INTRODUCTION

COLLECTION AND PRESERVATION

Fleas may be collected directly from the mammalian and avian hosts or their nests, runways, or burrows. In many instances certain species have been taken in sweepings and debris on the ground. Nests should be collected very soon after the young leave and each placed in a paper bag, or better under a bell jar where they can be watered occasionally to prevent drying out. If watered occasionally the immature stages continue to develop making it possible to obtain numerous specimens in all stages of development.

The hosts, themselves, should be captured by traps which take them alive, for fleas will soon leave the dead animal. After capture, the animal is anesthetized or killed by ether or chloroform and its ectoparasites dislodged by searching through the pelage with forceps or by combing with a fine-toothed comb. Taking the animal alive allows no opportunity for escape of the fleas, and thus best results are obtained. Under usual conditions, however, it is much more convenient to run traps which kill the animal. While a large percentage of the fleas are no doubt thus lost, a sufficiently large number remain to make this type of trapping worthwhile. Common mouse traps or guillotine traps may be used successfully to procure small animals such as wood mice and shrews. When abundant, rats and squirrels may be shot or even clubbed.

If possible, the dead animal should be placed immediately in a paper bag and carried to the laboratory where it can be examined under a binocular microscope. By this method not only fleas, but also lice, mites, and ticks can be collected. If an animal is heavily infested, it is helpful to stupefy its fleas with an insect powder, collecting them from white paper after combing the fur. Public health workers have found it easy to collect fleas from rats by placing the recently killed animal on a grating over water; the fleas in leaving the dead host jump into the water from which they may be collected readily.

Fleas are prepared for study by mounting in Canada balsam on glass slides. To accomplish this, various techniques have been used with good results. Soft parts and intestinal contents must be cleared before the important genitalia can be studied.

Hence, it is customary to use 10% potassium hydroxide in water to dissolve the unsclerotized structures. It is best not to boil the KOH, but to use it cold and allow action to go on for a day or two. Care should be taken not to allow the caustic to act too long, for it will distort, or even dissolve away entirely, important taxonomic structures. After its removal from KOH, the material is washed in water and dehydrated by use of several degrees of alcohol. If the material is to be cleared in xylol or oil of cloves, it is best to run it through two changes of absolute alcohol. The absolute alcohol may be eliminated, however, if beechwood creosote is used as a clearing agent.

The writer makes use of the following technique which reduces the entire procedure to six steps:

1. Drop living flea (or one which has been killed in alcohol) in KOH 10% in water. Allow to remain for a day or two.
2. Transfer to water to which a few drops of HCl have been added. Allow to remain for one-half hour.
3. Dehydrate by running through 50% alcohol and
4. 95% alcohol for one-half hour each.
5. Clear in beechwood creosote for one hour.
6. Mount in Canada balsam.

It is essential to label adequately. Two labels are generally used for each glass slide. One, placed to the left, bears the name of the flea and by whom it was determined; the other, placed to the right, bears the name of the host, the locality, the date, and the collector's name.

MORPHOLOGY AND TERMINOLOGY

The body of the flea, like that of all insects, is divided into head, thorax, and abdomen, and each of these regions is of importance in taxonomy. In the suborder Fracticipita the head is subdivided by a dorsal sulcus extending from the place of insertion of the antenna on one side across the dorsum to the place of insertion of the antenna on the other side. The fleas of the suborder Integricipita, however, have no such sulcus, although there may be a highly sclerotized thickening extending from the top of the antennal groove to the dorsum of the head. Antennae, one on each side, are situated in antennal grooves which set off on the head a preantennal region and a postantennal region, each of which may be armed with bristles the arrangement of which is of great aid in classification. The upper

portion of the preantennal region is called the frons, while the lower portion is known as the gena, but there is no distinct line of demarcation between the two areas.

In many genera the frons is notched or tuberculated, the anterior margin of the head bearing a notch or tubercle called the frontal notch or frontal tubercle. Frequently the gena is prolonged below and posterior to the eye into a heavily pigmented, highly sclerotized genal process, which may in some cases be difficult to distinguish from a spine of the genal ctenidium. Simple eyes, one on each side, are located near the third antennal segment; they vary in size and in prominence, being heavily pigmented and conspicuous in some groups, while vestigial or absent in others. When the preantennal region is armed with two rows of bristles, the lower row is called the ocular (genal) row, and its first bristle is termed the ocular bristle; the upper row is frequently designated as the frontal row. A conspicuous structure of the head, when it is present, is the genal ctenidium which consists of heavily pigmented spines. With the exception of the labial palpi, the mouthparts are of little systematic value. Each labial palpus (there are two) is variable in length and in the number of its segments; but the value of this variation is not the same in all groups, being of only specific importance in some cases while generic in others.

The thorax is of systematic importance because of the chaetotaxy of its sclerites which are formed as follows. Each segment (pro-, meso-, and metathorax) is divided into a dorsal notum or tergite and a ventral sternite. A vertical, rodlike sclerotization divides the meso- and metasternite into an anterior sternal portion and a posterior epimeron. The sternal portion is further divided into a lower part, the sternite, and an upper part, the episternum. The epimeron of the metathorax is broad and overlaps the abdomen supplanting the first abdominal sternite. The legs, with the exception of the tarsi, are of only occasional taxonomic importance. Each tarsus is armed on its fifth segment with plantar bristles whose position, whether lateral or ventral, and number are significant in generic delineation. A conspicuous feature of the thorax is the pronotal ctenidium, present in most groups but absent in some, which usually consists of long slender spines variable in number according to the group.

The abdomen is of importance to taxonomists largely because of the number of rows of bristles on each segment, the antepygidial bristles, and the genitalia. Each segment consists of

a dorsal tergite and a ventral sternite. The seventh tergite usually bears one or more stout bristles on each side, the antepygidial bristles, which are of great systematic importance because of their variablity in the different groups.

The genitalia of both sexes are of tremendous taxonomic importance. In the male they have evolved in part from the ninth abdominal segment, the tergite forming the clasper. Each clasper (there is one on each side) consists of a broad plate which ventrally is prolonged to form a manubrium and dorsally bears a conelike protuberance known as the process of the clasper. Articulated to the clasper on each side of the body is a movable process called the movable finger (exopodite, according to some authors) whose shape and size are very significant. Sometimes both processes are movable, but in most instances the arrangement is as described, with only one process capable of movement. The ninth sternite, which forms the lower clasper, has the shape of a boomerang since it consists of an anterior or vertical arm and a posterior or horizontal arm (also called the ventral arm). The penis is long and bladelike and bears posteriorly a paramere which in certain groups is very significant in classification. Below the penis is the spring which may be long or short and, if long, is frequently coiled distally. In the female the shape of the seventh sternite is of great importance, particularly if its posterior margins are sinuate or entire. The form of the heavily sclerotized receptaculum seminis, consisting of a head and tail, is also of great significance.

For illustrations of the structural terms discussed above, see Plate I.

LIFE HISTORY AND CONTROL

Fleas undergo complete metamorphosis involving four distinct stages—egg, larval, pupal, and adult. The eggs, larvae, and pupae are residents of the nest of the host and not parasitic, according to most authors; the adults, however, feed exclusively on blood. The eggs are laid by the adult female either in the nest of the host or among its hairs or feathers without any agglutinating material to keep them attached; hence, they are easily shaken off into places where the host sleeps or rests.

The rate of development of the cream-colored, oval eggs varies among the different species and also depends in a large measure on temperature and humidity. When the eggs hatch they give rise to white or yellowish larvae which are cylindrical in shape and very slender. The larvae are very active,

squirming about and feeding upon the organic debris in which they live, particularly the excreta of the adults. In structure they are more or less maggot-like, legless and eyeless. The body as a whole is divided into a head, three thoracic segments, and ten abdominal segments which are richly provided with bristles. When ready to pupate (after two moults according to many authors) the mature larva spins a silken cocoon covered with dust and attached to the substratum. Within this cocoon the pupa develops, and in the later stages of its development the species can frequently be identified. The length of life of the mature flea varies with the species and with conditions. Certain species are exceedingly hardy and are capable of going without food for unbelievably long periods. Bishopp (1931) states that during the summer the average longevity of the human flea without food is about two months, of the dog flea somewhat less, and the sticktight flea still less.

The fleas which have proven themselves pests in the East are the human flea, the dog and cat fleas, the two chicken fleas, and the oriental rat flea. When these are in human habitations, they usually originate from the sleeping places of animals. If they are in hog pens, barns, cellars, outhouses or beneath buildings the most effective control is spraying with creosote oil, according to Bishopp (1937), and usually one light spraying will wipe out an infestation. Since creosote oil is objectionable because of its odor and causticity, it is desirable to use some other material for controlling fleas in living quarters. The scattering of flaked naphthalene over the floor of each infested room at the rate of five pounds per room has been recommended.

Dogs and cats may be kept free of fleas by regularly applying derris or pyrethrum powder next to the skin. Hogs may be kept free of the human flea by sprinkling their backs with crankcase oil or crude petroleum every two or three weeks. For controlling the sticktight flea on chickens, dogs, and cats, it is necessary to bring derris powder or carbolated vaseline into actual contact with the fleas. Rat fleas and ground squirrel fleas can be controlled only by campaigning against their hosts. This may take the form of complete elimination of the animals by fumigation, poisoning, trapping, or shooting, or by rat-proofing buildings where rats can obtain food and shelter.