CHAPTER II.

MATERIAL AND METHODS.

The adult muscular systems of the following representative species of chief insectan orders have been studied, sketched, described and compared.

1) Thysanura.
   .. Lepisma saccharina, Linn.
2) Ephemeroptera.
   .. *Heptagenia diabasia*, Burks.
3) Odonata.
   a) Zygoptera.
      .. Lestes alata, Hagen.
   b) Anisoptera.
      .. Anax immaculifrons, Rambur.
4) Dictyoptera.
   .. Periplaneta americana, Linn.
5) Isoptera.
   .. Odontotermes assimuthi, Holmgren.
6) Orthoptera.
   .. Sathrophylia flmorata, Fabr.
7) Heteroptera.
   a) Gymnocerata.
      .. Cyclopelta sicifolia, Westw.
   b) Cryptocerata.
      .. Ranatra elongata, Fabr.
8) Neuroptera.
   .. Myrmelao singulare, Westw.
9) Hymenoptera.
   .. Apis dorsata, Fabr.

*(In the case of the ephemerid type the muscles of the head appendages are studied in the nymphal forms, since the mouthparts and their muscles degenerate in the imaginal stage).*
The muscular system of all these insectan types were investigated by dissections under a binocular microscope. The dissections were made of specimens fixed in chlor-picro-acetic fixative and stored in 70% alcohol to which a little quantity of glycerol was added. This fixative stains the muscles slightly yellowish and it also causes the shrinkage of muscles, thus separating them from each other when they are contiguous. It does not cause them to break away from their attachments until dislodged with instruments.

The sketches were made directly from the dissections; but the semidiagrammatic and semischematic method has been adopted while sketching the disposition of lateral and pleural musculature, since these muscles are too numerous.

The nomenclature used for the various complementary muscles (muscle groups recognisable as morphological and seemingly functional entities) throughout the present work is the one given currency by Snodgrass (1935). In addition, these muscles are also indicated by numerical denominations,
since this was found to be more useful while illustrating the sketches. Further, the terminology and denominations employed by Matsuda, (1965, 70) for the corresponding muscles or muscle-groups are also indicated in parenthesis wherever found necessary.

In order to make the comparative mylogy of the above listed insectan types more intelligible and interesting, emphasis is mainly placed on the detailed study of the individual complementary muscles (muscle groups recognisable as morphological and seemingly functional entities). The role of these various muscles in operating the cephalic and thoracic appendages, the flight mechanism, and of abdominal muscles in effecting the respiratory, circulatory and ovipository movements are studied purely from the anatomical view-point. It was hoped that this will help in understanding the major evolutionary trends in the hexapod muscular patterns as typified in the above-listed representatives of the different insectan groups.

However, it is recognised that the determination of the homology of various complementary muscles purely on the basis of comparative studies is not absolutely reliable. As Matsuda (1965) says, "the concept of homology, which denotes the continuity of structures in phylogeny must be a matter of probability as long as our method of study is
confined to the comparison of existing forms. Therefore in the present work attempt made has been extensive enough to obtain somewhat higher degrees of probabilities. In the process, however, various authoritative works in the field of comparative insect morphology and embryology and the works on innervations of the muscles have been also consulted, when required.

It is quite implicit in the above that the homologization of muscles require clear understanding of the conventional phylogeny of the insectan groups. In doing so, the scheme of insectan evolution, drawn after consulting the excellent works of the following authorities (PLATE NO. 1) is followed— Handlirsch (1906-8 & 1930); Tillyard (1918-20, 1926, '30, '31, '30-35); Carpenter G.H. (1928); Imms (1936, 49, '61); Lemche (1940-42); Wigodzinsky (1941); Ewing (1942); Chen (1946); Jeannel (1949); Carpenter F.M. (1947, '53); Hennig (1953); Shrock (1953); Remington (1954); Teigs and Manton (1955); Ross E.H. (1936, '37, '55); Ghararov (1956); Hockett (1957); Hinton (1958); Chapdivick (1959); Easton (1960); Wille (1960); Kukalova (1960); Rodendorf (1962); Ross M.H. (1964); Sharov (1966); Carpenter and Richardson (1968); Manton (1972). However, as and when this work is deemed to throw new light, the consequences on the phylogenetic relationships among orders of insects are discussed. In the process, Hennig's (1953) terminologies are employed.
The various observations and the discussions are presented in three parts as follows —

Part I - deals with the muscles of the head appendages.
Part II - is concerned with the thoracic muscles.
Part III - pertains to the muscles of the pregenital abdominal segments.

Finally, the conclusions reached are presented summed up in distinct units.