CHAPTER II

DIETARY VARIATION AND KIDNEY METABOLISM IN THREE DIFFERENT SPECIES OF BIRDS, PIGEON, SPARROW, AND SWIFT

Morphological, histological, biochemical, physiological and experimental studies on kidney of mammals and to a certain extent in very few groups of birds have provided enough basic information about their metabolic pecularities and adaptations. Much of the physiological studies concerned with avian water economy under varying conditions such as water deprivation and saline stress have been done in past few years (Mcnabb, 1969a,b; Ohmart and Smith, 1970; Braun and Dantzler, 1972; Skadhauge, 1974a) where ecological adaptation was the major theme. In addition to these various findings, Ward *et al.* (1975a,b) have shown that changes in diet, water availability, and feeding time cause diurnal variations in the rate of urine flow and in urinary uric acid and ammonia concentration, in some representatives of birds.

Although majority of its functions are concerned with excretion, kidney after attaining structural and functional maturity, carries out several other functions also. Kidney is known to play an important role in glucose homeostasis (Krebs and Yoshida, 1963; Exton, 1972; Shen and Mistry, 1979). It is reported that kidney takes the compensatory role of producing more glucose when liver functions are altered as in diebetes

(Kida *et al.*, 1978). In birds, kidney is a major gluconeogenic organ, whereas the liver is a specialized lipogenic organ and thus forcing kidney to become the predominant gluconeogenic tissue.

Different types of foods are consumed by different groups of birds and this can be easily correlated with the feeding habit. The feeding adaptations impose restrictions on the diet of birds. Most of the avian species have developed adaptations for one type of food or other. Thus some birds are exclusively graminivorous (e.g., pigeon), some are insectivorous (e.g., Swift) and a few are omnivorous (e.g., sparrow), the adaptations of birds to one type of diet or lack of it should necessarily be reflected in the metabolic machinery of the organs. In birds, liver plays a central role as far as metabolic adaptations are concerned but at the same time kidney may take up the compensatory role in metabolic homeostasis according to diet and specialization of birds. The present investigation was carried out to evaluate the gluconeogenic functions of the kidney in three different species of birds, swift, sparrow and pigeon, having different dietary habits.

MATERIALS AND METHODS

Adult Blue rock pigeons (*Columba livia*) weighing around 250-300 gms. were used in the experiments and were acclimated to laboratory conditions, caged in groups and fed *ad-libitum*.

Adult house swift (<u>Apus affinis</u>) weighing around 22-25 gms were captured from the colony from the University Campus. Adult house sparrow (<u>Passer Domesticus</u>) weighing around 20-22 gms were procured from the local animal dealer. Both sexes of birds were utilized in the experiments. The birds were sacrificed by decapitation and the kidney was excised immediately. After noting the weight the kidney was processed for various enzyme estimations.

The activities of acid and alkaline phosphatases, transaminases (GOT and GPT) and protein, glycogen and lipid contents of the kidney of blue rock pigeon, house sparrow and house swift were carried out by methods described in Chapter 1.

RESULTS

Results are presented in Table 1 and Figs. 1-4.

The pigeon and swift are stenophagous, the former consuming a carbohydrate rich diet of grains while the latter an insect diet, rich in protein. Sparrow on the other hand is euryphagous, the diet being a mixture of grains and insects.

Kidney of sparrow showed the maximum protein content while it was least in that of pigeon. Alkaline phosphatase activity was maximum in swift kidney whereas sparrow kidney showed the least enzyme activity. Acid phosphatases too showed a similar variation; maximum in swift and least in sparrow. GOT (Aspartate amino transferase) and GPT (Alanine aminotrans-

Table 1 : Comparative account of biochemical profile of kidney of pigeon, sparrow and swift (Mean $\pm$ S.E)

Parameters	Pigeon	Sparrow	Swift
Protein	13.956 $\pm$ 1.038	38.649 $\pm$ 1.704	19.520 $\pm$ 0.914
Alk. Pase	2.229 $\pm$ 0.308	1.920 $\pm$ 0.305	3.611 $\pm$ 0.179
Ac Pase	0.652 $\pm$ 0.031	0.149 $\pm$ 0.028	0.752 $\pm$ 0.048
GOT	116.404 $\pm$ 10.12	47.056 $\pm$ 2.887	149.100 $\pm$ 2.837
GPT	151.162 $\pm$ 10.77	29.478 $\pm$ 5.764	336.660 $\pm$ 21.22
Glycogen	0.027 $\pm$ 0.002	0.298 $\pm$ 0.036	0.198 $\pm$ 0.046
Lipids	19.480 $\pm$ 0.551	21.29 $\pm$ 1.15	4.37 $\pm$ 1.12

EXPLANATIONS TO GRAPHS - CHAPTER II

Fig.1 Graphs showing comparative account of glycogen and protein contents in the kidney of pigeon, sparrow and swift.

Fig.2 Graphs showing comparative account of lipids in the kidney of pigeon, sparrow and swift.

Fig.3 Graphs showing the comparative account of GOT and GPT in the kidney of pigeon, sparrow and swift.

Fig.4 Graphs showing the comparative account of Alk Pase and Acid Pase in the kidney of sparrow and swift.

FIG. 1

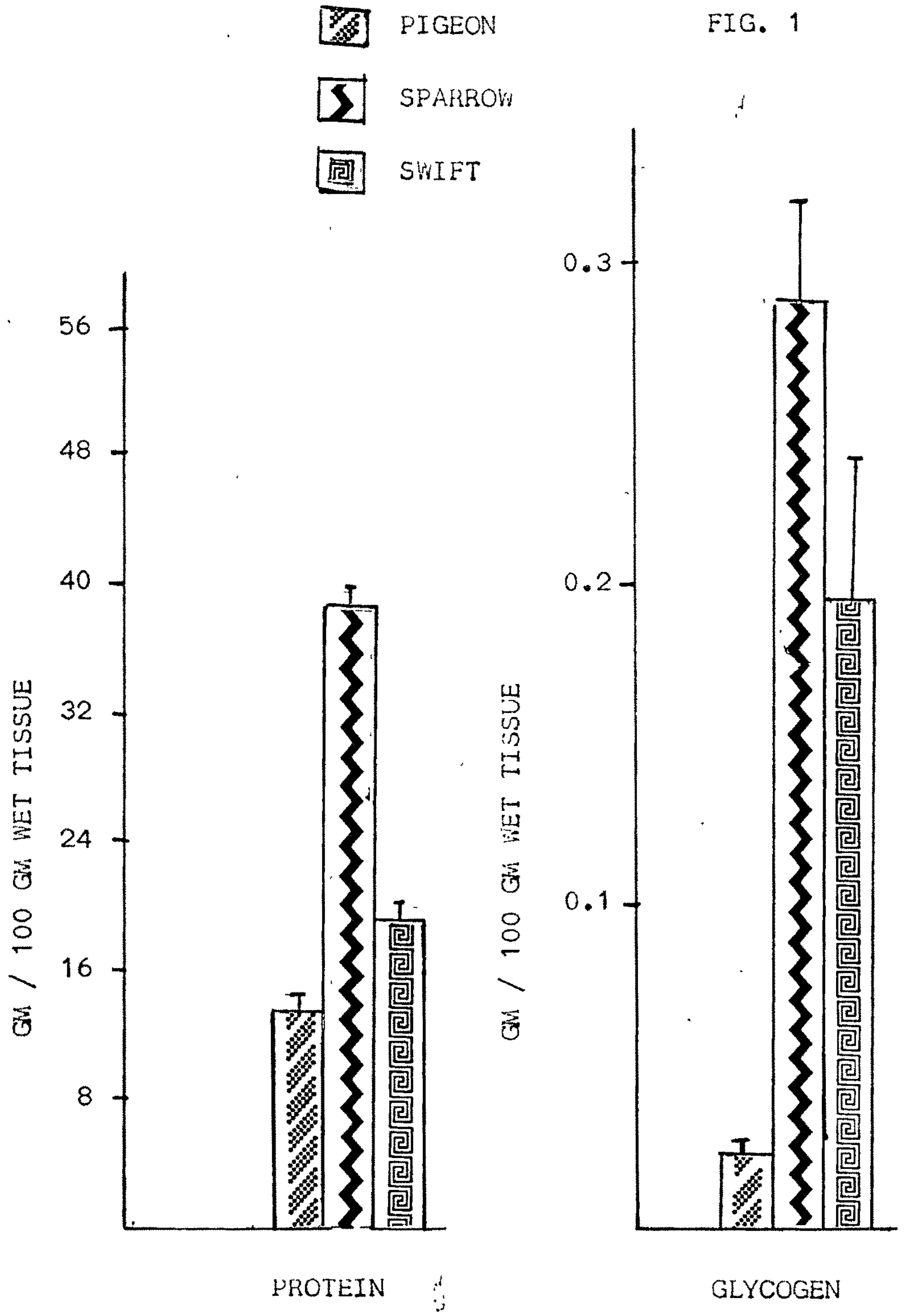

PIGEON
SPARROW
SWIFT
56
48
40
32
24
16
8
GM / 100 GM WET TISSUE
PROTEIN
0.3
0.2
0.1
GM / 100 GM WET TISSUE
GLYCOGEN

FIG. 2

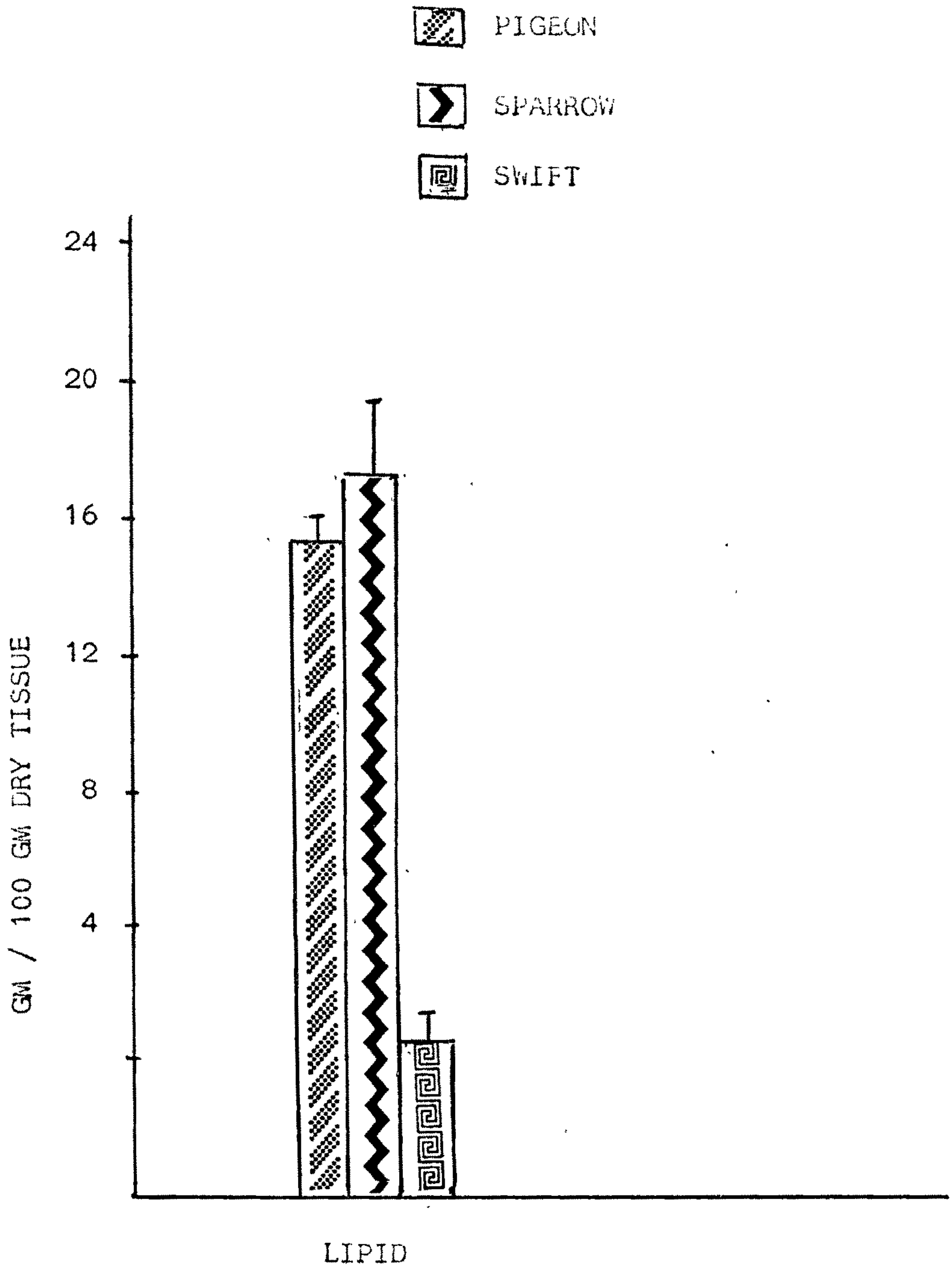
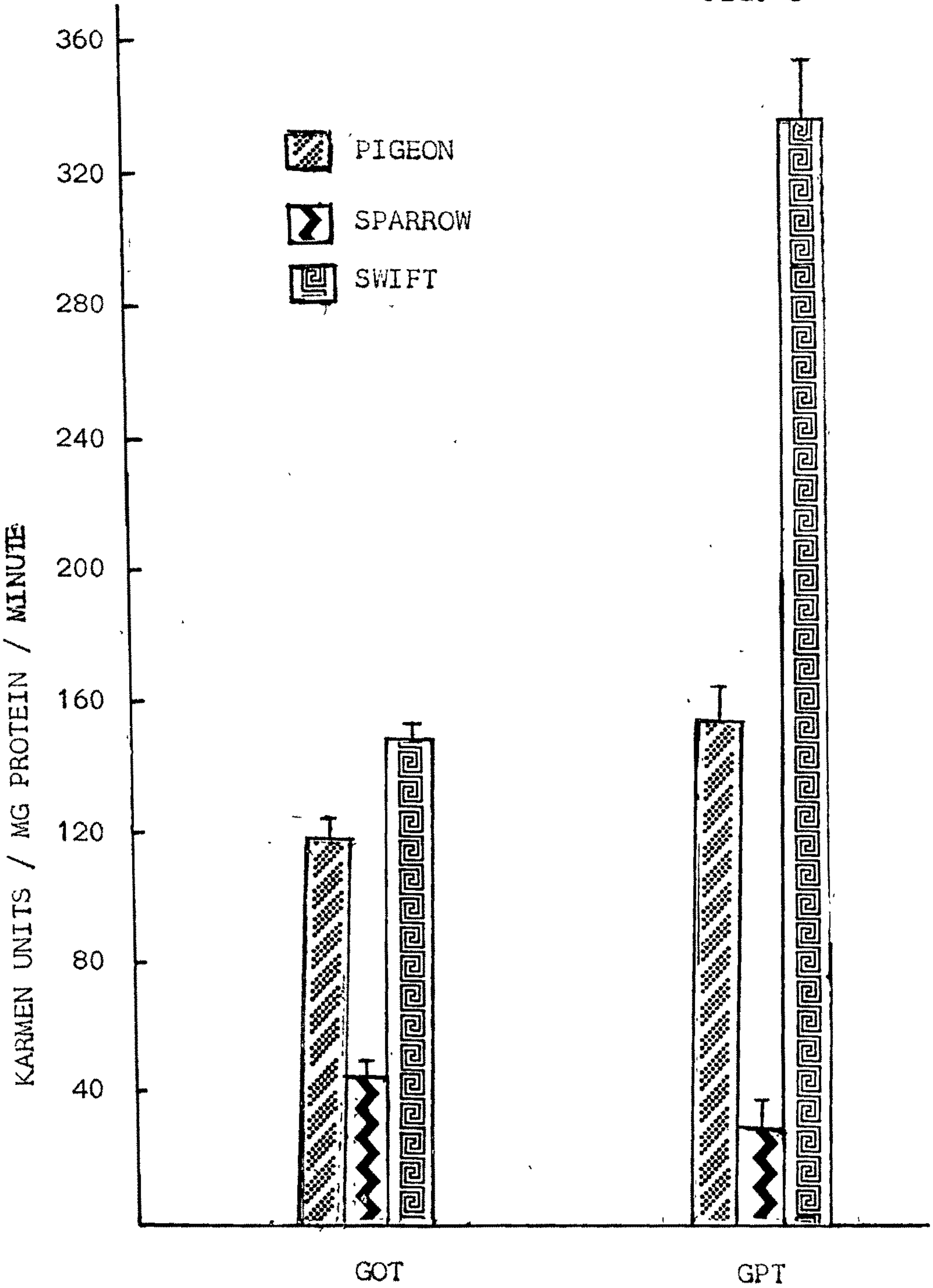


FIG. 3


360
320
280
240
200
160
120
80
40
KARMEN UNITS / MG PROTEIN / MINUTE
PIGEON
SPARROW
SWIFT
GOT
GPT

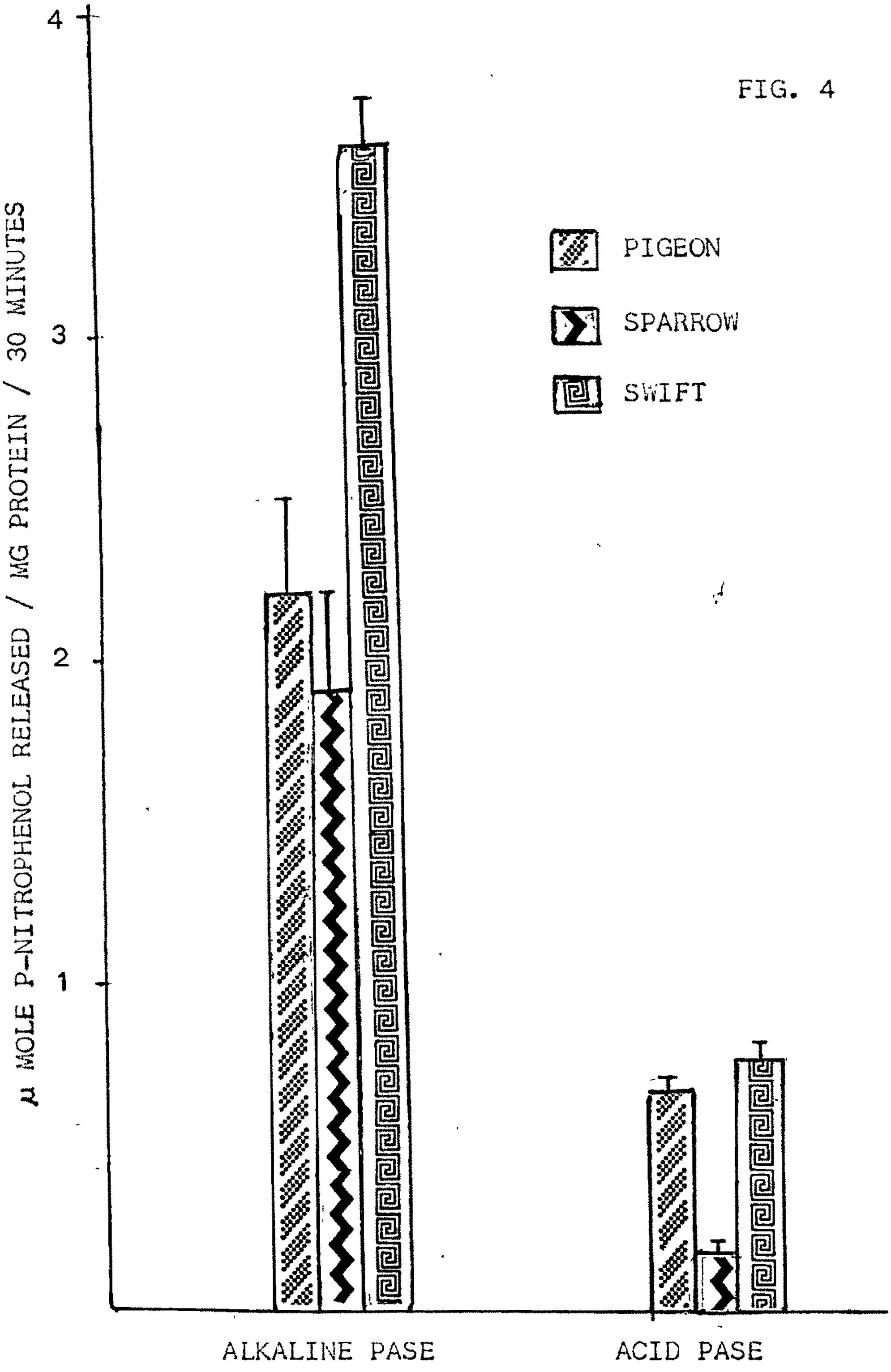

4
3
2
1
μ MOLE P-NITROPHENOL RELEASED / MG PROTEIN / 30 MINUTES
PIGEON
SPARROW
SWIFT
ALKALINE PASE
ACID PASE

FIG. 4

ferase) activities were maximum in the kidney of swift while the kidney of sparrow exhibited the lowest level.

Sparrow kidney showed the maximum protein content while the lowest content was exhibited by pigeon kidney. Lipid content was highest in the kidney of sparrow while the lowest was seen in the kidney of swift. Sparrow kidney also exhibited highest glycogen content whereas that of pigeon presented lowest value of glycogen content.

DISCUSSION

The main function of kidney is excretion but by and large, the organ is also capable of performing metabolic activities. In birds it is a prominent gluconeogenic tissue (Pearse, 1977). Gluconeogenesis is resorted to when food intake is curtailed (starvation) or when the food contains no carbohydrates. Amongst the three birds studied, the diet of pigeon (graminivorous) and sparrow (omnivorous) contains carbohydrates while the diet of swift (insectivorous) contains practically very little carbohydrate. In general, metabolic activities in these birds should then show some adaptations with respect to dietary variations. Liver, the major metabolic tissue showed tremendous metabolic adaptations according to diet of birds (Shah _et al._, 1972a ; 1972b; 1975; Pilo _et al._, 1973a, 1973b). Alkaline phosphatase activity in the liver of insectivorous and carnivorous birds was more than acid phosphatase while in graminivorous birds, acid phosphatase was more (Shah *et al.*, 1972a). These authors opined that as the liver of birds consuming protein rich food showed alkaline phosphatase, this enzyme must be involved in gluconeogenesis. In the kidney of all the three birds studied, alkaline phosphatase was more than acid phosphatase denoting both its involvement and the kidney's importance in gluconeogenesis in birds. Apart from the higher alkaline phosphatase activity compared to acid phosphatase, in the kidney of all birds the swift kidney showed the maximum activity when intra-species comparision was made. This observation makes it all the more convincing that alkaline phosphatase facilitates gluconeogenic activity and the kidney of swift is more adapted for such metabolic activities than that of pigeon and sparrow.

Acid phosphatase activity in the kidney of all the three birds was much less than that of alkaline phosphatase. In the liver of pigeon acid phosphatase is reported to be higher than alkaline phosphatase, While in that of swift and sparrow alkaline phosphatase predominates (Shah *et al.*, 1972a). However, between the three birds, acid phosphatase activity was least in the kidney of sparrow. Acid phosphatase activity level in the liver of birds was found to be correlated with lipid metabolism (Shah *et al.*, 1972a). In the kidney of migratory birds (Rosy pastor and Wagtails) the kidney showed increased enzyme activity towards premigratory period when the lipid deposition was taking place at very high rate (Shah *et al.*, 1976). Hence, it could be stated that in the kidney of both pigeon and swift, the acid

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phosphatase is involved in lipid metabolism. Lipid content in the liver of insectivorous bird like swift and graminivorous bird like pigeon were found to be very high (12.6 % and 12.11 % respectively) while the liver of omnivorous bird like sparrow had only 9.8 % (Pilo et al., 1973). These authors have commented that the liver of omnivorous group do not have a high rate of lipid metabolic activity (lipid synthesis or lipid mobilization). Kidney of omnivorous birds like wise, showed least gluconeogenic or lipid metabolic activities as their diet invariably brings in adequate amount of carbohydrate and lipid.

In rats, the gluconeogenic rate in the kidney is higher than in the liver when they were fed on a carbohydrate low diet (Krebs, 1963). A clear correlation is thus observed with diet and renal gluconeogenic rate. In the light of these observations, it was not surprising to find higher rate of GOT and GPT activities in the kidney of swift which consumes an insect diet, low in carbohydrate. As against this, omnivorous sparrow showed the lowest activities of transaminases. However, the presence of fairly high activities of these enzymes in the pigeon kidney cannot be explained from this angle. Probably, pigeon kidney transaminases are involved in synthesizing amino acids.

The fact that glycogen content of kidney of graminivorous pigeon was the lowest, indicates that the tissue makes no apparent attempt to store carbohydrate. This may be due to steady supply through diet and due to the fact that major part of this metabolic commodity that gains entry into kidney is probably utilized for production of other form of organic chemicals such as lipids and amino acids. Pigeon kidney understandably stored large amount of lipid (19.5 %). Glycogen content of swift kidney was 10 times more than that was observed in pigeon kidney, indicating an adaptive storage of a commodity that is never adequate in the diet (insects). Presumably this carbohydrate is produced through gluconeogenic activity. On the other hand, lipid, which is available in more than sufficient quantity through the diet, was least in the kidney of swift. The lipid must be getting utilized for energy as well as for the production of glucose. Interestingly, sparrow kidney exhibited high contents of both glycogen and lipid. This may be due to high degree of intake of these metabolities through diet as well as due to very little interconversions. It should be recalled here that sparrow kidney showed the least activities of all enzymes studied. A similar situation also arises with respect to protein content. The sparrow kidney exhibited a very high amount (38 %) of protein. Again this could be correlated to the lack of or redundency of metabolic interconversions. Although both pigeon and swift kidneys showed low protein content, the reasons are not akin. In pigeon the amino acids and thereby proteins are to be synthesized from carbohydrates as their diet is too low in protein. On the other hand, swift kidney converts most of the dietary supply of amino acids into carbohydrate. Both these conditions limit the mass of labile protein in the kidney.

In conclusion, it could be stated that a mixed diet places no stress or strain of compensatory or adaptive metabolic activities (interconversions), while a stenophagus diet forces a tissue to adaptively orient its metabolism. Such metabolic adaptations are seen in kidney of pigeon and swift, while that of sparrow, being an omnivore, shows practically no adaptations at all.