

complete specialization for boring, but in the flattened form of young and adult show adaptation to the particular portion of the tree which they affect. The bark beetles present a somewhat different condition, but are no less distinctly specialized for their particular habitat. They live for the most part between the bark and hard wood and construct intricate tunnels sometimes of most peculiar pattern, and frequently occasion very great injury to the trees infested. The habit in these different groups has very evidently been reached by entirely independent routes and the lines of adaptation must be traced in each group separately. Often the particular steps of adaptation are very beautifully shown in the series of species which illustrate the divergence from external leaf eating forms to those which are most perfectly fitted for living within the plants.

Of the Hymenoptera the horn-tail borers are the most distinctly specialized in this direction, and these show a derivation from the leaf feeding saw-fly forms. The ants and bees which burrow into wood or into the stems of plants show certain other forms in which the habit has been adopted by isolated small groups, but not adopted by the larger divisions.

THE PARASITIC PATHWAY.

In the direction of parasitic life some groups of insects have traveled very far and show almost as distinctly as any group of animals the effects of the parasitic life. So numerous are the examples in this line that we must select only a few of those which are most specialized or which illustrate most perfectly the lines of derivation for the habit. In the Mallophaga we have a group in which the parasitism is distinct for all the known species and in which the result of parasitism is shown in the entire absence of wings and in the very perfect adaptation of clasping organs in the feet. In their mouth parts and other structure, however, they show very perfectly their derivation from some psocid ancestor, and by selecting series of genera we can trace quite clearly the different steps in adjustment from forms which are but slightly parasitic to those which are most extremely dependent upon their attachment to a host. In some cases migration from one kind of animal to another is possible and probably frequent, but in other species more strikingly specialized there is a most rigid restriction to a single species and absolute dependence upon the association of individuals in that species for its distribution and survival.

The bot flies illustrate remarkably well the degrees of specialization in the parasitic life, the sheep bot which lives in the frontal sinus of the skull representing a much less important departure from a non-parasitic form than the horse bot which lives within the stomach and must be adapted not only to a special mode of nutrition but to a particular limitation in the matter of respiration, a feature which goes still further in the case of the ox bot with its circuitous route from egg through alimentary tract to its final resting place beneath the skin. We cannot conceive this latter form of adaptation except as a derivation from the more simple form of parasitism, and our classification in this group may well take this into consideration. A particularly extreme form of parasitism with the results of parasitic life is exhibited in the sheep tick and its allies where there has been not only a striking modification of the structures of the body, but a profound modification in its mode of development. In this it shows an extremity which is perhaps not exceeded by any other group of animals though paralleled by the parasitic Stylopidae, and in every detail of which we must recognize the effect of the parasitic life. The other forms of parasitism such as the occupancy of the nest of bees by flies or other species of bees which occur in a bewildering number of intricate forms cannot be dwelt upon here. The remarkable adaptations of such parasitic forms as the Ichneumons and Chalcids in their adjustment to plant lice and scale insects, and the egg parasites in their extreme adjustment to the completion of a life cycle within the minute egg of some other species of insect, cannot fail to occur to all who have become at all familiar with the complexities of insect life.

I may perhaps be permitted to further illustrate this idea with one other example drawn from a group which has been one of my special studies. The Pediculidae are, I will grant, a not very popular division of insects and yet in some of their adaptations and in the long course of parasitism which they seem to have undergone, they give us some of the most positive evidences as to the effects of the parasitic habit and also as to their course of evolution. We may readily appreciate their long adoption of the parasitic habit when we consider the wide divergence they show from other groups of insects, and the range of their hosts, and yet we must assume beyond question that their establishment as a parasitic group has been subsequent to the evolution of the group of mammals of which they are exclusively parasites.

I have elsewhere indicated my belief that the group originally came from some division of the Heteroptera and I am still skeptical concerning the recent attempts to relate them to Mallophaga, but for the present study this point is not essential. Granted a primitive form assuming the parasitic relation to some primitive mammal and we have the materials on which to construct a tentative phylogeny which we may test by such evidences from morphology, distribution and habit as may be available.

There are of course at least two plans on which we may account for the present distribution of the species of this family. One that the primitive parasitic form appeared at some time in the early history of the mammalian stem and that its subsequent history and the divergence of the various species has gone along parallel with the divergence of the host forms; the other that it appeared much later in history after the establishment of the mammalian groups and that from an establishment on some one group of animals it migrated to other mammals and the various species developed on new hosts by more recent evolution. The fact that most of the species have a single host to which they are restricted gives unusual opportunity to test any theory of evolution.

Confining ourselves to the Pediculidæ, although it would be interesting also to examine the relation of the Polyctenidæ occurring on bats, we have a group showing very clearly a common origin and possessing some very homogeneous characters, the most evident the single jointed rostrum and the single clawed tarsi. The separation of the genera has always seemed somewhat arbitrary and based as a matter of necessity in such simple forms on rather trivial characters, but some of these characters take on entirely new significance if correlated with the distribution of the genera with reference to their hosts.

It will be noticed from the diagram (Pl. II) that the groupings of these parasites bear a distinct relation to the main divisions of the class of Mammalia. While this is not presented as an accurate statement of the phylogeny of the mammals, nevertheless it represents the remoteness of some of these groups and illustrates something of the possible relationships between them. Assuming that the primitive parasitic group established itself on a primitive mammal, we can follow the divergence of the different groups with considerable assurance. There is a distinct type belonging to the group of rodents, another for the insectivora, another for

the ungulates, still another for the elephant, and a group covering the primates. Comparing these it appears that the ungulate and primate groups have really a closer relationship than either of these with the rodent forms, although in existing classifications the ungulate and rodent forms are embraced within the same genus. It appears to me more in accord with the facts, especially if we take into account this distribution and habit, to separate the rodent forms, and this will necessitate the forming of a new genus.

Clasping organs show distinct types for a number of these groups and quite varied forms in such apparently nearly related species as those affecting Horses, Hogs, Cattle, etc. The Insectivore type is extreme and introduces new features.

We have traced a few of the many lines of adaptation that have been followed by the groups of insects in their adjustment to the many and varied conditions of life; adjustments so numerous and so perfect that insects are today not only the most numerous in species but fitted to a greater range of conditions than any other class of animals. We certainly should take account of these different conditions in our systems of classification if we hope to have them represent the true relationships in nature. We should use the lines of divergence in habit to point the way to natural affinities. Distinct morphologic changes are almost invariably associated with adaptations, if indeed, they are not the direct response to these adaptations, and hence when habit, distribution, function and structure are read together, we should, if reading correctly most nearly approach the rational arrangement of groups.

I would not be understood as ignoring the fact that this principle has been recognized in the past. Such names as *Phytophaga* and *Parasitica* in Hymenoptera, *Phytophaga*, *Mycetophaga*, *Hydrophilus*, *Gyrinus*, *Cryptophagus*, etc., in Coleoptera, or such specific names as *aquaticus*, *arborea*, *sub-terraneus*, *cavicola*, etc., testify to due appreciation of habits by many systematic workers. But I wish to emphasize my belief that this principle may be used to advantage not only in tracing larger phylogenetic lines but in solving the perplexities of specific affinities among the minor taxonomic groups.

Students of animal behavior and psychology are beginning to associate the differentiation of groups with psychic characters, and such a claim as physiological species is not new even to ento-

mologists. It is evident that if systematists would keep their field of work abreast with the movements in other lines it will be necessary to take into account all the factors that may seem to give evidence as to affinity.

It should be clearly appreciated, however, and I think will be recognized by entomologists as quickly as any body of naturalists that habit is only one factor, that while it has had a determining influence in producing structure it has so frequently occurred in parallel lines in different groups that fundamental structures based doubtless on the more remote habit, must be taken into account. To ignore this would carry us back to such inconsistencies as placing whales with fishes, or the parasitic insects, fleas, lice, bird-lice, etc., in one group, Aptera. We must fully determine the significance of the deeper adaptations as revealed in more fundamental character along with the superficial modifications of more recent habit.