discussion

CHAPTER FOUR

D I S C U S S I O N

DISCUSSION ON HISTOLOGY AND HISTOCHEMISTRY OF MUCOSUBSTANCES IN -

A. OESOPHAGUS

B. PROVENTRICULUS

C. GIZZARD

D. DUODENUM

E. SMALL INTESTINE (ILEUM)

F. LARGE INTESTINE OF A. PHOENICURUS PHOENICURUS.

Among the submammalian groups, class Aves has been subjected to point out different aspects concerning mucosubstances in the alimentary tract. The present dissertation deals with the mucosubstances existing in the various strata from mucosa (innermost) to serosa (outermost) in the oesophagus, proventriculus (cardiac stomach), gizzard (pyloric stomach), duodenum, small and large intestine of male and female A.phenicurus phoenicurus. Jadhav (1985) and Malvadkar (1985) tried to point out sexual dimorphism, species differences, relationship of feeding habit and mucosubstances in their respective dissertations. Author has selected omnivorous bird to point out the relationship of food with mucosubstances in the digestive tract of A.phoenicurus phoenicurus. The existing literature on mucosubstances in the alimentary tract of several vertebrates has already been summarised in the chapter one of the present dissertation. Hence to avoid voluminous discussion, only literature on mucins in the avian alimentary tract is considered here. Jadhav (1985) investigated location, characterisation and chemical nature of mucins in the alimentary tracts of 2 birds, one carnivorous (king fisher) and another frugivorous (parrot), Malvadkar (1985) subjected one more carnivorous bird viz. pond heron to study mucins in its alimentary tract. Much literature is available concerning mucins in alimentary tract of several vertebrates right from pisces to mammals. To make the present chapter concise, another has concentrated on the results obtained in his present investigation (mucins in the alimentary tract of waterhen) and

existing literature on mucins in the avian alimentary tract.

The discussion here involves five aspects for each organ, viz. Histology, Histochemical reactivities, distribution of mucosubstances, sexual dimorphism if any, and functional significance.

A) OESOPHAGUS -

In waterhen, oesophagus is muscular, slightly thicker extensible elongated tube that conveys food material from pharynx to proventriculus.

1) HISTOLOGY :

In contracted condition, the tube appeared narrow, and hence the lumen, also appeared narrow. In fixed condition, epithelial lining and its underlying layers became strongly folded. As usual, it had 4 tunics viz. mucosa, submucosa, muscularis and adventitia. Mucosa exhibited thick stratified squamosal epithelial cells and mucosal glands. Submucosa was predominant. Keratinisation was not observed.

Warner et al. (1967) demonstrated alveolar mucus glands in the oesophagial mucosa in Japanese quill. Feder (1972) used light and electron microscopy techniques to study mucosal glands in several birds. Magon and Mohan (1976) pointed out cornification of mucosa in the oesophagus of Passer and Corvus. Trimorphic muscularis in oesophagus of O.cruris and I.major was demonstrated by Hanke (1957). Malvadkar (1985) reported no atypical aspect as such in oesophagus of pond heron. Jadhav

(1985) reported high degree of cornification in mucosa in parrot than in kingfisher. He demonstrated broad longitudinal folds in the mucosa in both the birds, but mucosal gland were demonstrated only in oesophagus of kingfisher and found to be absent in oesophagus of parrot.

2) HISTOCHEMISTRY :

The histochemical reactivities indicated glycogen, neutral, sulfo and carboxy-mucins singly or in combinations in the different histological sites in the oesophagus of waterhen. However atypical mucosubstance was not demonstrated.

3) DISTRIBUTION OF MUCOSUBSTANCES (AVIAN ALIMENTARY TRACT ACCOUNT).

The stratified epithelium in the oesophagus of waterhen exhibited only glycogen while mucosal glands showed existance of neutral, sulfo and carboxy-mucins therein. In pond heron, the same distribution was reported (Malvadkar 1985). In king-fisher and parrot, the stratified epithelium showed only glycogen while mucosal glands in the oesophagus of kingfisher (in parrot, glands were absent) exhibited poor quantities of neutral, sulfo and carboxy-mucins (Jadhav, 1985). Concerning mucosal mucins in oesophagus of tother birds, earlier Bradfield (1951) reported presence of glycogen in oesophagus of chicken exhibiting poor keratinisation. He further showed an inverse relationship between amount of glycogen in the epithelial cells and the degree of keratinisation i.e. keratinisation is

inversely proportional to glycogen amount. Grossi and Millo (1967) demonstrated acidic mucins (predominantly carboxymucins) in the mucosal glands of oesophagus in some birds. Allenspach and Berlin (1971) supported Grossi and Millos' results. Van Alten and Fennel (1957) demonstrated only sulfomucins in the oesophegial glands of a few birds especially during histogenesis. Rangel et al. (1970) showed neutral muco-polysaccharides, sulfated, nonsulfated polysaccherides in the oesophageal glands of the fowl (G.gallus).

In the submucosal connective tissue, in the oesophagus of waterhen only neutral mucins were demonstrated. Presence of hyaluronic acid was demonstrated in the submucosal layer of oesophagus in some birds by Meyer (1947), Wislocki et al.(1947), Duran-Reynals (1958), Jackson (1964), Nalavade (1975) and Gaikwad (1981). However hyaluronic acid was found to be lacking in submucosal layer in oesophagus of waterhen. Jadhav (1985) reported neutral mucins + hyaluronic acid in the submucosa in the oesophagus of parrot and kingfisher.

Tunica muscularis in the oesophagus of waterhen contained only glycogen. Nalavade and Varute (1973); Nalavade (1975); Gaikwad (1981) reported the same in the oesophagus of submammalian groups of animals. Malvadkar (1985); Jadhav(1985) reported presence of glycogen in muscles in pond heron, parrot and kingfisher respectively. The importance of glycogen as energy source for contraction-relaxation of the muscularis has been well established (Parnas and Waghner, 1914; Meier and

Meyerhof, 1924). The muscularis in other organs of alimentary tract also contains glycogen.

The tunica adventitia in oesophagus of waterhen exhibited poor quantities of neutral mucosubstances.

4) SEXUAL DIMORPHISM :

Identical histological and histochemical results were obtained both in male and female waterhens. Thus it was concluded that there was no sexual dimorphism among mucosubstance in the oesophagus of both the sexes.

5) FUNCTIONAL SIGNIFICANCE :

The present research work does not add an additional information on this aspect. But on the basis of available literature and experimental work done to point out functions of oesophageal mucins, it could be concluded that mucin in oesophagus of waterhen might be playing the same role as a lubricant. Nalavade and Varute (1973) suggested role of mucin as a lubricant making deglutition of food easy and quick (especially of prey). Lison (1960), Goudsmit (1972) demonstrated lubricant role of sulfomucins. Guyton (1964) suggested protective role of mucins. The gastric juice with HCl from stomach may have adverse effect on oesophageal mucosa, but mucin covers it and thus mucins perform protective role. The acidic mucosubstance were demonstrated to be having protective role in oesophagus of man (Kathleen et al., 1977; Logen et al., 1977). So to summarise, mucin in oesophagial tissues have two

roles viz. lubrication and protection. The same functions are applicable to mucins in oesophagus of waterhen. This is the only suggestion which could further be studied and confirmed by some additional experimental investigations. With regards to the feeding habit, on the basis of existing literature and work done on avian alimentary canal it can be said that carnivorous birds like kingfisher (Jadhav, 1985) and pon heron (Malvadkar, 1985) possess mucosal glands in oesophagus which contain elaborate mixture of neutral + sulfo + carboxymucins. The author also recorded the same histological and histochemical observation in waterhen. However frugivorous bird like parrot lacks any glands in its oesophagus (Jadhav, 1985).

Another difference pointed out by Jadhav (1985) was that submucosa in oesophagus in parrot contained a mixture of neutral mucins + hyaluronic acid, while the same layer in oesophagus of carnivorous birds like kingfisher (Jadhav 1985) and pond heron (Malvadkar, 1985) contained only neutral mucins. However in omnivorous bird, waterhen (present investigation), the oesophagial submucosa showed only neutral mucins and no hyaluronic acid. So whether these two aspects (existance of mucosal glands, and presence of hyaluronic acid in submucosa in oesophagus) depend on the feeding habit of the bird or whether it is merely a species diversity should be confirmed by studying more number of carnivorous, frugivorous and omnivorous birds. But one thing can be said with certainity that mucosubstances in oesophagus have a role of lubricant making deglutition of food (especially prey) easy and quick.

STOMACH :

Among the vertebrate series, with exception of ruminant mammels, it is the group Aves which exhibits great variation and modification in the stomach as far as morphology, anatomy and to some extent physiology is considered. The avian stomach is a dual structure viz. proximal thin walled, glandular proventriculus or cardiac stomach and distal highly muscular gizzard a pyloric stomach (Patt and Patt, 1969). Magon and Mohan (1976) also reported the same nature in passer and crovus. Malvadkar (1985) and Jadhav (1985) reported the same dimorphic structure in pond heron, kingfisher and parrot. A.phoenicurus phoenicurus was no exception to this. A small pyloric bulb was located behind the gizzard. Functionally, proventriculus is meant for food storage, protein digestion, HCl secretion and possibly fat break down (Patt and Patt, 1969) while ventriculus or gizzard acts as a grinding mill (tooth replacer).

B) PROVENTRICULUS :

1) HISTOLOGY :

In waterhen, it exhibited usual four tunics as in oesophagus. However tunica muscularis was slightly thinner than in oesophagus and submucosa was indistinct and scanty. Mucosal stratum exhibited elaborated structure with numerous folds forming gastric pits and epithelial lining consisted of only one type of cells viz. goblet. Mucosal glands were tubulo alveolar type and extended into submucosal layer. The

glands exhibited ducts opening at the base of gastric pits. The ducts exhibited lining cells in the form of mucus neck cells. The remaining cells in glands were equivalent to oxyntic cells of mammals. Probably secreting HCl (Patt and Patt, 1969; Jain, 1976).

2) HISTOCHEMISTRY :

At various sites like surface epithelium, glandular epithelium, duct cells, and usual 3 coats like submucosa, muscularis and serosa, presence of neutral + sulfo + sialo-mucins and glycogen either singly or in different combination was conformed. Atypical mucosubstances was not observed.

3) DISTRIBUTION OF MUCOSUBSTANCES :

It was observed that avian proventricular mucosubstances and those in proventriculus of waterhen were almost identical. Lippa (1959) demonstrated hyaluronidase resistant acid polysaccharide - protein complex in gastric glandular epithelium in embryonic chick. Mogil'naya et al. (1978) observed the presence of neutral polysaccharides, sulfo and sialo-saccharides in gastric epithelium of some birds. Mogil'naya and Bogatyr (1983) reported neutral glycoproteins, sulfo and sialo-glycoproteins in gastric epithelial lining of a few birds. Migicovsky (1961) indicated presence of sulfomucins in the cells lining the glands and ducts in proventriculus. Belanger and Migicovsky (1961) demonstrated incorporation of radiosulfate in superficial gland and duct cells in proventriculus of chick, indicating presence

of sulfomucins in these sites. Patt and Patt (1969) suggested that glandular epithelial cells except cells in the ducts are analogous to pepsin and HCl secreting cells of mammalian stomach, secondly these cells show poor quantities of neutral mucins (in sub-mammalian groups, these cells remain unstained). Jain (1976) studied histomorphology and physiology of oxyntico-peptic cells in the proventriculi of three species of birds. Malvadkar (1985) showed presence of neutral mucosubstances (poor quantities), sulfo and sialomucins in the surface goblet cells in the proventriculus in pond heron. He observed predominant quantities of sulfomucins in the cells lining the ducts of glandular proventriculus. Jadhav (1985) reported identical mucosubstances in the proventriculi of parrot and kingfisher as in pond heron.

4) SEXUAL DIMORPHISM :

Histological and histochemical results obtained were identical in both the sexes in waterhen, hence sexual dimorphism was not observed. The existing literature also shows absence of sexual dimorphism in mucosubstances in proventriculi of other vertebrates.

5) FUNCTIONAL SIGNIFICANCE :

Contribution of various workers has thrown some light on the possible role of mucosubstances in proventriculus. But more work for confirmation is needed to determine exact function of mucins in proventriculus.

Moneaux (1935) reported that mucins absorb acidity and hence provides optimum pH. Hence it was concluded that, the mucins in the proventriculus of waterhen may be acting as a buffer preventing action of HCl on gastric mucosa. They may also act as lubricants. However, this is merely suggestion and more work to confirm the functional aspect is needed. Kent (1971) suggested that mucins, being slimy, might be playing a role of lubricant and possibly they prevent dehydration of tissue cells. Other workers like Komarov (1936), Leveyr, Sheinfeld (1954), Lambret et al. (1968), Martin et al. (1968), Milluhi and Hotta (1979) suggested that secreted mucins form a protective sheath on mucosal layer and thus they protect the tissues from action of digestive enzymes and HCl. Mogil'naya et al. (1978) stated that mucin acts as a barrier allowing transportation of various substances.

C) GIZZARD (Ventriculus) :

In waterhen, similar to other birds, it is highly muscular organ acting as a tooth-replacer. In addition to its grinding role, it has a role in storage and to some extent in protein digestion also (Patt and Patt, 1969). Magon and Mohan (1976) described gizzard as a posterior chamber of the stomach in passer and corvus, containing grits or small stones which aid in mechanical break down of food stuffs.

1) HISTOLOGY :

Gizzard of waterhen was moderate in size but distinctly muscular as compared to muscular nature of whole remaining

alimentary tract. Same nature has been reported in pond heron (Malvadkar, 1985) and in kingfisher, parrot (Jadhav, 1985), corvus and passer (Magon and Moha, 1976).

In waterhen, gizzard showed usual 4 tunics, with mucosa having much folded crypts, surface epithelium with only goblet cells and tubular glands. The distinct peculiarity was presence of non-cellular innermost lining called 'koilin'. Magon and Mohan (1976) reported deep amber coloured 'koilin' in corvus showing prominent grooves and ridges while in passer. 'Koilin' appears dark greenish yellow also with grooves and ridges. Patt and Patt (1969) studied structural aspects of 'koilin' under ultramicroscope. They showed that 'koilin' consists of horizontal laminated structure with clear perpendicular striations containing debris and bile pigments. 'Koilin' is formed due to secretary activity of glandular epithelium of mucosa. Aswamy [illegible] (1976) demonstrated four zones in the 'koilin' layer in the gizzard of P.philiippensis viz. outermost hardest containing quinone, second harder zone with tanning, third zone with S-S bonds and innermost fourth zone with collegenous protein. Jadhav (1985) showed that Koilin layer was broader in parrot than in kingfisher.

2) HISTOCHEMISTRY :

Histochemically, different mucosubstances in different sites from mucosa (innermost) to serosa (outermost) in the ventriculus of waterhen were as usual and atypical mucosubstance was not seen. Mucosubstances present comprised neutral,

sulfom sialomucins and glycogen.

3) DISTRIBUTION OF MUCOSUBSTANCES :

The histochemical results obtained in the bird under study indicated sulfomucins (predominant) and sialomucins (poor quantities) in the surface goblet cells and crypt cells, neutral mucins in the glandular epithelium, submucosa and serosa while muscular coat as usual contained glycogen.

Existing literature on ventricular mucosubstances is scanty. Mogil'naya and Bogatyr (1977, 1983) demonstrated presence of neutral carbohydrates, sulfosaccharides and sialosaccharides in avian gizzard. Belanger and Migicovsky (1961) demonstrated sulfomucins in the superficial portion of gastric glands and cuticle in chick. Aswamy (1976) used electrophoresis and chromatography techniques to demonstrate four kinds of proteins with different amino acid sequences and glucosamine, glucose and fructose in the gizzard lining. Malvadkar (1985) reported identical mucosubstances in gizzard of pond heron so also in parrot and kingfisher (Jadhav, 1985). Thus available data is in good agreement with the results obtained in the bird under investigation.

4) SEXUAL DIMORPHISM :

It was not observed in mucosubstances in the gizzards of male and female waterhens, since histological and histochemical aspects were identical in both the sexes.

5) FUNCTIONAL SIGNIFICANCE :

At a gross level, it appears that neutral mucosubstances are quantitatively more in gizzard of waterhen, so it may be suggested that they may act as buffer against the proventriculer chyme containing digestive enzymes and HCl. Mogil'naya et al. (1978) proved that mucins (especially neutral) protect gastric mucosa against enzymes and HCl. The same role may be applicable to mucosubstances in gizzard of waterhen. But to confirm it, more work is needed.

INTESTINE :

It extends right from the stomach upto anus. Paired, narrow upwardly directed caeca are the demarkation marks between small and large intestine. Waterhen is no exception to this. Small intestine though not morphologically but histologically can be differentiated into proximal a few cm^{8} part duodenum and distal remaining part upto caeca the ileum. Post-caecal part of intestine hence will be large intestine.

D) DUODENUM :

1) HISTOLOGY :

It revealed presence of usual four tunics. The mucosa was thrown into many fingerlike blunt ended villi projecting into lumen. The shape, number of villi and number of goblet cells in mucosa are the aspects to distinguish duodenum from ileum (external demarkation lacking). Duodenal mucosa of waterhen exhibited many finger like villi with less number of goblet

cells while in ileum region, villi were broad at base which tapered abruptly distally, and goblet cells in ileum were still more numerous. Mucosa consisted of dimorphic cells viz. absorptive columnar epithelial cells and goblet cells. Glands were not seen but crypts were distinct, submucosa was comparatively thin and contained connective tissue, thin muscularis and serosa were typical type.

Similar histological structure was also observed by Magon and Mohan (1976) in the duodenum of corvus and passer. Hodges and Michael (1975) studied ultra structure of cellular elements in mucosal crypts of leghorn cockrel. Malvadkar (1985) and Jadhav (1985) reported the same structural details in the duodenum of pondheron, kingfisher and parrot respectively.

2) HISTOCHEMISTRY :

There was no indication of any atypical type of mucosubstance in duodenum of waterhen. Various cellular elements like columnar epithelium, surface goblet cells, crypt goblet cells showed neutral, sulfo and carboxymucins either singly or in combination with others. Submucosa and serosa as usual indicated only neutral mucins while muscularis contained only glycogen.

3) DISTRIBUTION OF THE MUCOSUBSTANCES :

Surface columnar epithelium exhibited only neutral mucins (poor quantities) while surface and crypt goblet cells indicated mixture of neutral + sulfo + sialomucins (poor quantities). Sulfomucins were predominant in goblet cells,

while quantitatively neutral mucins were slightly more in submucosa than in mucosal layer. In distal region, lamina propria showed a distinct glandular structure, the cells here exhibited predominant acidic mucins. Malvadkar (1985) demonstrated neutral + sulfomucins in mucosal cellular elements in the duodenum of pond heron. Jadhav (1985) reported identical results in the duodenum of kingfisher and parrot (carboxymucins were not reported in duodenum of pondheron, kingfisher and parrot).

4) SEXUAL DIMORPHISM :

It was not evident in the duodenum of male and female waterhens as far as histological and histochemical observations are considered. The absence of sexual dimorphism among the mucosubstances is evident in other groups of vertebrate animals from fishes upto mammals. But noteworthy thing related to sexual dimorphism in mucosubstances came into a light in 1978 when Shackleford and Wilborn (1978) for the first time described sexual dimorphism in the duodenal mucosubstances in hamsters. According to them, Brunner's glands in male contain double quantity of acidic mucins as compared to those in female, however with reference to neutral mucins, the reverse reports were presented i.e. neutral mucins are more predominant in Brunner's glands of female than in male.

5) FUNCTIONAL SIGNIFICANCE :

More confirmatory reports are available throwing some light on the possible function of mucosubstances in the duodenum. Definately, they have protective role, since the mucins act as

a buffer against gastric acidic chyme. Uspenskii (1972) proved that when gastric acidity increases and attains chronic stage, then duodenal mucosa actively secretes more and more amount of sialomucins and sulfomucins. This may be true in avian group of animals also, but further confirmation is essential. After studying the duodenal mucosubstances in the several species of bats, Forman et al. (1979) and Deshmukh (1984) reported that there is no relationship between the diet of the animal and nature of mucosubstances in the alimentary canal. Jervis et al. (1973) and Sheahan and Jervis (1976) reported that variation in mucosubstances may reflect dietary, genetic and other unknown influences.

E) ILEUM :

1) HISTOLOGY :

All the concluding activities involved in the digestion and absorption are carried out by the small intestine, in that sense, this part is important one. In waterhen, ileum revealed usual four tunics. The villi were more in number, each with proximal part slightly flattened and abruptly tapering distal end. Goblet cells were still more numerous as compared to those in duodenal mucosa. So also crypts were well demarked than in duodenum. Similar histology was reported by Patt and Patt (1969) in avian ileum. Magaon and Mohan (1976) found similar histological structure in passer and crovus. Bayer et al. (1975) studied intestinal goblet cells of chick by scanning and electro microscopic techniques. Malvadkar (1985) studied pondheron

alimentary canal, he also recorded the same histological pattern, however shape of the villi in ileum of pondheron was finger like. Jadhav (1985) reported, existance of more elongated villi in the small intestine of two birds viz. parrot and kingfisher.

2) HISTOCHEMISTRY :

In waterhen ileum, the histochemical results obtained almost resembled with those obtained in duodenum. Atypical mucosubstance was not observed. Mucosubstances like neutral mucins (poor quantities) sulfomucins (predominant) and sialomucins (poor quantities) were detected either singly or in combination with others in various sites in the ileum. Muscularis contained only glycogen.

3) DISTRIBUTION OF THE MUCOSUBSTANCES :

In the present investigation, the mucosal columnar epithelial cells exhibited only neutral mucins while crypt and surface goblet cells contained mixture of neutral + sulfo + sialomucins. Submucosa and serosa as usual contained poor quantities of neutral mucosubstances and muscularis contained only glycogen. Kim (1972) reported predominant quantities of sulfomucins + poor quantities of neutral mucins in the goblet cells in the small intestines of eight species of birds. Malvadkar (1985) and Jadhav (1985) observed the same typical mucosubstances in the small intestine of pond heron, parrot and kingfisher respectively.

4) SEXUAL DIMORPHISM :

No sexual dimorphism was seen in the mucosubstances in the small intestine of male and female waterhens. In the exhisting literature also there are no reports on sexual dimorphism among the mucosubstances in the small intestine of birds.

5) FUNCTIONAL SIGNIFICANCE :

Shafi (1974) suggested that in fish intestine, the mucus secreted provides lubrication making food propelling easy. The mucus also protects mucosal cells from autodigestion and mechanical injuries. Buche (1971) remarked that neutral and acidic mucins assist in digestion, absorption, protection and lubrication. Gillies and Ballien (1981) pointed out role of mucins in absorption of digested food in the intestine. Mitjavila et al. (1968) stated that mucins can protect mucosal cells from toxic substances like tannin (rat intestinal mucins). Fox (1979) suggested altogether different role of mucins. Due to slimy mucinal coating on mucosal surface, micro organism can't anchor to mucosal cells, thus infection is prevented. To conclude, one may say that mucins in intestine play protective and lubricative roles. The same functional aspects may be allotted to mucins in the ileum of waterhen (present investigation).

F) LARGE INTESTINE :

Generally in the vertebrates, it has been observed that

large intestine is slightly thin walled as compared to small intestine (musculature ill developed). But in birds (waterhen), large intestine was slightly thicker as compared to small intestine and extended from the point where caeca open, to the anal aperture. In this bird, intestinal caeca were paired, well developed and upwarly directed.

1) HISTOLOGY :

In cross sections, it appeared circular, more thicker in musculature than ileum. H-E stained sections revealed usual 4 tunics from innermost mucosa to outermost serosa. The mucosal folds were slightly long and narrow with numerous goblet cells but number of columnar cells was found to be reduced as compared to that in small intestine. Glands were found to be absent. Submucosa, muscularis, layers were well defined, especially muscularis was well defined offering thickness to large intestine. Serosa was typical. Similar histological structure was reported by Patt and Patt (1969), Magon and Mohan (1976) and Malvadkar (1985) in avian large intestine. Jadhav (1985) reported that in parrot large intestine, mucosal folds are short while those in kingfisher are comparatively elongated and villi like.

2) HISTOCHEMISTRY :

Atypical or rearly occuring mucosubstance was not observed. The mucosubstances at various site in the large intestine were identical to those observed in small intestine.

3) DISTRIBUTION OF MUCOSUBSTANCES :

The results obtained indicated existance of poor quantities of neutral mucins in the surface epithelium, serosa and submucosa (here slightly enhanced quantity). Sulfo, neutral and sialomucins (predominent and poor quantities respectively) were the mucosubstances in goblet cells. Kim (1972), Malvadkar (1985) and Jadhav (1985) reported same mucosubstances in the respective sites in avian large intestine.

4) SEXUAL DIMORPHISM :

It was not observed in waterhen. This is in good agreement with the existing literature on the large intestine of other vertebrates.

5) FUNCTIONAL SIGNIFICANCE :

Large intestine plays no role as such in the process of digestion (Reeder, 1964), but certain substances may undergo break down (hydrolysis) here, followed by their absorption. Mainly water and salts undergo absorptions in the large intestine. Forstner (1978) allotted protective and lubricative role to mucins secreted by large intestinal cells. He explained that, mucins not only lubricate but protect the mucosal cells against injurious chemicals, digestive enzymes, bacteria and other harmful dietary constituents. Due to their slimy nature mucins prevent dehydration of tissue cells. The same functional significance may be assigned to mucosubstances in the large intestine of waterhen, but merely this is suggestion and needs more confirmation by studying other species of birds.

Table No.8 :- MUCOSAL-MUCOSUBSTANCES IN ALIMENTARY CANAL OF FOUR BIRDS VARYING IN FEEDING HABITS

- A COMPARISION -

Bird	ORGAN					
	Oesophagus	Proventriculus	Ventriculus	Duodenum	Small Intestine	Large intestine
A.grayii (pond heron)	1) Stratified epithelium - glycogen only. 2) Mucosal glands - sulfo + sialo + neutral mucins. 3) Submucosa - only neutral mucins.	1) Surface goblet cells - neutral + sulfo + sialo-mucins. 2) Glandular duct cells - Sulfo-mucins + neutral mucins. 3) Glandular secretary cells- only neutral mucins.	1) Surface goblet cells - sulfo-mucins + sialo-mucins. 2) Crypt cells - sulfo + sialo-mucins. 3) Glandular cells- only neutral mucins.	1) Columnar epithelium - only neutral mucins. 2) Surface goblet cells - Sulfo + sialomucins. 3) Crypt goblet cells - sulfo + sialomucins.	1), 2), 3) - same as in duodenum.	1), 2), 3) - same as in duodenum.
C.radius (kingfisher)	1) Stratified epithelium - without keratinisation. 2) Epithelium - only glycogen. 3) Mucosal glands well defined containing neutral + sulfo + sialomucins.	1) Surface goblet cells - neutral + sulfo + sialo-mucins. 2) Glandular duct cells - sulfo-mucins + neutral mucins. 3) Glandular secretary cells - only neutral mucins.	1) 'Koilin' layer - narrow, thin. 2) Surface goblet cells - sulfo + sialomucins. 3) Crypt cells - Sulfo + sialo-mucins. 4) Glandular secretary cells- only neutral mucins.	1) Columnar epithelium - only neutral mucins. 2) Surface and crypt goblet cells - neutral + sulfomucins. 3) Submucosa - quantitatively neutral mucins more.	1) Same as in duodenum. 2) Surface and crypt goblet cells - sulfo + sialo-mucins.	1) Mucosal folds long, villi like. 2) Columnar cells - only neutral mucins. 3) Goblet cells - Sulfo + neutral mucins.

P.krameri (Parrot)	1) Stratified epithelium - keratinised. 2) Stratified cells- only glycogen. 3) Mucosal glands - absent. 4) Submucosa - neutral mucins + hyaluronic acid.	1), 2) and 3) -same as in kingfisher.	1) 'Koilin' layer broad. 2) and 3) - same as in kingfisher. 4) Glands - absent.	1), 2) and 3) - same as in kingfisher.	1) and 2) - same as in kingfisher.	1) Mucosal folds short 2) and 3) - same as in kingfisher.

- A COMPARISION - (Contd..)

Bird	ORGAN					
	Oesophegus	Proventriculus	Ventriculus	Duodenum	Small Intestine	Large Intestine
A.phoenicurus phoenicurus (Waterhen)	1) Stratified epithelium - no keratinisation 2) Stratified cells- only glycogen. 3) Glandular mucosal cells - neutral + sulfo + sialo- mucins. 4) Submucosa with neutral mucins only.	1) Surface goblet cells - neutral + sulfo + sialo- mucins. 2) Glandular duct cells - sulfo + sialomucins + neutral mucins. 3) Glandular secre- tary cells - only neutral mucins.	1), 2) and 3) - same as in pond- heron.	1) Columnar epithelium - only neutral mucins. 2) Surface and crypt goblet cells - neutral + sulfo + sialo- mucins (poor). 3) Lamina propria with well defined glandular structure rich in acidic mucins.	1) and 2) - same as in duodenum.	1) Mucosal folds long, narrow villi like in proximal region, while distally, the folds appear short and narrow. 2) Columnar epithelium - only neutral mucins. 3) Surface and crypt goblet cells - neutral + sulfo + sialomucins.

COMMENTS : (Table no.8)

Various mucosubstances in various strata in the alimentary tract of a few birds like pond heron, kingfisher (carnivorous), parrot (frugivorous) and waterhen (omnivorous), if studied comparatively, some conclusions, rather suggestions, could be made, however more confirmation is needed by studying a still good number of birds varying in feeding habits and species.

A) OESOPHAGUS :

1) Stratified epithelium in parrot shows keratinisation, which is not reported in remaining three birds. Magon and Mohan (1976) reported noticable degree of cornification in passer than seen in corvus. Is there any relationship between keratinisation and food must be confirmed by studying some more frugivorous birds.

Bradfield (1951) demonstrated co-relation between glycogen contents in stratified epithelium and degree of keratinisation. Keratinisation is inversely proportional to glycogen amount. So glycogen contents in these cells should be studied quantitatively by subjecting a good number of birds to throw some light on this relationship.

2) Oesophageal mucosal glands are reported to be present in most birds, but found to be absent in parrot.

3) Submucosa in parrot contains neutral mucins + hyaluronic acid both, while in other three birds, it exhibits only

neutral mucins.

Whether these two aspects [(2) and (3)] are due to different feeding habit or species diversity should be confirmed by studying more number of birds.

B) PROVENTRICULUS :

Mucosubstances here in all the four birds are almost identical.

C) VENTRICULUS :

1) 'Koilin' layer is broad in parrot as compared to it in other three birds. This might be in accordance to frugivorous habit of parrot which feeds generally on hard coated food stuffs. What type of koilin exists in other frugivorous birds should be studied.
2) Tubular glands exist in gizzard of waterhen, kingfisher and pond heron but reported to be absent in parrot.

D) DUODENUM :

1) Poor quantities of carboxymucins exist in addition to neutral and sulfomucins in goblet cells in waterhen only. In remaining three birds, non-sulfated mucosubstances are not reported.
2) Lamina propria in the distal region of duodenum in waterhen exhibited well defined glandular structure, the cells of which elaborated predominant acidic mucins (Fig.24). Such structure is not reported in other birds. Further histochemical and histological study is needed.

E) ILEUM :

Mucosubstances are almost identical in all the four birds.

F) LARGE INTESTINE :

In parrot, mucosal folds are short while they are long and villi like in kingfisher. In pond heron, folds are broad and short; while in waterhen, the folds vary much as per the region of the large intestine i.e. the folds are long and villi like in proximal region, while the folds show short and narrow nature in distal region of large intestine (Fig. 29 and 35). Such dimorphic nature of mucosal folds should be studied from functional point of view.

CONCLUDING REMARKS :

The main aims of the present investigation were -

1) To study histological aspects of the alimentary tract of white breasted waterhen (A. phoenicurus phoenicurus).
2) To characterise mucosubstances histochemically in the organs from oesophagus to large intestine.
3) To point out pattern of distribution of mucosubstances in the various histological sites of these organs.
4) To compare the results obtained in the present investigation and the existing literature on the mucosubstances in the alimentary tract of other vertebrates.

5) To concise the comparative account, literature on muco-substances in the alimentary tract of other birds (pond heron, kingfisher, parrot) was considered predominantly.

6) To attribute, some physiological role to the mucosubstances in the alimentary canal of waterhen, circumstantial evidences were considered.

7) It is said that the smallest complete deed is better than the grandest good intension. By keeping this view in mind, author completed his small dissertation. It is hoped that the aims and objectives of the present investigation have been satisfactorily achieved.

While concluding the present investigation, the author is fully aware of the shortcomings. The author had to depend on the histochemical techniques which do not give the exact location of the mucosubstances in the particular histological sites It is said that colours speak all languages which comes true in this regards. However, these well established techniques do not give information in terms of quantity in mathematical figures (Bioassay method is suitable here). Attempts are made in the present investigation to point out staining intensities of the various mucosubstances in visual terms like poor, weak, moderate, intense etc. This, though roughly, can indicate relative amount of mucosubstances in terms like poor, moderate, predominant etc.

With all these shortcomings in mind, the author feels

grateful that he had atleast presented, though preliminary, additional information as the mucosubstances in the alimentary tract of one more bird (omnivorous), by employing a series of well established histochemical techniques according to the availability of the stains and chemicals in this laboratory.

The author keeps no right to ask others to do this and that, but it is customary to suggest what more could be done and how, concerning the histochemical research.

1) By employing recent bioassay studies, the mucosubstances in the organs of the alimentary canal should be studied quantitatively in exact mathematical terms (merely relative quantity of a certain mucosubstance provides a little information).

2) The mucosubstances reported in a particular site of a particular organ must be further confirmed by autoradiography. So that artifact, if any, will be tested well.

3) Characterisation of an individual mucosubstances should be done by chromatographic technique.

4) Presence of neutral, sulfo and carboxymucins is incomplete information, each must be further identified.

5) Except hamster, in no other species sexual dimorphism is reported concerning mucosubstances in the alimentary canal. So further attempts should be done to point out other species, if any, exhibiting sexual dimorphism among mucins.

6) The above point is applicable to the presence of atypical

or rare mucosubstance also. Sulfated sialomucins have been reported in the colon of some mammals. Jadhav (1985) reported atypical mucosubstances which were AB and CI unreactive but PAS and AF positive in the gastric mucus neck cells in turtle (L.punctata lacepede). So the study must be further extended to find out other atypical mucosubstances, if any, and exactly where?

7) Existing literature fails to prove the relationship between mucosubstances in the alimentary canal and dietary habit. Almost similar mucosubstances have been reported in alimentary tract of parrot (frugivorous), pondheron, kingfisher (both carnivorous) and waterhen (omnivorous). So further work is essential by considering still more number of carnivorous, herbivorous and omnivorous birds having species diversities.

8) Further confirmation is needed to point out physiological signfficance of mucins in alimentary canal of a bird.

9) Co-relation, if any, between mucosubstances and reabsorption of digested food is one more aspect to be confirmed by using suitable method.

So there are several avenues open to continue the research in the field of histochemistry. There is unlimited scope for the research work concerning mucosubstances and their physiological role in the alimentary tract of avian fauna. The author is fully aware that the research work done is by no means

perfect since some omissions and errors are bound to remain somewhere in the body of the dissertation.

"I do not know what I may appear to the world, but to myself, I seem to have been only like a boy playing on the seashore and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilist the great ocean of truth lay all undiscovered before me."

Sir Isjac Newton
(1642-1727)