

INTRODUCTION

For very long time pineal was described in scientific literature as vestigial organ, cerebral appendix, third eye or seat of the soul. The most modern techniques have revealed its widespread occurrence in all present day vertebrates with significant scientific literature being generated concerning pineal anatomy, biochemistry and pharmacology. Exceptions where pineal is unrepresented are the hagfish, crocodilians, edentates and probably dugongs (Adam, 1957; Ariens-Kappers, 1965; Oksche, 1965). During the past decade, considerable research work has been done on physiology of the pineal organ and its role as an endocrine organ with many controversies and pitfalls in it. Voluminous ^{data} regarding the influence of environmental lighting on gonadal maturation and secretory activity of pineal organ has been piling up. Despite this, it is not yet possible to speak of one simple function as a common one applicable to all vertebrates. Present studies of pineal literature does not permit us to ascribe a unique function

to it in vertebrates as a group. However, it has not yet been demonstrated that any physiological process in the body^{is} influenced by the pineal organ. Though there have been speculations about special physiological role of pineal, no generalisations could be formulated so far. The pineal of lower vertebrate groups (fishes, amphibians and reptiles) is photoreceptive. The pineal of several mammalian species has shown its relationship with the reproductive system while that of other higher vertebrates is exceedingly active biochemically, secreting certain hormones. Pineal in recent times is implicated more convincingly with three functions; reproduction, rhythmicity and thermoregulation. The influence of pineal on reproduction is best documented in mammals (Reiter, 1974a, 1975a, 1978). Data on similar studies on non-mammalian species appear to show variations in pineal function ranging from progonadal to anti-gonadal and even total refractoriness. Great variability of the pineal made the problem more complicated in clarifying the functional significance of the avian pineal. Evidences for the involvement of avian pineal in circadian rhythmicity is well documented (Binley^k et al., 1971; Gaston and Menaker, 1968; Menaker and Zimmerman, 1976; Rutledge and Angle, 1977; ~~G~~winner, 1978). Generally, to study the effect of hormones, either deficiency of hormones is created or they are administered into the animal body. The easiest way to create deficiency is by removing the internal source

of the hormone. When an endocrine organ is removed from the body, notable changes must take place, which should predictably be manifested in physiological alterations. The regulatory mechanisms of the body respond to all external and internal factors, this in turn is reflected in metabolic responses.

Pineal, now known to be a neuroendocrine gland, is expected to show some physiological alterations when ablated. In birds and mammals it secretes physiologically active compounds such as melatonin, serotonin, histamine and arginine vasitocin and is regulated by the autonomic nervous system. Pineal secretion mediating the influence of light on reproductive activities and development is well known in birds and other classes of vertebrates. Pineal is supposed to be a neuroendocrine device, receiving exogenous and endogenous inputs and having output to several peripheral systems (Wurtman and Tay, 1969). In this context, Quay, (1969) has considered pineal to be primarily concerned with adaptation to the environment. Scant studies have been done on the involvement of pineal on certain aspects of metabolism (Delahunty et al., 1978; Damian et al., 1979). Most of these reports come from vertebrate groups other than birds. Despite the incomplete physiology of pineal, the literature available suggests that the avian pineal may be involved directly or indirectly in the processes

of photoreception, reproduction and circadian rhythmicity, i.e. pineal has got integrating role on several internal responses to its external, especially photic, environment. Number of published data are available on domestic species of birds having non-seasonal reproductive cycle. Modulations of reproductive changes that can be evoked by photic environment in pinealectomised birds are diverse. Several factors, such as temperature variations, ratio of photophase to scotophase, sex, age, species and state of gonadal function modify the effect of pinealectomy in birds (Hoffman and Reiter, 1966; Herbert, 1967; Damian et al., 1979; Gwinner and Dittami, 1980). Domestication is known to modify or eliminate entirely the influence of environment on reproduction. Moreover, involvement of pineal is considered to depend on photo-regimes. The possibility of long term effects of pinealectomy depending on the reproductive state of birds revealed the importance of temporal factors in manifestation of the effect of pineal gland (Saylor and Wolfson, 1967; Barfuss and Ellis, 1971; Saxena et al., 1979; Gwinner and Dittami, 1980). Available literature concerning the pineal, photoperiods and reproductive activity are based on artificial illumination and that too short duration effects in birds with non-seasonal cyclic reproductive activity. Keeping the current status of pineal, and the literature available investigations on the influence of pineal on general metabolic profile in relation to reproductive

phases were carried out in the wild pigeons, Columba livia, (pinealectomized, sham operated and intact controls) under natural environmental conditions during the three phases of reproductive cycle viz. recrudescence, breeding and regression. To ascribe the involvement of pineal, if any, in general physiology of this bird, analysis of the metabolic performance of liver, muscle, kidney and gonad was attempted by quantitatively measuring the levels of certain enzymes and metabolites during all the three phases of reproductive cycle in normal and operated birds. Considerable amount of documented reports suggest that the avian and mammalian pineal participate in the affairs of the gonads, the thyroid, the brain and many other organs and organ systems. Studies indicate that the pineal action on reproductive cycle is probably mediated via other endocrine systems (Reiter, 1973; Quay, 1974). Most of the reports on the role of pineal on various endocrine organs come from mammalian species. An attempt has been made here to find out the role of pineal on the cyclicity and functioning of spleen, pancreas, adrenals, thyroid, gonads and uropygeal gland in relation to seasonal cyclic reproduction under natural photo regimes (Chapter 1). It is generally expected that the amount of energy required by the body for its varied activities is derived from the chief metabolites. It is known that hormones influence the metabolism of carbohydrates, lipids and proteins and also the content of

vitamins, water and electrolytes. To have an insight into the general metabolic performance of the wild pigeon, blood glucose, tissue glycogen, tissue proteins, total tissue lipids and ascorbic acid (vitamin C) were assayed. Results accrued herein have revealed seasonal pattern of alterations of these metabolites and the role of pineal in such alterations (Chapters 2, 3, 4 and 7). Variations obtained in the total tissue lipids after pineal removal could be due to some ^{changes in} lipid component of the total lipids; and the role of pineal in the rate of lipogenesis and lipolysis has been studied by measuring the levels of total cholesterol, phospholipids and triglycerides (Chapter 5).

To get a generalized idea of various metabolic pathways and the total energy flux under the influence of pineal ablation, activities of certain enzymes were determined. Phosphorylase activity would reflect the state of glycogen metabolism in various tissues which is known to be affected by blood glucose. Hence, phosphorylase activity was quantitatively assayed in the liver and muscle (Chapter 3). The observations were also extended to succinate dehydrogenase, adenosine triphosphatase and glucose-6-phosphate dehydrogenase to ascertain the alterations, if any, in oxidative metabolism, and energy equilibrium and shunt pathways (Chapter 4).

It was also thought desirable to study certain haematological aspects namely haemoglobine content, blood clotting time (hemostasis) and erythrocyte sedimentation rate (ESR), so as to see whether pineal has any influence on composition and properties of blood (Chapter 2). In the physiological process of the body, electrolytes play an important role. Cellular influx and outflux of inorganic cations (Na^+ and K^+) affect cellular excitability and membrane permeability. Calcium acts as a coupling factor in muscle functioning and certain endocrine secretions (Hasselback and Makinose, 1963; Hasselback, 1964; Weber, 1966; Weber et al., 1966). Electrolytic balance also influences intercellular movement of metabolites and water content. Observations on sodium, potassium and calcium ions and water content (Chapter 6) might throw some light on the causative factors underlying the observed alterations in various metabolites and enzymes studied, and the relationship with the pineal gland.

Ascorbic acid levels in different tissues of birds and mammals have been reported to be associated with reproductive activities and its participation in the metabolic turnover. Significance of ascorbic acid in steroidogenesis, haemopoiesis etc., is well established. Disturbances in vitamin C content alters carbohydrate, lipid, protein and iron metabolism (Rusch and Klaine, 1941;

Levine et al., 1941; Banerjee and Ghosh, 1947; Mazur et al., 1961; Banerjee and Ganguli, 1962). The manifold functions of vitamin C in general physiological processes and the reported influence of pineal on reproductive function of birds (Damian, 1979) have prompted the present study on ascorbic acid (Chapter 7).

In birds, about one-fifth of the fat-free body is protein found in feathers, bones, muscle, skin etc. The role of protein in the body is exemplified by enzymes, plasma proteins and hormones. Available information regarding avian protein metabolism is mostly from domestic species. Reports on wild species are extremely scant. For a proper understanding of protein metabolism and its interaction with seasonal reproductive cyclicality and pineal factor/s, tissue protein contents were assayed (Chapter 8). It has been reported that hormones influence activity of acid and alkaline phosphatases in rats and chicks (Manwell and Betz, 1966; McWhinne and Thommes, 1973; Yeh and Moog 1977; Wilfred and Rao, 1977). These enzymes involved in cellular metabolism are sensitive to hormones and other factors. Influence of pinealectomy on the activity of these non-specific phosphatases was also evaluated for better understanding of the pineal and its involvement in general metabolism.