainoya (1980) studied inguinal glands of the Thomson's gazelle, Gazella thomsoni, that consisted of superficial layer of sebaceous glands and a deeper-lying layer of apocrine glands which are well developed in males than females and the apocrine glands also appeared to be more active in males only.

6) Flank glands

Quay (1968) described the presence of enlarged and modified sebaceous glands in postero-lateral zone of the skin in microtine rodents. Balkrishnan and Alexander (1977) reported that flank glands in musk shrew, Suncus murinus viridescence becomes functional by 9th day after parturition and exhibit a secretary rhythm with a nocturnal peak. Balkrishnan et al. (1984) showed that castration effected a considerable atrophy of the secretary epithelial tissues of the flank glands in males with marked regression in their secretory output.

7) Supracaudal glands

These are scent glands located mid-dorsally to the caudal vertebrae in male and female Guinea-pigs (Price and Martan, 1961; Martan, 1962). Histologically they are aggregations of large crowded

sebaceous glands which open into their hair follicles. In female sebaceous acini are fewer and smaller. Albone and Flood (1976) studied histology of supracaudal gland of red fox, Vulpes vulpes. The glands consisted of tubular apocrine sweat glands and massively developed sebaceous glands.

8) Sternal glands

Dixon (1976) described sternal glands in male and female galago, Galgo crassicaudatus crassicaudatus containing many large sebaceous and apocrine glands. Mainoya and Urasa (1982)-Studied sternal glands in male greater bush-baby, G. crassicaudatus. Histologically, revealed presence of a few lobules of alveolar sebaceous glands and well developed layer of hypertrophied coiled apocrine tubules.

9) Dorsal glands

A single median dorsal gland consisting of sebaceous alveoli and apocrine glands composed of highly coiled tubules with large dilated lumina was reported in pronghorn by Moy (1971). Quay(1953) reported a specialized sebaceous dorsal gland of kangroo rat (Dipodomys) that follows a different patterns of activity in different species and that sexual and seasonal differences are present in some species and not in others.

10) Ventral Glands

Pearson (1946) described a single ventral gland formed by sebaceous units in short tailed shrews. The gland is odouriferous and scent marking and is well developed in both the sexes. Quay and Tomich (1963) described a mid-ventral cutaneous glandular area of sebaceous glands in Hawaiian rat, Rattus exulans. The sebaceous glands and proliferative activity are largest in adult males. Doty and Kard (1972) reported on midventral sebaceous glands in Peromyscus maniculatus. Thiessen et al. (1971 a,b) reported presence of ventral sebaceous scent glands in male and female gerbils, M.unguiculatus. Recently Saroj et al. (1981) studied histological structure of midventral gland in Indian desert gerbil, Meriones hurrianae. The gland is composed of enlarged sebaceous alveoli, of the typical holocrine type, each with its own duct. Males had larger glands than females. Saroj and Prakash (1983) reported on seasonal variations in the ventral scent marking gland of two gerbils, Tatera indica and M.hurrianes and a metad, Rattus meltada pallidior. Peaks in the gland size occur late in winter and monsoon which generally correspond to the maximum breeding activity of these rodents during the year. Idris and Prakash (1985) reported on testosterone propionate therapy on castration gerbils, T.indica. It revealed that - (castrated) reduces the frequency of scent marking and

hormone injections response was gradual and the peak scent marking activity was attained after 8 weeks.

11) Interdigital glands

Quay (1955) reported on interdigital glands in forefoot and hind foot of caribou, R.tarandus. These areas consisted of sebaceous and apocrine sudoriferous glands. Glycogen was identified in the apocrine cells. Seasonal variation in three ketones in the interdigital gland secretion were reported by Brudin and Anderson (1979) in R.tarandus. Interdigital glands consisting of both, sebaceous and sudoriferous apocrine components have been reported in white tailed deer, O.verginianus (Quay,1959); in mule deer, O.hemionus hemionus (Quay and Muller-Schwarze, 1971); in pronghorn (Moy, 1971); in O.hemionus columbianus (Quay and Muller-Schwarze, 1970); in wildbeest, C.taurinus (Mainoya, 1976) and in red duiker, C.natalensis (Mainoya, 1978).

12) Tarsal glands

Histological and histochemical studies on tarsal gland of R.trandus by Quay (1955) showed that the gland consisted of sebaceous and apocrine components and glycogen was reported in apocrine tubules. Tarsal glands in deer, O.virginianus (Quay, 1959); in one humped camel (Fahmy et al., 1971); in mule deer O.hemionus hemionus (Quay and Muller Schwarze,1971) in black tailed deer, O.hemionus columbianus (Quay and

Muller-Schwarze, 1970), histologically consists of sebaceous and sudoriferous components.

13) Metatarsal glands

These glands were reported in white tailed deer, O.verginaianus by Quay (1959) which consisted of a central glandless area and a bordering highly glandular area containing enlarged sebaceous and apocrine sudoriferous tubules. Quay and Muller - Schwarze (1970) reported similar observations in black tailed deer, O.hemionus columbianus. Kleiman (1974) reported on scuffing scent marking behaviour, males exhibited more and larger metatrsus scuffing than the females. Broom and Johnson (1980) studied metatarsal glands in C.capreolus. The gland odour cues are used in individual recognition.

14) Subauricular glands

The paired subauricular glands, found only in bucks, are located beneath the ears. It is elonagated dorsoventrally and appears externally as a dark patch surrounded by lighter hairs. Canton(1877) and Seton (1929) reported that this gland is associated with the mating behaviour. Moy (1970) showed that the gland of male pronghorn, A.americana ord, histologically consists of sebaceous glands and apocrine tubules with few clumps of cells in association with apocrine tubules. Single undivided extremely enlarged sebaceous gland was reported by Claussen and

Janguis (1973) in redbuck, R.aurindinum.

15) Perineal glands

These glands are present in mid-ventral area of scortum. Kleiman (1974) reported a large oval gland covered by paired hairy labia in binturong, Arctictis binturong. Stewart and Brooks (1976) reported on perineal gland in adult male brown lemmings, Lemmus trimucronatus. The gland consists of specialized pad of sebaceous glands and resemble, histologically, with rump gland. Wellington et al. (1979) analysed volatile components of secretion from perineal glands of wild and domestic male guinea pigs, Cavia aperea and C.porcellus.

16) Hip glands and glands at hind quarter

Quay (1968) described presence of enlarged modified sebaceous glands in posterolateral zone of skin in microtine rodents. Clarke and Frearson (1972) reported that the sexually matured male volves, M.agrestis, develop oily fur on the hindquarters. Skin of this region contains very greatly enlarged holocrine sebaceous glands found only in males and are androgen dependent. Sebaceous patches are more highly developed during the breeding period.

At a comparative level scanty data are available on other specialized skin glands and non specialized skin glands in body surface. The following is a brief resume of these glands.

The presence of musk gland is characteristic of the family Mustelidae and its secretion has sexual and individual characteristics. Iwase (1976) reported that secretion of the musk glands of Meles meles increases with growth and development. Miraglia and Dos-Santos (1971) described lip glands which consists of sebaceous alveoli. Quay (1962) studied coiled tubular apocrine sudoriterous glands in angulus oris of Microtine rodents. The glands were found to contain glycogen and pigments. Wilborn and Montes (1978) studied auxillary apocrine sweat glands of human by scanning electran microscopy and reported four types of modes of secretion : merocrine, apocrine, holocrine and microapocrine whereas Schamburg-Lever and Lever (1975) studied apocrine glands of human skin and reported only three modes of secretion : apocrine, merocrine and holocrine. Skin glands in nonhuman primates were studied by Montagna (1972) and reported presence of eccrine sweat glands on friction surfaces of all the species but only apes, the true prehensile tailed new world monkeys and old world monkeys have them also into the hairy Skin. Sweat glands from different areas of horse were studied by Sorensen and Prasad (1973). They reported PAS positive granules in the columner cells. The secretion was apocrine. Rumpler and Andriamiandra (1971) studied the histology of marking glands in Madagascan lemurs. The glands were found to contain sebaceous and /or sudoriferous holoapocrine glands.

Intermandibular glands consisting of sebaceus and apocrine glands were described by Cohen and Gerneke (1976) in steenbock, Raphicerus campestris. The Mongolian gerbil, Meriones unguiculatus possess a large chin or submandibular gland consisting of sebaceous gland complex (Thiessen et.al., 1970). Holt and Jones (1973) demonstrated light and dark cells in sebaceous acini in chin glands of cuis, Galea musteloides. Rump glands of modified enlarged sebaceous glands nature were reported by Quay (1968) in a microtine rodent (Lemmus) and in pronghorn, Antilocapra americana by Moy (1970). Caudal glands consisting of enlarged modified sebaceous glands occur in microtine rodent, Dicrostonyx (Quay, 1968). Muller-Schwarze et.al. (1977 a) studied histology of these glands in reindeer, R. tarandus. Lateral glands mainly composed of sweat and sebaceous components were described by Pearson (1946) in short tailed shrew in both sexes. Yohro and Kamia (1973) reported the lateral glands of big clawed shrew, Sorex unguiculatus consisted of three epidermal derivatives. Anal glands of sebaceous nature were reported in three species of microtine rodent by Harbe (1973).

II) Sexual dimorphism in specialized skin glands :

Although most of the specialized skin and scent marking glands described above are found in both the sexes, some of these glands exhibit sexual dimorphism in occurrence, histology and functional activity. Such glands are present and/or well developed in males as compared to the females.

In bats a number of skin glands show sexual dimorphism and seasonal variations in morphology and histology of these glands. Stubbe (1969) observed odour gland at throat region only in male bats, M. ater. Hall and Gordon (1982) reported on throat-pouch of the yellow bellied bat, T.flaviventris that there was no indication of throat-pouch in females. Male bats possessed throat-pouch with keratinized epithelium and sebaceous glands that produced neutral fatty substances. Quay (1970 b) observed larger para-anal glandular organs in male than in the female bats, E. spelaea. Mainoya and Howell (1979) studied histology of neck glandular skin patch in these Pteropodid bats. In E.helvum the patch is better developed and more active in males than in females. A comparable area in R. aegyptiacus containing non-specilised sebaceous gland alveoli which are more active in males and in R. angolensis, the skin patch is much longer and coarser in males. A sexually dimorphic skin gland in Pteropodid bat, M. lagochilus is restricted to males (Hood and Smith,1984).

Mainoya and Howell (1977) described sexual dimorphism in three species of hipposiderid bats. They reported that frontal sac gland is more prominent in males than in females in H. commersoni. The gland was found to be well developed in males of H. Ruber but was rudimentary in females. In third species, T. persicus, the complex gland was more active in males than females.

The frontal sac gland in two species of Indian Hipposiderid bats, H. fulvus fulvus (Chandak and Nalavade, 1980) and H. speoris (Chandak, 1981) shows sexual dimorphism. In both the species the gland is well developed and functionally active in males as compared to rudimentary and non-functional frontal papilla in females.

Subauricular glands are found only in the male pronghorn (Moy, 1970) and that the scent in pronghorn is produced by subauricular and dorsal glands, only by males (Muller-Schwarze and Muller-Schwarze, 1972). Clarke and Frearson (1972) reported that in sexually matured male volves, M. agrestis develop patches of bright pink skin on the hind quarters which emmit musky odour. Such patches are entirely absent in females.

Holt and Jones (1973) reported that the sebaceous acini in chin glands of cuis G. mustelloids are larger in males than the females. Singh and Bhardwaj (1978) found poll glands in male camel, but absence in she camel. Rumpler and Andriamiandra (1971) described sex dimorphism in marking glands of neck in lemur, Varecia Variegate. The neck glands were found to differentiate only in the males. Iwase (1976) found sex dimorphism in musk glands of M. meles. Prairie deermice P. maniculatus bairdii possess a mid-ventral sebaceous gland pad which is larger in males than in females (Richmond and Roslund, 1952). In mongolian gerbil, M. unguiculatus the males posses a gland about twice as larger than in the females (Thiessen, 1968; Thiessen et.al.,1970). Inguinal glands in male Thomson's gazelle, G. thomsoni, had more developed sebaceous glands

than females and the apocrine glands also appeared to be more active in the males than in the females (Mainoya, 1980). The ventral gland field in S.paradoxus froms extended unpaired ventral gland in males whereas females have a small gland (Starch and Poduschka, 1982). Forehead glands in white tailed deer, O. virginianus show moderate glandular activity in the rut, and very high in males which is consistent with the annual testosterone cycle (Atkeson and Marchinton, 1982).

III) Pheromones, Scent and/or some isolated and purified compounds :

A great deal of social behaviour in mammals is dependent on an intact olfactory system. (Bandler and Chi, 1972). It is becoming increasingly evident that a large share of mammalian social behaviour centres around the active deposition of organic chemicals or pheromones, chemical that integrate individual and population behaviours. Mykytowycz (1970) suggested that besides defensive materials, pheromones (or chemo-signals) have alarm, individual and group and recognition, sex attraction, trail marking, aggression and reproductive status recognition functions. Though pioneering work in this field has been done by Ruzicka (1926), comparatively little is known about mammalian pheromones or scent marking.

Stinson and Patterson (1972), reported that sweat glands distributed throughout the skin of male pig were found to contain sweat musk smelling Δ 16 androgen steroid, 3α-hydroxy-5α-androst-16-ene present in

submaxillary glands of the boar, as opposed to more pungent 3<-androst-16 ene-3 one in surrounding fat which is responsible for "boar taint" order. Both steroids are porcine pheromones, found only in males. Goodrich and Mykytowycz (1972) reported that secretions of chin, inguinal and anal glands of rabbit, O. cuniculus contained proteins and carbohydrates. Muller-Schwarze et.al. (1974) identified isovaleric acid in secretion of subauricular glands of male pronghorn and Thiessen et.al. (1974) identified phenylacetic acid as ventral scent marking pheromone in male Mongolian gerbil.

Nicholaides et.al. (1972) separated sterol esters from wax esters in the lipids of V.caseosa and adult human skin surface. Luedcke and Sens (1975) demonstrated unspecific cholinesterase in lumen of apocrine sweat glands and sebaceous glands of laboratory animals and man. Presence of dehydroepiandrosterone and androsterone sulfate in secretions of human apocrine axillary sweat glands was reported by Labows et.al.(1979).

Andersson et al.(1975) found saturated aldehydes and alcohols in tarsal glands of male and female reindeer. Muller-Schwarze (1976) described a pheromone, (z)-4-hydroxy-6-dodeceionic acid lactone in tarsal glands of the black tailed deer. Brudin et al. (1978) reported the presence of short chain acid fraction in the interdigital gland secretion of reindeer, R. tarandus, Further, Brudin and Andersson (1979) studied seasonal variation of 3 ketones in interdigital gland secretion of reindeer, R.tarandus. The variations are cyclic and reported from year to year.

Wellington et al. (1979) reported presence of fatty acids, alcohols and ketones in the perineal gland secretion of the wild and demestic pigs. Wheller et al. (1982) analysized temporal gland secretion of the African elephants and reported presence of five volatile components, P-cresol was present in all samples. Bakke and Figenschou (1983) studied volatile compounds of tail gland secretion from red deer C. elaphas. The major volatile organic compounds secretad by the tail gland were identified as phenol, m-cresol, cyclohexanecarboxylic acid, benzoic acid, phenylacetic acid, ethylphenol, dimethyl sulfane, O-Cresol and 3 phenylpropanoic acid. Several volatile compound have been reported but not yet identified from other skin glands and there is no work on frontal sac gland of the bats.

IV) Seasonal variations in skin glands :

Seasonal variations in accordance to the breeding cycle occur in different types of specialized skin glands. Seasonal variations in size and activity have been studied in few glands only.

Seasonal variations in secretions of preorbital gland of reindeer were reported by Andersson (1979). Stoddart (1972) reported lateral scent organs in male A.terrestris undergoing cyclic activity with a peak in the secretory activity following the peak of testicular weight. Moy (1970) reported annual proliferation and regression of subamricular glands of male pronghorn followed cyclic changes in testes. In camel Singh

and Bhardwaj (1978) reported on poll glands in male. In rut, poll gland produced coloured and pungent secretion and the tubules and alveoli were lined by high cuboidal cells with apical blebs. In non breeding period the secretion was scanty and epithelium varied from simple to squamous to low cuboidal. Saroj and Prakash (1983) reported similr histological changes in scent marking gland of three desert rodents. In similar studies cyclic variations in histology and amount of secretions have been reported in anal glands of rabbit (Hesterman and Mykytowycz, 1968), dorsal gland of pronghorn (Moy, 1971), perineal glands and anal sacs of G. genetta (Souloumiac and canivenc, 1976) and forehead gland in roebuck, C. caprolus (Johnson and Leask, 1977).

Gutierrez and Aoki (1973) studied gular glands in male bats, T. brasiliensis. The gland consisted of tubuloacinar units, the number of which varied seasonally. Mainoya (1979) reported on seasonal variations and probable androgenic control over the frontal sac gland of the bat, T. persicus. Chandak et al.(1980 b) demonstrated histological and histochemical variations in non-specitic esterases. The study revealed that not only the histological structure but the enzymes in the frontal sac gland are androgen dependent. Chandak (1981) studied frontal sac gland of the Indian leaf-nosed bat, H. speoris. The gland undergoes seasonal variations in size, histology and different metabolites and these

variations are correlated with the changes in spermatogenic activity in testes, indicating androgenic control over the gland.

V) Hormonal control on specialized Skin glands :

Most of the information on gonadal dependency of the specialized skin glands is based on castration and hormone replacement experiments which in some cases prove that the glands are dependent on testicular homones in males and some of the glands in females are dependents on estrogens.

Dryden and Conaway (1967) reported that bilateral castration in S. murinus caused sweat gland atrophy and cessation of musk production. Testosterone or estradiol implants caused sweat gland recovery and the resumption of odour production in castrates of both sexes, as did progesterone in males. (Moy (1970) reported that the subauriculr glands in castrates are smaller and inactive as compared to normal glands. Clarke and Frearson (1972) demonstrated role of testis and androgen in maintainance and development of sebaceous glands on hindquarters of vole. Stoddart (1972) showed that bilateral castration in male A. terrestris caused involution of lateral scent organ which were reconstituted by testosterone administration. Singh and Bhardwaj (1978) reported regression of the poll glands in male camel following castration.

Evidence that apocrine glands are androgen-dependent has been obtained for the chin glands, inguinal gland and anal gland of wild rabbits, which are larger in males than females, reduced [illegible] and restored

by testosterone treatment (Mykytowycz and Goodrich, 1974).

Androgen dependency of ventral glands and control of scent marking has been reported in Mongolian gerbil (Glenn and Gray, 1965; Lindzey et al., 1968; Thiessen, 1968; Blum, 1970; Thiessen and Yahr, 1970; Whitsett; 1970; Thiessen et al., 1971 a, 1973; Sales and Bergerot-Bloudel, 1975) and in P. maniculatus (Doty and Kard, 1972). Further White and Thiessen (1972) reported that gonadectomy did not lead to decrease in marking by ventral glands in female gerbils. Blum et al. (1971) demonstrated disappearance of ventral glands in male deermouse following castration and the gland was androgen dependent.

Balkrishnan and Alexander (1976) reported that castration reduced scent marking and methyl testosterone and ethinylestradiol reactivated scent marking in castrated male shrews. Androgen dependency of flank glands in male musk shrews was demonstrated by Balkrishnan and Alexander (1977). Balkrishanan et al. (1984) showed that castration effected considerable atrophy of the secretory epithelium of flank, oral lip and perineal glands with marked regression in their secretary output. Progesterone administration reactivated all these glands and scent marking frequency in male shrews. Similar observations are reported by Idris and Prakash (1985) in Indian desert gerbil.

In addition to the gonadal hormones, in some cases the hormones of other endocrine glands have been shown to influence skin glands. Thody and Shuster (1970)

reported that the rate of sebum secretion was less in castrated male rats and was progressively less in adrenalectomized-castrated and thyroidectomized-castrated rats. Further, Thody and Shuster (1972) showed that thyroidectomy of intact and castrated rats reduced the rate of sebum production, whereas thyroxin treatment increased the rate in castrated thyroidectomized rats. These studies indicate that the sebaceous glands are influenced by pituitary glands through thyroid, adrenals and gonads.

Mainoya (1979) indicated possibility of androgenic control on frontal sac gland of T. persicus. Chandak (1981) reported that the frontal sac gland of H. speoris under goes seasonal variations in accordance to the annual testicular cycle that suggested androgen dependency of the gland.

VI) Functions of specialized skin glands :

The mammals are equipped with odour producing skin glands. The scent produced by skin glands may closely linked with sex and other behavioural situations. Ewy (1973) reported that the odouriferous substances excreted by skin glands play a major role in animal biocommunication.

Individual recognition has been suggested to be the function of interdigital glands in deer (Quay,1959). In this studies on tarsal and metatarsal glands of black tailed deer, Muller-Schwarze (1971) suggested that trasal glands were found important as pheromones producing for sex, age and individual recognition and the metatarsal gland discharged scent in fear inducing situations.

Species identification as a role for tarsal glands in black tailed and white tailed deer was suggested by Muller-Schwarze (1975). Broom and Johnson (1980) reported that the function of metatarsal glands in roe deer concerned with individual recognition and the secretions of fore-head gland were important as a mean for warning and repelling intruders in a territory.

Territorial marking and sexual segregation during breeding seasons in short tailed shrews, were the functions assigned to the secretions of ventral gland by Pearson (1946). Similar function has been suggested for ventral gland in gerbil by Thiessen et al. (1970,1971 a, b, 1973). Quay and Tomich (1963) suggested olfactory communication role to mid ventral gland in rat, R.exulans. Recently August (1978) reported that ventral gland odour cues are likely used in sex-recognition during breeding season.

Odours from subauricular glands in pronghorn may serve for sex recognition, stimulation and territorial marking (Moy,1970; Muller-Schwarze et al., 1974). Gorman et al. (1974) and Gorman (1976) described mechanism for individual recognition and social communication for anal secretions in H.auropunctatus. Steiner (1974) reported that apocrine glands at the mouth corner in squirrels are probably involved in individual, group and mother offspring recognition and territoriality.

Secretions from preorbital glands are considered to play a role in individual recognition and territorial marking in G. gazella (Estes,1967) and in wildbeest (Mainoya, 1976). Volkman et al. (1978) reported that

secretions from antorbital and forehead glands in black tailed deer play a role in age and class recognition. Intermandibular glands in steenbok are used in territorial marking and marking females during mating (Cohen and Gerneke, 1976). Secretions from temporal glands of male elephants may possibly function as identifiers in indicators of sex and age (Estes, 1971) and that chemical individuality in cholesterol level in temporal gland secretions may serve a pheromone for identification of members of other groups (Buss et al., 1976).

According to Comfort (1971) human odours might yield some very valuable results for likelyhood of human pheromones. Mykytowycz (1972) described occurence of behavioural functions of skin glands in mammals including man.

Hall and Gordon (1982) reported that the individuals of both sexes in bat, T.flaviventris may use the throat area during [illegible] territorial makring. Mainoya and Howell (1977) considered the role of frontal sac gland in mediation of behavioral and physiolofical responses related to reproduction. Mainoya (1977) suggested that the activity of the frontal sac gland in H. ruber is seasonal and that it is related to the breeding behaviour. Chandak (1981) reported that the frontal sac gland in males of H. speoris may be involved in sex recognition, individual recognition and territorial marking.

VII) Critical analysis of the literature and reasons that stimulated the undertaking of the present investigation

(1) Most of the work at histological, histochemical and biochemical levels has been carried out on skin glands on body surface but comparatively less attention has been paid to specialized skin glands in mammals (Quay, 1970 a; Straus and Ebling, 1970; Thiessen and Rice, 1976; Johnson, 1977). At present some histological information on frontal sac gland is available on three species of African bats (Mainoya and Howell, 1977) and two species of Indian leaf-nosed bats (Chandak et al., 1980 a; Chandak and Nalavade, 1980; Chandak, 1981).

(2) The available literature on specialized skin glands show that some of the glands exhibit sexual dimorphism being well developed and more active in males. Such a sex dimorphism is well established among African bats by Mainoya and Howell (1977) and Chandak and Nalvade (1980) and Chandak (1981) in Indian Hipposiderid bats.

(3) Some information is available for isolated and purified componets from glands and/or secretion of other glands. Scent substances or pheromones have been isolated and purified from different scent glands. At present pheromones or scent marking, substance/s have not been isolated from frontal sac gland of bats.

(4) There is scanty literature on enzymes, lipids, proteins and carbohydrates present in skin glands. Moreover, the lipids and their components have been analyzed by gas chromatography and mass spectroscopy from some skin glands. Chandak (1981) reported on occurence of enzymes, mucopolysaccharides, proteins, lipids and other metabolites and seasonal alterations in them in frontal sac gland of H. speoris.

(5) At present adequate information is available to show the steroid hormone dependency of the different seent glands. There is scanty literature to show that pituitary gland also influences sebaceous glands through thyroid and adrenal as well as through gonads. Androgen dependency of frontal sac gland has been reported in bats.

(6) In some cases definite functions such as sex attraction, individual or group recognition, tereitorial marking, mother-offspring recognition, identification of age group of individual etc. have been suggested for different glands and some of them have been confirmed by applying synthetic and isolated compounds. Mainoya and Howell (1977) opined on the role of frontal sac gland in bats in relation to reproduction, territorial behaviour and individual recognition. Chandak (1981) assigned individual recognition and territorialism functions to frontal sac glands in H. speoris.

Thus the present study aims :

1) To find out seasonal histological alterations, if any, in frontal sac gland in the bat, H. fulvus fulvus.

2) to find out localization of mucosubstances.

3) to find our seasonal alterations (qualitative) if any, in carbohydrates in frontal sac gland of the bats according to the different phases of the sex cycle.

4) To find out relationship in seasonal variations in histology and mucosubstances in accordance to the testicular changes in annual breeding cycle and possibility of hormonal control.

5) To suggest some functional significance of frontal sac gland based on some circumstantial evidences.

VIII) Plan of Proposed Research :

Keeping in view the aforementioned points of interest and information on frontal sac gland of the bats, it was decided to investigate the histological variations if any, localization and seasonal alterations, if any, in mucosubstances in frontal sac gland of H. fulvus fulvus. Such an investigation was also thought to give some information on gonadal hormone influences over the frontal sac gland, since seasonal changes depend on gonadal hormones.

(A) Choice of the Animal :

While selecting the animal thr following points were kept in mind.

1) They show a clear reproductive cycle involving a period of sexual quiescence, a prebreeding period of

gametogenesis, a breeding period and a postbreeding period involving gonadal regression and hypotrophy of accessory & reproductive organs.

2) Their testes, ovaries and non-gonadal sex accessories undergo clear histological alterations.

3) Some information of their sex-cycle and hormonal variations therein is available.

4) Their availability in required number (both male and females) throughout the period of annual breeding cycle.

Keeping in view these requirements, H.fulvus fulvus was found suitable for this type of investigation. Some of the information about their locality, colonies, number of individuals in a colony and sex cycle will be given in chapter II on Material and Methods.

(B) Choice of Techniques :

Histology and histological alterations in frontal sac gland of the bats were studied in Haematoxylin-Eosin (H-E) stained preparations. Histochemical staining techniques were employed for localization of mucosubstances in frontal sac gland of the bats.

(C) Critical Evaluation of the observations :

It was decided to analyze critically the observations made on frontal sac gland in bats, H. fulvus fulvus during their sex cycle in relation to :

1) The histological alterations in frontal sac gland according to the different periods of the sex cycle of the bats.

2) The localization of mucosubstances in various histological sites of the frontal sac gland of the bats.

3) The cyclic histochemical variations in mucosubstances in various histological sites of the frontal sac gland of the bats.

4) To compare the observations in the present investigation and the existing literature on frontal sac gland or other skin glands.

5) To project some ideas about the probable gonadal hormone influence on various metabolites in frontal sac gland of the bats during their breeding cycle.

Finally to project ideas about the functional significance of frontal sac gland in the biology of the bats.

IX) Presentation of the dissertation :

It was decided to divide the present dissertation into four chapters, the first chapter being on the introduction which gives information on various types of specialized skin glands their histology and the existing literature on these glands, sexual dimorphism of the skin glands, some isolated components, pheromones and scent material in skin glands, seasonal variations in skin glands, effect of hormones on skin glands, functional role of skin glands, reasons that stimulated to undertake the present investigation and plan of the proposed research work. The second chapter deals with the material and methods employed in the present investigation. Chapter III outlines the observations on frontal sac gland which mainly concern with the histological

variations and localization and seasonal alterations in mucosubstances. The fourth chapter is devoted to the discussion on present observation in relation to histology, histological alterations and seasonal alterations in mucosubstances, if any, which are duly compared with the existing literature. The last chapter will be followed by summary and concluding remarks. A complete bibiography of the literature cited in the dessertation will be given at the end of the dessertation.