INSECTS AND OTHER ARTHROPODS OF MEDICAL IMPORTANCE

Edited by Kenneth G. V. Smith

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With contributions by

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FOREWORD

THE present work replaces *A Handbook for the Identification of Insects of Medical Importance* by John Smart, first issued in 1943. Smart's book went through four editions and proved very useful to medical entomologists and to students generally. The text was written during the Second World War to fill a need felt by the many medical entomologists employed in the tropical war zones of the Old World. Insects of the Americas were largely omitted.

The original book was, to a great extent, prepared entirely by Smart himself, adapted from the specialist literature, with chapters on fleas by Karl Jordan and on arachnids by R. J. Whittick. Many of the figures were from published works but the numerous new ones, mostly prepared by Arthur Smith, were all of the highest standard. Since 1943, however, the nature of medical entomology has changed considerably and fields that were of lesser importance at the time have now assumed greater prominence. An entirely new book seemed necessary with a rather different approach.

On considering the preparation of a new manuscript, it was obvious that, whilst retaining identification as the main purpose, it would be desirable to bring in more discussion on the biological and medical side. In 1943 it was still possible for one man to prepare the major part of the manuscript. This is no longer practicable and to give an adequate consideration of the rapidly changing scene in medical entomology with ~~its~~ complex zoonoses and disease-distribution problems, it was decided to invite specialists to contribute chapters on their own groups, under a general editor. I am glad to say that we received a most enthusiastic response from all the specialists we approached.

The work is now expanded to include the whole world and fuller treatment of groups of minor medical importance is given. The original book included keys to all stages of species of Anopheline mosquitoes known from the Old World, but in a group in which knowledge changes as rapidly as in the mosquitoes, such keys seem out of place nowadays. Instead, Dr Mattingly has prepared entirely new keys to mosquito genera on a world basis. A fuller treatment has been given to arthropods other than insects, and the title altered accordingly.

The work is intended primarily for identification and as a stepping-stone to the specialist literature, and to serve this end extensive bibliographies are given. In preparing the bibliographies, we have had in mind the needs of the student and of the younger medical entomologist working in the field, often isolated from major libraries. For this reason, many important references are cited even if they are not specifically mentioned in the text, and in addition, as far as possible all recent important works have been added right up to the time of going to press.

We have been very fortunate in being able to call on the services of Kenneth G. V. Smith to act as general editor. Not only has his extensive knowledge of Diptera been of great value, but it has been mainly through his drive and determination that the book has been published at all.

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EDITOR'S PREFACE

In a work of this sort it is inevitable that there will be some overlapping of subject matter, but I have been at pains to see that each chapter stands as an entity, although adequately cross-referenced. Further, as far as possible, authors have not been restricted in their approach or in the length of their contributions. Thus, where no recent comprehensive account of a group exists (e.g. Simuliidae), a fuller treatment is given than where such comprehensive studies are available (e.g. lice, cockroaches).

The chapters and sections are arranged approximately in order of medical importance of the group, and within a rough taxonomic framework for the Diptera. A full general index gives page reference to all mention of an animal or disease and a separate index is given to all authors cited which should facilitate use of the bibliographies. Finally a vector table is given, arranged under the insect orders rather than the usual arrangement by disease, and illustrated by distribution maps for some typical diseases.

The co-operation of the contributors has lightened the editorial task considerably, and I thank those of my colleagues who have shown so much interest in the work as a whole, over and above their own particular chapters, especially R. W. Crosskey, P. Freeman, D. J. Lewis and P. F. Mattingly.

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Illustrations are such a valuable feature of a work concerned primarily with identification and for those not prepared by the contributors we thank Dorothea Baker, M. Druckenbrod, Thelma Ford, Maureen Grogan, Alan Palmer, Arthur Smith and the late A. J. E. Terzi.

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Kenneth G. V. Smith

August, 1971

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1. INTRODUCTION

by Paul Freeman

GENERAL

INSECTS belong to the great group or Phylum of invertebrate animals called the Arthropoda. This group comprises at least 85 per cent of all known species of animals and includes such familiar forms as crabs, shrimps, spiders and centipedes, as well as the true insects (Insecta).

The Arthropoda have the body divided into separate rings or segments, each of which may bear jointed limbs. The whole of the body and limbs is covered by a cuticle, hardened areas of which form an exoskeleton, with flexible connecting membrane between the segments allowing movement. The cuticle contains chitin. The heart is dorsal and the body-cavity is a haemocoele; the central nervous system consists of a ganglionated ventral nerve cord, linked to a ganglion above the oesophagus, often referred to as the brain.

The Insecta (fig. 1) are the largest Class of the Arthropoda and adult insects possess the following characteristics:—

1. The body is divided into three regions: head, thorax and abdomen.
2. The head carries one pair of antennae only, one pair of mandibles and two pairs of maxillae, the second pair fused medially to form the labium.
3. The thorax carries three pairs of walking legs and usually one or two pairs of wings.
4. The abdomen has no walking appendages.
5. Respiration is by means of ramifying tubes or tracheae connected to the exterior by openings or spiracles along the sides of the body.

Larvae of the more advanced insects may be profoundly different from the adults and in particular, structures such as wings, legs, compound eyes, mouthparts and external genitalia are either entirely absent or considerably modified.

The other main groups of Arthropods, none of which possess wings, can be distinguished from Insecta as follows:—

1. *Crustacea* have two pairs of antennae and at least five pairs of legs; when the body segments are grouped, they are arranged in two regions only (e.g. lobsters and shrimps). Respiration is never by tracheae.
2. *Arachnida* have no antennae and four pairs of legs; the body segments are either grouped in two regions or are fused into an unsegmented whole. Respiration may be by tracheae or by 'lung-books'.
3. *Diplopoda* (Millipedes) have a single pair of antennae, the body trunk not differentiated into thorax and abdomen and each apparent segment carrying two pairs of legs and two pairs of spiracles; respiration is by tracheae.

4. *Chilopoda* (Centipedes) resemble Millipedes superficially but each segment is a true segment and thus carries only a single pair of legs and spiracles. The first pair of legs is modified to form poison claws.

More than three-quarters of a million insect species have so far been described and many more remain to be discovered. It is thought that the final figure for existing species may be nearly two million. They are amongst the most abundant living animals and have successfully colonized practically all terrestrial and freshwater ecological niches; a small number have succeeded in adapting themselves to life below the high tide mark and a very few to the open sea.

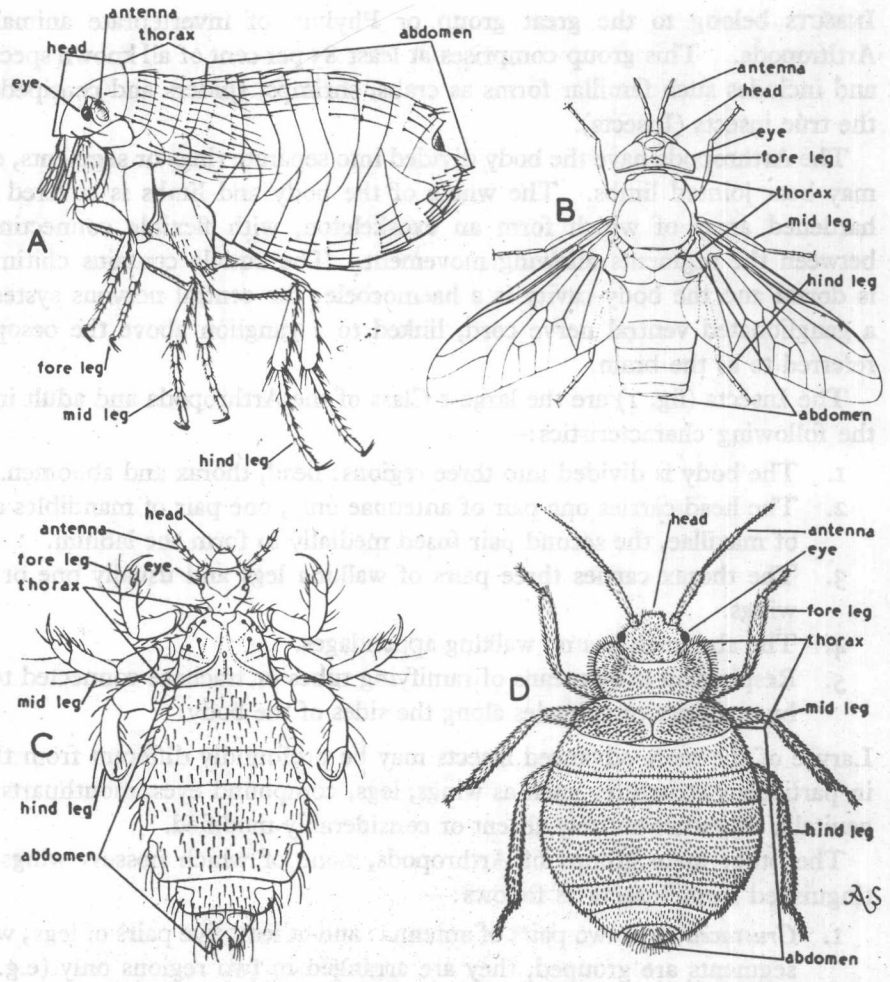

Fig. 1 A, Human flea (*Pulex irritans*); B, Horse-fly (*Chrysops*); C, Body louse (*Pediculus humanus* var. *corporis*); D, Bed-bug (*Cimex lectularius*) (various magnifications).

Insects are one of man's main competitors and many species impinge directly upon his activities. A considerable number are active transmitters of various diseases, of which malaria is perhaps the best known; others, such as the house-fly, are more passively involved.

In addition to the true insects, the Arachnida also include many pest species, a number of which may carry diseases. It is usual for books on medical entomology to cover these and a chapter has therefore been included to give some account of their structure and classification, with details of the groups of medical importance.

DEVELOPMENT AND LIFE HISTORY OF INSECTS

Most insects start life as eggs laid by adult females following mating with adult males. Occasionally the eggs hatch before being laid, so that the female appears to lay larvae. Other insects are able to lay unfertilized eggs that hatch normally (parthenogenesis) and in still other, much rarer cases, immature forms may reproduce (paedogenesis). On hatching, young insects may resemble the adults in general features, e.g., young cockroaches, or they may be very different, e.g., caterpillars and fly maggots. Young insects, with the possible exception of mayflies, never have functional wings, since these are only found in the adults.

As in the adult, the young insect is covered by a chitinous cuticle, with hardened parts and plates. The softer parts are provided with a loosely fitting and folded superficial epicuticle which allows room for growth. The more rigid parts such as mandibles and legs have no room for growth after their initial hardening. When the limit set by the extensibility of the epicuticle and the size of the harder parts, is reached, the inner layers of the old cuticle are dissolved from within and a new cuticle, a size larger, is laid down beneath the old one. After an appreciable thickness of new cuticle has been laid down, the old cuticle is ruptured along definite lines of weakness and the insect gently withdraws itself from the remnants of the old skin. The new skin in turn becomes extended to its limit and is cast off, until, after a series of such moults or ecdyses, maturity is reached and, normally, growth ceases.

The life cycle of an insect may be divided into three distinct phases: (1) the egg; (2) the growing stage, or larva; (3) the adult or imago, when it becomes sexually mature. In the higher Orders, where the difference in form and habit between larva and adult is great (as between a maggot and a blue bottle, fig. 6), there is an intermediate quiescent stage, called the pupa. In those Orders of insects in which the young resemble the adults in form and to some extent in habit, and in which this pupal stage is not present, the young insect is usually termed a nymph. Some entomologists do not use the term nymph, but refer to all as larvae. The changes of form through which an insect passes are collectively termed metamorphosis.

With a few rare exceptions, it is only in the adult stage that insects are sexually mature and capable of reproduction. With the exception of some of the very primitive insects, moulting ceases with sexual maturity. The young stages are usually voracious feeders, the adults are more concerned with reproduction and seeking new feeding grounds for their young.

The young stages of many insects live in places quite different from those in which the adults are found. Thus, mosquito larvae are aquatic; whilst many fly maggots live and grow in decaying flesh and other putrid matter. Invasion of quite different habitats by the young stages has become possible with the evolution of metamorphosis.

THE STRUCTURE OF INSECTS

General

Insects are invertebrate animals and thus do not possess an extensive internal skeleton to give support to the body and attachment to the muscles. Instead, these functions, as in other Invertebrata, are mainly performed by the thickening and hardening of the integument, more particularly of the outer layer or cuticle. The thickening is not uniform and continuous, otherwise complete rigidity would ensue, but takes the form of a series of plates, or sclerites, linked by thinner, membranous connective cuticle allowing flexion. When great muscular effort, such as that involved in flight, is not needed, the cuticle may remain relatively soft, and rigidity of the body is then derived from the interplay of muscular tension on the cuticle on the one hand, and the internal pressure of the body fluid brought about by this tension on the other. Such soft-bodied forms, which include many larvae, usually have the integument of the head thickened and strengthened giving a framework for the attachment of the muscles operating the mouth-parts.

The basis of insect cuticle is chitin, which is a fibrous nitrogenous polysaccharide. Chitin by itself is not a suitable covering for a terrestrial animal, although being tough and flexible it is well suited to provide hinges or joints between segments. In most insects the greater part of the cuticle undergoes a hardening process called sclerotization, which is brought about by the deposition of sclerotin. Sclerotin is an extremely strong skeletal substance and is formed by the addition of protein to the cuticle and by its subsequent tanning, which converts the protein to a cross-linked plastic. Parts of the cuticle thus thickened and hardened are spoken of as being sclerotized and the whole integument is said to form an exoskeleton.

The cuticle extends to some internal organs that are of ectodermal origin; these include the proctodeal and stomodeal regions of the alimentary canal, the lower ducts and certain accessory organs of the reproductive systems of both sexes and the tracheae of the respiratory system. In these parts, since they originate as invaginations of the ectoderm, the cuticular surface is a lining, i.e., it is internal in relation to the particular organ under discussion. In some parts of the body, the integument becomes invaginated and hardened to form a rigid endoskeleton which supports certain organs and provides for the attachment of muscles. The separate parts of such an endoskeleton are termed apodemes.

The surface of the integument may carry a variety of scales (which are flattened), hairs, spines and bristles. Scales, hairs and bristles are alike in that they are articulated to the body surface and when one is broken off, the articulation can be distinctly seen in the form of a pit-like mark termed an alveolus. These articulated hairs, etc., are also termed setae or macrotrichia. The minute hairs on the wings of many insects and on the general body surface are termed microtrichia and are not articulated to the surface by an alveolus. Spurs on the legs of many insects are large hairs differing in origin from the macrotrichia but similar to them in that they articulate in alveoli. The sclerotized cuticle may be drawn out into spines, horns, knobs, etc., which naturally do not have alveoli at their bases; it may also be sculptured and coloured in such various