INTRODUCTION

Studies on the cardiovascular structures of vertebrates have always been a subject of great interest. The cardiovascular system is one of the most important systems in the whole of the animal organisation, which apart from its own role, sets into motion all other organs and systems of the body. The arterial and venous pressure, to considerable extent, determine the metabolic state of the heart and thus play an indirect role in the mechanism of the cardiac conduction. The heart assumes the conducting function from its very inception in the early embryonic stage. To elucidate the mechanism of cardiovascular conduction attempts have been made by investigators as early as in Seventeenth Century. Despite the great importance of the subject and several attempts by innumerable workers, our knowledge is incomplete on the various aspects of this problem.

Precise knowledge on the gross morphology and histology of the cardiovascular conducting system is an essential pre-requisite for the investigators of the cardiovascular conduction. The pathway for the conduction of the cardiac stimulus of contraction in vertebrates is of great importance in the interpretation of electrocardiograms. Our knowledge in respect of cardiovascular conducting structures of vertebrates is meagre and a number of facets of cardiovascular conduction deserve serious study and investigation. The available literature reveals that majority of investigations on the cardiovascular conduction, have been restricted to mammals and the cardiovascular conducting structures have been neglected in lower vertebrates and birds. In fishes, the amphibians and reptiles most of the studies are restricted to the constructional
morphology of the heart and do not account for the mechanism of the cardiac conduction. In this context it is pertinent to note that in the absence of detailed information in the lower vertebrates a comparative evaluation of the system is difficult. Moreover, the phylogeny of the cardiovascular conducting system remains a matter of speculation. The inadequacy of our information is coupled with controversies.

In the heart of mammals and birds certain impulse-initiating and conducting structures have been reported. Many other probable functions have been attributed to these strikingly different structures. Recent investigations of Foxon, Griffith and Price (1956), Mahendra (1942), Mathur (1944), Kashyap (1951) and Gyevai (1962) either do not report the presence of impulse-initiating structures or completely deny their presence in lower vertebrates. In complete contradiction to these workers Keith and MacKenzie (1910), MacKenzie (1913) Lewis (1915, 1921) and Kuhn (1912) and several others reported the presence of specialised impulse-initiating and conducting structures on an enormous scale. Davies and Francis (1941) and Davies et al (1952) alleged that the impulse-initiating and conducting structures of the birds and mammals are neomorphic in origin.

(In recent years, another line of thought (Prakash 1953, 1954a, 1954b, 1956, 1957, 1960; Bhatnagar 1957, 1959, 1962 and Diamond 1959) has emerged, which states that the cardiac conducting system shows a progressive evolution from lower to higher vertebrates. This view markedly differs from the neomorphic concept of cardiac conducting structures of higher vertebrates. It may be recalled that none of
the above workers examined the cardiovascular system in all the classes of vertebrata, and in most of the cases the conclusions derived are even based on the observations restricted to one or two animals of a particular group. The theory of cardiovascular conduction based on specialised structures and muscle fibres was completely contradicted by Glomset (1941), Glomset and Birge (1945, 1948), Glomset and Cross (1952) and several other workers in a series of publications. These investigators not only denied the myogenic cardiovascular conduction but even criticised it to the extent of considering it as irrelevant and immaterial. These investigators solely attributed the cardiovascular conduction to the nerves. Surprisingly, these workers either do not state the role of these muscle fibres or regard them as lesions in the heart. However, it hardly seems convincing that the specialised cardiovascular conducting structures should have been located in a number of animals and in all cases are mere lesions.

A complex system of cardiovascular innervation has been demonstrated in the heart of several mammals and birds. Tcheng (1951), Baird and Robb (1950), Rosai (1955) and several other investigators studied the intrinsic cardiac innervation in mammals. It is generally held that the cardiac nerve elements are both sympathetic and parasympathetic in origin. In addition to these, highly differentiated corpuscles have been reported in the heart of many vertebrates. In some cases these have been associated with the cardiac conduction and cardiac metabolism.

There is much controversy whether or not the specialised cardiac conducting structures are supplied with nerves. Truex
and Copenhagen (1947), Davies, Francis and King (1962) and Halpern (1965) observed nerve fibres in the specialised cardiac conducting muscles. Contrary to these observations, Baird and Robb (1960), Glomset and Corsa (1952) and several other recent workers noted the complete absence of nerves or nerve fibres in the atrioventricular bundle or atrioventricular node. In view of this controversy, it seems necessary to examine the relationship between the cardiac conducting structures and the cardiac innervation system. Moreover, the available literature indicates that more attention has been paid on the study of mammalian cardiovascular conduction and innervation than on other classes of vertebrates. Dearth of information in lower vertebrates makes it difficult to arrive at a conclusion on the phylogeny of the cardiac specialised conducting muscles and innervation system.

Since the heart is supplied with both sympathetic and parasympathetic nerve fibres, it is not conclusively known which type of nerve fibres are efferent and afferent in their role of conduction. Davies, Francis and King (1952) alleged that the bipolar cells are afferent while the multipolar cells are efferent in function. Many other investigators believe that there is no distinction between the afferent and efferent nerve fibres of the heart.

Haray (1962) in the tissue culture of the heart of rat reported that cells believed to have been derived from the specialised conducting tissue beat spontaneously while the cells derived from the other cardiac tissue beat only in contact with the cells of the conducting system. The experiment of Haray (1962) indirectly
suggests that the specialised conducting structures possess the inherent power of contraction.

The process of cardiac conduction in vertebrates still stands in a state of controversy and serious discussion. Divergent and conflicting views are expressed on this subject. It is, therefore, imperative that a careful consideration should be given to the various aspects of this problem. According to Bossi (1955) the only proper procedure for studies concerning this question is the combined examination of both the nervous and muscular structures of the septa. Both myogenic and neurogenic structures related to the cardiac conduction have been examined in the present study. The dual nature of the cardiac conduction on account of the cardiac nerves and cardiac specialised muscles has also been considered as a probability.

Isolated researches have certain limitations and they create many controversies and confusion. This has been particularly true of the cardiac conduction. In the present investigation, therefore, an attempt has been made to study this problem without prior assumptions to avoid futile controversies. The comparative anatomy of the vertebrate heart highlights a progressive trend in evolution from lower to higher vertebrates. How far this trend in the structures of the conducting and innervation system of the heart is manifested is yet to be ascertained.