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Final Report on

"Insects and Other Animals of Interest to the Quartermaster Corps"

by

Charles H. Blake
with collaboration of
Henry D. Russell

Div 11
OEMsr 888
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NATIONAL DEFENSE RESEARCH COMMITTEE
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Final Report on

"Insects and Other Animals of Interest to the Quartermaster Corps"

Service Directive QMC-22

Endorsement (1) Lawrence W. Bass, Special Assistant to the Chairman of NDRC

"This report represents an exhaustive compendium of insects that have been reported to cause damage to articles of the character represented by Quartermaster items. The various indexes should make it a very valuable reference work on such questions. The information which it contains will doubtless stimulate and facilitate research on certain definite problems encountered in the handling of Army supplies in the field."

This is the final report under contract OEM sr-888 with Massachusetts Institute of Technology.

INSECTS AND OTHER ANIMALS OF INTEREST TO THE QUARTERMASTER CORPS

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by

Charles H. Blake, Ph.D.
Associate Professor of Zoology
Massachusetts Institute of Technology

with the collaboration of

Henry D. Russell, Ph.D.

Being the report on a project carried out under the auspices of the National Defense Research Committee.

September, 1943

PREFACE

No two investigators would precisely agree on a list of animals of interest to the Quartermaster Corps, although, obviously, everyone would agree on a certain minimum list. The basis of the following report represents necessarily, to a considerable extent, my own personal reaction to the problems as I see them, and I can merely hope that my reactions have not been abnormal. I have felt free throughout the work to make choices between inclusion and exclusion. For example, I have included a considerable number of beetles that are fairly certain to be purely predacious, and therefore, actually beneficial, but the data at hand is not sufficient to prove this point. On the other hand, I have excluded all those insects which are of relatively frequent occurrence in connection with grain and wood, but which are known to be definitely parasitic or predacious. What may appear to be a more serious omission is that of the two or three springtails which have been reported in connection with stored products, and a few species of true bugs (Hemiptera). For what appeared to me to be even more compelling reasons I have been frankly eclectic in my consideration of control measures. It seemed useless, for example, to list all of the described ant baits when a simple comparison shows that many of them are extremely minor modifications of others, and there is no clear evidence that the modifications have any real value. I have, therefore, attempted to include those measures whose efficacy is vouched for by a sufficient background of practical experience.

For the most part I have omitted references to the literature. The material in this report is derived from a consideration of material contained in some thousands of papers, which I have examined either in the original or in abstract. Many such papers each contained only a single fact of use.

It has been my hope that this report would serve as a basis for the selection by the proper authorities of a series of control measures and for the establishment of a control organization, which should lead as far as possible to the amelioration of damage from insect attack.

I feel that I should address one word specifically to the gentle reader. This report is in a manner of speaking an 8-ring circus, and I therefore urge the reader to make full use of the Table of Contents and the Index in following up any one line of thought.

There remains the pleasant duty of extending my thanks and appreciation to those who have also labored upon it. My collaborator, Dr. Russell, performed certain very necessary, and it must be added, time-consuming and tedious work. My only regret is that his health did not permit him to continue to the end of the undertaking. He is not to be held responsible for any errors of omission or commission. The actual work of putting the report into typewritten form in its various stages was performed by Miss Frances A. Kerr, Mrs. J. R. Finton and Miss Louise M. Miller.

Note to the Mimeographed Edition

This edition differs in a few minor details from the original typewritten report. All the additions and corrections except two have been embodied in the text. A very few common names have been added, but no essential changes have been made.

It is to be regretted that so many common names of insects as found in print are literary rather than "vulgar". This appears to be especially true of the French names, where the situation is further complicated by the failure to distinguish fundamentally different insects.

The conversion from the typewritten to the mimeographed form has been carried out by Mrs. John G. Whelan.

Charles H. Blake

Cambridge, Mass.
November, 1943

ADDITIONS and CORRECTIONS

Page 124 - lethane is n-butylcarbitol isothiocyanate.

Page 148 - add additional poisons for rat baits, barium carbonate and arsenic trioxide.

INSECTS AND OTHER ANIMALS OF INTEREST TO THE QUARTERMASTER CORPS

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INSECTS AND OTHER ANIMALS OF INTEREST TO THE QUARTERMASTER CORPS

1. INTRODUCTORY

The scope of the present investigation, which is largely, of cours dependent upon the literature, reflects my own conviction that the basic factor involved in insect attack is the insect itself. From the standpoint of the user of a certain product or material, that product or material seems all-important; however, there is so much overlapping of insect attack upon somewhat various materials that in most cases a consideration of the biology of the insect may enable us to protect a variety of materials by a single method. One need only point to the essential similarity of termite attack upon wood, paper, cloth, and even other materials, to demonstrate this point. By the same token, insects fail to recognize any of the dividing lines which for other purposes may be drawn within an organization like the army. As a consequence, I have not confined myself to a consideration only of those materials which are supplied by the Quartermaster Corps. The attack of insects upon materials which would be ordinarily supplied by the Engineer Corps or the Signal Corps may well be instructive, and in addition, the Quartermaster Corps may be expected at some time to do something about such insect attack.

If we must divide the protection of the army against insects into more or less watertight compartments, then it would seem that the only reasonable division is between those insects which attack living organisms, man and animals, and which I leave as the province of the Medical, Sanitary, and Veterinary Corps, and on the other hand, those insects which attack non-living materials, whose control is outside the province of the corps just mentioned.

Aside from the utilization of materials existing in the ordinary published literature, I have drawn as freely as possible upon the variou unpublished and mimeographed materials which have been made generously available to me, and upon my own observations.

1a. The substances considered and their composition.

Since there are in the literature very few direct references to damage to military equipment by insects, it was necessary to consider the substances of which military equipment and supplies are composed and to base the study of the literature on these components. It was also necessary to take into account the various methods used in packing and storing equipment.

In the most general terms everything of animal origin we taken into account, whether food, fur, fiber or adhesive; similarly, all materials of plant origin such as wood, fiber, adhesive or food. In the case of foods, account was taken of the form in which they were likely to be utilized. For example, both fresh and dried meats were included, but for the most part only dried fruits and vegetables. A few native products, for example copra, were included since their presence on or very near scenes of operation could be a source of infestation of imported food. Over and above these more obvious materials a record was kept of all insects attacking certain other substances; metals, rubber goods, synthetic fibres, plastics.

It is rather unfortunate that many of the materials which are listed as attacked by insects are of indefinite or variable composition. This is especially true of fabrics which in addition to the fibre may have finishes of very diverse chemical composition.

In addition to those insects which have been associated with particular substances, I have included a considerable number that are found in buildings although no definite information on their food is available. In almost all of these cases their close relations are known to infest substances of interest to us.

1b. Sources of information.

The primary source of information was Series A of the Review of Applied Entomology (1913- date). Numerous individual references were looked up, so that all essential earlier articles were seen. In addition a number of persons contributed personal data on special points. It is not assumed that every existing item of information was located, but I do feel that no important insect was omitted.

As mentioned above, I have been generously allowed to utilize certain actually unpublished material. Part of this consists of observations which have been recounted to me by other entomologists and by pest control operators over a period of some years. Even more important has been the contribution of the current reports of the regional conferences of the National Pest Control Association, which were very obligingly loaned to me by the secretary of the association, Mr. William O. Buettner. These contain many excellent summaries of existing information in a form which is more usable than appears in any ordinary publication.

1c. Limitations of the survey.

Any survey of this sort is subject to considerable limitations. In the first place, our knowledge of the habits and requirements of animals, especially in the less accessible parts of the world, is extremely deficient. Second, even where we have considerable lists of materials attacked we may not be able to conclude anything with regard to the nutritive requirements of the pest or the purpose which is served by the attack. It is, in fact, probable that in very many cases materials are infested only because they are adjacent to adequate food, or because they attract the insect as though they were food. Third, the development of information with regard to new materials is rather slow. As a consequence there seems to be no information on most of the newer synthetic fibres and plastics. The false assumption tends to be made that such substances, because they are relatively stable and are artificial, are immune to damage. The small amount of data on nylon points out the invalidity of such assumptions. Lastly, the large number of of insects to be considered and the numerous questions which arise in investigators' minds make it impossible, within reasonable limits of time, for one or two persons to carry every line of thought to its ultimate limits.

1d. Kinds of damage done by animals.

Practically all of the insects that we shall have to consider do their damage by the actual biting off and chewing up of the material. Hence, whether or not they digest any of the material, they still effectively remove it. This sort of attack leads to several results.

First, the usable material is actually diminished in quantity Second, a good deal of it which is not digested is ground into powder. This is a very characteristic sort of damage by grain insects. Third, the food is more or less contaminated by excrement and by the dead bodies of the insects. This means that it suffers both in appearance and in flavor.

A few insects, notably roaches, by merely passing over food may leave behind substances of disagreeable odor so that whether or not they have actually attacked the food, it is more or less spoiled.

It often happens, especially with paper and cloth, that damage is found but the culprit cannot be caught in the act. Fortunately from experiments carried out by Dr. H. L. Sweetman we have authentic examples for study, representing some of the more obscure types of damage. The less obscure cases are well known to specialists. However, the busy officer may readily overlook the actual insects, which may be present, particularly if the insects are agile, small in size and few in number.

The evidence which pests leave behind consists of (a) the actual damage, (b) chewed bits of the material (frass), (c) droppings or excrement (which sometimes is almost wholly frass), (d) dead insects, fragments of insects, cast skins of larvae.

The diagnosis of damage is further complicated by the possibl presence of insects which have nothing to do with the damage. Some of these are parasites and camp-followers, a few are looters, and some may even be considered innocent bystanders.

There are four main classes of organisms which do appreciable damage. These are the mammals, the insects and arachnids, and the fungi. Damage by birds is known but is rare and usually highly specialized, such as the caching of acorns in telephone poles.

Damage by mammals is due chiefly to rodents, rats, mice, etc. A few carnivores, bears and wolverines, will break into food stores.

1e. Relations of the animals to the Materials damaged.

Obviously, most of the insects which come into consideration are actually feeding on the materials which are affected. This results, as I have already indicated, in more than one kind of damage. In the case of food, the mere presence of the insects may render it essentially inedible to an American, although natives in some parts of the world don't mind. In the case of equipage, the essential point is not deterioration of the appearance of the material or the presence of the insects, but the loss of strength.

The second relationship is especially met in the case of certain wood-boring organisms like carpenter ants, which use wood only as a place of residence. They derive their food from some other material. Here again, it is loss of strength which is important.

The third relationship is similar but temporary. It is illustrated by various larder beetles and their relatives which, infesting a food material, leave it at the time of pupation and produce cavities of relatively slight depth in nearly any sort of adjacent material. When the transformation of the insect is complete, it leaves the cavity as an adult. Here again, long continued attack leads to loss of strength as well as making possible the maximum increase in the population of the food-infesting insect.

A more interesting, and in some ways, more useful classification of the relation of insects to the materials - derives from a classification of wood-boring beetles proposed some years ago by Professor Tragardh.

(1) Permanent pests - those pests which are able to infest continuously the same material as long as it has adequate food or shelter value. So far as wood is concerned, these are termites, many beetles, carpenter ants, and in other materials, we may especially point out the bean weevil and a large proportion of the grain insects.

(2) Bark pests - this category applies to wood only and refers to those beetles that are able to infest wood continuously as long as it is covered by bark, but which cease operations when the bark finally falls away.

(3) One-generation pests - here are placed the insects that require the material to be in some special state of curing in order to infest it, and which go through only one life cycle and then look for new material since that from which they have emerged is no longer suitable for oviposition. A considerable number of wood-boring beetles occur here, but in addition there are a few other insects in the same category. Perhaps the best one of these is the pea weevil, which is able to infest peas in the field but will not lay its eggs on dried peas.

(4) Secondary pests - these insects follow up some sort of damage by primary insects (those of the first three categories and the following category), or are attracted by the presence of some particular microorganism (mold or yeast) which is the source of primary damage. In a few instances, such as the flour beetles of the genus <u>Tribolium</u> mechanical damage may be all that is required to give the insect a start.

(5) Temporary pests - the insects included here are for the most part carpenter bees and wasps. They are but little concerned with the actual state of the material, but utilize it only in connection with some special part of the life cycle and are absent from the material during some portion of the year. We can scarcely envisage such a category among food or fabric insects.

(6) Accidental pests - this is by way of being a catch-all for the cases that do not fall readily into the preceding groups. It may be used to include, for example, instances of attack on inedible materials or edible materials far out of the ordinary range of an insect's food. It is probable that, for the most part, damage to metals might be placed here.

(7) Predators and Parasites - only a few of the insects that fall into this category have been considered in this report at all. The criterion that I have used is whether or not the insect was able on its own account to do some real damage to the material. In the case of the red-legged ham beetle and the larder beetle, we can be reasonably sure that their interest is very often that of scavengers upon insects already present, or as predators. I know of no parasites which, in themselves, cause damage. Ultimately, in the control of household insects, this category will achieve great importance.

1f. Basic biological information on insects.

In this section I intend to notice briefly some points in the biology of insects which are requisite for the understanding of what follows and for a reasonable system of control measures and regulations.

1f1. Structure of insects.

The body of an insect is divided into three regions which, beginning at the front end, are: head, thorax, and abdomen. In adult insects there is usually no difficulty in distinguishing these three regions. We begin with a description of these regions in the adult. It is not my intention to be exhaustive with regard to unimportant structures.

The whole body of an insect may be thought of as composed of a series of horny rings enclosing the viscera, each ring being attached to the adjacent ones by an extremely thin portion of the same horny material. The same ring structure is also characteristic of the true appendages.

The head is a horny capsule usually of somewhat globular form. It bears several appendages and the eyes and mouth. With but two or three exceptions the insects with which we deal possess eyes. These are located on sides of head toward the front, and are composed of many facets. In addition on the top of the head near the center line there may be one, two or three much smaller simple eyes. The antennae, popularly called feelers, are usually slender and many jointed. They are attached to the head above and behind the eyes in most cases. The antennae may be used as tactile organs but chiefly they are the seat of the sense of smell. On the lower front part of the head will be found the mouth appendages. The actual mouth opening is some distance behind them at the base of a mouth cavity. Practically all the insects we are interested in possess a pair of strong biting mandibles or jaws. Unlike our own jaws these work crosswise. The actual biting edge is toothed. The exceptional groups are the moths and the flies in which, so far as we are concerned, mandibles are wanting in the adult. Behind the mandibles come two other pairs of mouth parts. They are not adapted to biting and are chiefly interesting because they are the main location of the sense of taste. As a consequence an insect may taste without taking any food into the mouth. These mouth parts may be modified to form all or part of the sucking tube with which adult moths and flies are provided.

The thorax is composed of three segments more or less firmly soldered together. In passing it should be pointed out that bees, wasps and ants absorb into the apparent thorax, the first of the abdominal segments. This fact causes no practical difficulties. With few rare exceptions the thorax is provided with three pairs of legs. This is probably true in the adults of all the species we list. One pair of legs arises from each of the three segments. The names of the important parts of the legs are shown in figures 1 and 2. In addition to the legs the thorax may bear one or two pairs of wings, never more. The wings are usually broad and long structures but in few cases one or both of the pairs may be reduced, if not wholly wanting, or may be considerably thickened. The first pair of wings arises from the middle segment of the thorax and the second pair from the third segment. In the true flies the one pair of evident wings is the anterior pair. In the beetles the wings used for flight are the posterior pair. The same is true of the earwigs.

The underside of the tips of the legs may be a seat of the sense of taste.

The abdomen consists of a variable number of visible segments, never more than 12. At first sight it does not possess appendages but at the hind end are various accessory reproductive structures such as claspers and egg layers which are partly, at least, appendages. In a few groups the tip of the abdomen is provided with a pair of thorn-like structures called styli. It may also have a pair of cerci. These may hardly differ in appearance from styli or they may be very long many-jointed tails or they may be a pair of forceps. When the cerci are tail-like as in silverfish and may-flies there is commonly present a third tail of similar structure in the mid line.

As will be brought out further in Section 1f3, the young of insects in some cases are exceedingly like the adults, differ only in smaller size, lack of fully developed wings and lack of development of accessory reproductive structure. In other cases the young are of quite different structure from the adults. The body regions are often less distinct; the legs and antennae shorter or even apparently wanting. Such young insects, called larvae, may also possess sucker-like false legs on the underside of the abdomen. Where it is necessary to determine the body regions this can be done by remembering that the head consists of a single apparent segment and contains the mouth opening and that the thorax does not consist of more than three segments. The rest of the body is then abdomen. The only cases in which the body regions must be made out the head is quite distinct and the thoracic legs are evident and tipped with claws, not with suckers.

1f2. Food habits and food getting.

The insects with which we are concerned feed by two methods: by chewing or by sucking. In the first case the mandibles are well developed. In the second case they are more or less wanting and other mouth parts are developed into some sort of tubular apparatus. The young or larvae of the flies are an exception since they do not have chewing mandibles nor sucking mouth parts but rather lap up liquified food produced either by microbic decay or by external digestion due to the insects themselves.

It is evident that only the insects with chewing mouth parts can, generally speaking, attack solid foods. Those with sucking mouth parts being limited to liquid food.

In those cases in which there is no great distinction between the structure of adults and young both feed, almost without exception, on the same kind of food by the same method. Where, however, the larva differs greatly from the adult it may feed by entirely distinct methods on entirely different food. This is shown in the case of moths where for example clothes moth larvae chew up dried animal substances or seeds and the adult imbibes at the most only a small amount of fluid. Probably the adult clothes moth takes no food whatsoever. Even where the mouth parts of young and adults are essentially similar as in the beetles there may be a good deal of difference in their food. The carpet beetles of the genus Anthrenus have young that feed mostly on dead animal matter. The adults, however, feed mostly on pollen and are common on flowers. Even in these cases of divergence of foods the adults lay their eggs under conditions suitable for the development of the young and usually directly on the larval food.

In general, insects find food first by their sense of smell which leads them to it from a distance and second by their sense of taste which identifies the food substance upon actual contact. It is highly unlikely that many of our forms find their food by sight.

In ants, bees, and wasps there is a variable development of the habit of transporting food back to the nest and sharing it with other adults and with the young. This transportation occurs in two ways. First, the actual food material, a bit of meat or the leg of a dead insect or a seed, may be carried back as such and in the nest broken up, sometimes by special individuals, into fragments suitable for eating. Or the food, particularly if fluid, may be taken into the crop of the ant that finds it and so transported. It is then regurgitated to other individuals. In the meantime, it has been to some extent modified by digestive processes. This sort of food transportation is not entirely confined to liquid foods.

1f3. Reproduction and development

In their development insects pass through a number of discrete stages separated by molts and these stages may be considered as forming 3 groups. First, the egg; second, the immature stages, and; third, the adult.

The eggs of insects are generally somewhat elongate small bodies invested with a flexible and very impervious shell. Within the egg the early development takes place and upon hatching the young animal is quite clearly an insect, although it may differ in many respects from the parent. The eggs of insects are laid in a great variety of situations but usually on or near appropriate food for the young insect. In exceptional cases, such as the flesh flies, the eggs are hatched within the body of the female. All aspects of the development of insects vary in their speed with temperature. There is, however, a minimum temperature below which development does not occur and similarly a maximum temperature above which the insect dies. It is generally considered that the minimum temperature is the same for all stages of a given species but it is known that the maximum temperature varies slightly depending upon the stage. The increase in the speed of development is considerably greater than the rate of change of the temperature. As a rough guide we may say that for each 18°F rise of temperature the rate of development is doubled. Consequently all estimates of the time required either for the hatching of eggs or for the completion of development are uncertain unless stated in terms of the temperature. In general, however, the eggs of most pest insects hatch within a rather few days unless they are subjected to low temperature when they may survive without hatching for weeks or perhaps months.

The eggs of insects are extraordinarily resistant to most of the chemical agencies used for insect control and it can generally be assumed that an insecticide will not kill eggs, although it kills all of the other stages. For this reason, it is often necessary to make two or more applications at short intervals in order to kill the young which have hatched from eggs present when the first application was made. On the other hand, insect eggs are readily killed by exposure to elevated temperatures and sometimes by drying.

While a majority of insects with which we are concerned lay their eggs loosely in the food material a few make special provisions either by inserting the egg into the food material, as in the case of the grain weevils, or by fastening it to the material as is done by the bean and pea weevils and the powder post beetles.

The immature stages of insects, after hatching, are separated into two general types, depending upon the method of transition of the last immature stage to the adult insect and on the method of wing development. In the more primitive insects these immature stages are called nymphs. A nymph resembles the adult of the same species in most respects except for smaller size, incomplete development of wings and of external reproductive structures and on the whole the transition from the newly hatched nymph to the adult is a rather gradual one. The exceptional cases are almost entirely confined to aquatic insects, such as may-flies and dragon flies. Generally speaking, in insects of this type there is no quiescent stage preceding the adult.

The other type of development involves young insects which are very different in appearance from the adult and are called larvae. In general, a larva has the body less heavily armored than the adult, shows a much less development of legs, antennae, and eyes; frequently has quite different mouth parts; shows no indication of growing wings. When the larvae is full fed it ordinarily retreats to some sheltered place, often enclosing itself in a silken cocoon and molts at least once. In this quiescent stage it is referred to as a pupa. After a resting period the adult insect emerges from the pupal coverings.

We have already spoken of the relation between temperature and the rate of development and it remains to point out that under natural conditions, especially in the temperate zone, most species of insects must find some way of passing the winter. The stage in which this occurs may be any one of the developmental stages and it may be invariably the same one for a given species or it may vary among individuals. In many species the life cycle is less than annual and only part of the individuals have to over-winter. Hence, the great variation assigned in the literature to the developmental period of a particular species. For many insects, it is much more convenient to state merely the number of generations per year. In many instances the same species of insect overwinters in the temperate zone but breeds continuously in the tropics.

I have not given much information concerning the number of eggs laid by insects. The variation is considerable among individuals of the same species. The figures are not very trustworthy. The variation from one species to another is not extremely great. I would assign a ratio of 4 or 5 to 1 between the most and the least prolific. Furthermore, such figures give no indication of the death rate during development. Since the variation in fecundity is relatively small, as a practical matter the rate of increase of an insect population is more dependent upon the number of insects introduced at the beginning than upon the number of eggs each one can produce. It will be quite evident that if we introduce 10 fertilized females, capable of laying 100 eggs each, we give an infestation a much better start than by introducing one fertilized female, capable of laying 500 eggs.

1f4. Requirements for existence.

At the risk of being trite, I venture to summarize the well known requirements for the existence of insects at a given point on the earth's surface.

a. Air. No insect can get along continuously without an adequate supply of oxygen. On the other hand, many insects, particularly adults, can suspend their respiratory movements for considerable periods of time, sometimes 24 hours or more, and get along on air stored in sacs within the body. This is possible partly because insects do not require large quantities of oxygen in unit time and partly because many of them can withstand considerable concentrations of carbon dioxide. For this reason fumigation with irritant gases, for example formaldehyde, is unsatisfactory unless the fumigation times are very lengthy. For this reason also, it is desirable to fumigate, if possible, at moderate or even elevated temperatures, in any event above 60°F. Below that temperature for many insects the rate of breathing is extremely low. On the other hand, it is known that under some conditions insects are killed quite quickly if confined in hermetically sealed containers. I have not found any adequate discussion of the contained gases but I would surmise from the materials in which the insects were that the oxygen in the container was used up very quickly.

b. Moisture. No living organism can survive indefinitely without moisture. Many insects, particularly adults, have low rates of moisture loss, but they do lose water. Consequently, we find in all the cases which have been investigated that some water as such must be contained in the food, the amount depending upon the species of insect and to a lesser extent upon the kind of food. It seems to be a fair generalization that the minimum amount of moisture in the food is, at least, 6%, for some species it is, of course, very much higher and it is important to note that this figure is below the moisture content of most of the substances like wood or grain which we think of as perfectly dry.

c. Food. So far as our knowledge goes at present we can define the food of insects only in terms of very complex material We may hope ultimately to be able to state it in terms of chemical entities. However, this is less important than it seems because insects choose their food or the food of their young apparently in great part on the basis of substances which have no known nutritive significance. The most important of these are undoubtedly odoriferous substances. A homely example of this is the attraction of carrion feeding flies by the flowers of the skunk cabbage and the carrion flower. In a few cases, in any event, the adult actually determines the presence of proper nutritive materials. This is the case in the powder post beetles. Consistency may also be a factor in food choice, although, in general, this affects the individual and is not involved in the choice of egg laying site by an adult female. For example, some insects can attack whole unbroken grain where other insects are able to attack only grain which has been previously injured. This appears to be due to the relative ability to bore through the bran layers.

d. Temperature. I have already spoken of the effects of temperature under <u>1f3</u> and but little need be added here beyond pointing out that the total amount of heat available plays a part in the existence of insects. For example, an adult insect may survive at an average temperature too low to permit of reproduction. As a consequence some insects may occur out-of-doors in temperate zones in the summer but do not, so far as we know, reproduce under such conditions.

e. Enemies. It is perfectly obvious that no insect can survive in the face of an overwhelming population of its enemies. It is not appropriate here to go into a long discussion of insect enemies. We will point out, however, that occasional infestations of food infesting insects or of wood boring beetles are eliminated by predaceous insects, although, generally speaking, the latter insects are regarded with as much distrust as the real infestant. Certain types of insects are unable to exist in competition with a heavy growth of molds but here again the cure is at least as bad as the disease.

1f5. Distribution and dissemination.

It is perfectly obvious that an animal can only survive in such places as the environment completely meets at least its minimum requirements for existence. The general nature of these requirements has already been discussed in 1f4. The chief significance of the preceding statement is that we do not find ordinarily a uniform distribution of animals over wide areas. For example, in northeastern America the black cockroach is a house insect and is wanting, therefore, at all those points which are not occupied by heated buildings, in spite of which we say that its distribution is cosmopolitan. What we really mean by such a statement is that the black cockroach is as nearly uniformly distributed over the earth's surface as its special requirements for existence permit and that it may be expected to appear at any point where those requirements become established in the future. In addition to the restriction of distribution imposed by the character of the environment there are further restrictions imposed by natural barriers, such as bodies of water, deserts, and mountain ranges. The effect of these barriers is different upon different insects. Certain insects of powerful flight, for example, are able to transgress most barriers of moderate extent. They may even appear far north of the areas in which they can breed. Perhaps fortunately almost none of the pest insects have more than quite limited power of flight, but this type of distribution does come into the agricultural picture.

A large number of pest insects with which we are concerned may be considered as domesticated insects and the question may well arise: have their characteristics been changed as a consequence of domestication. I think we can safely say "No". It is true that the domestication has been an advantage to the insect from the point of view of more ready dissemination and more uniform living conditions, but so far as I can see none of the insects have been to our knowledge altered by domestication, although one or two of them are perhaps not now known in the wild state. This enables us to answer negatively another question; namely, whether it is likely that the introduction into dwellings or storehouses of an insect not now found there will result in the insect becoming specifically adapted to such an environment and more difficult to eradicate.

Insects may be disseminated in two main ways, naturally and artificially. Natural dissemination depends either upon the unaided efforts of the insect or upon its carriage by some natural agent such as wind, water or another animal. It is evident that this is a slow and, from the standpoint of the insect, hazardous process. Artificial dissemination is the transportation of insects from place to place by man and in the case of many pests this is an extremely satisfactory method. The insect need merely find an appropriate food and stay in it and it will be carried then to any region to which the food itself is taken and there it has usually a good chance of finding uninfested and appropriate food. Undoubtedly all of the cosmopolitan pest insects are of wide distribution due to artificial dissemination.

There are certain types of insects, particularly termites, which are difficult to disseminate. In such cases, it does not suffice to carry one fertilized female. In general, both a male and female are required plus a greater or lesser number of workers, so that with the exception of one or two powder post termites there are very few records of the artificial introduction of a termite into a strange locality.

Prof. E. O. Essig of the University of California has recently written a summary of the conditions conducive to insect infestations and of some of the methods of introduction of pest insects which I quote with a few modifications.

Household conditions conducive to pest infestation.

1. Poor housekeeping - any departure from scrupulous cleanliness leading to minor but numerous accumulations of edible substances.
2. Accumulation of edible waste - unnecessary storage of garbage, skins, hair or wool.
3. Poor storage facilities - damp, dark closets or basements, lack of light and ventilation, imperfectly closed containers, incorrect stacking of cases.
4. Wild or dimestic animals, indoors or under buildings - shed hair and scales, dung.
5. Defects of construction - cracks and other hiding places or access ways, ineffective screening, insufficient space under buildings.

Means of introduction of pests.

1. By natural means through attraction by odors, for example -
    (1) Vinegar flies - fermenting fruit juices, olive pickling brine, etc.
    (2) Cheese skippers - aged cheese.
    (3) Dermestid beetles - ill-smelling cured meats, hides, bones, and damp woolen materials, furs, hair, feathers, and other animal products, etc.
2. By man.
    (1) In supplies from infested stores and warehouses.
        (a) In cereals, etc.
        (b) Propinquity to infested native materials

Relations of insects within the household.

Insects once established indoors may furnish suitable living conditions for the entrance and livelihood of other insect pests.

(1) Honeybees nesting in chimney attract -
    Waxworms
    Dermestid beetles
    Flour moths
    Ants

(2) Insects living in cereals, dried fruits, and other products may soon be accompanied by:
    Dermestids living on the cast skins
    Parasites and predators attacking them
    Scavenger beetles and flies feeding on the offal.

In order to show the extent to which pest insects have become widespread I introduce the following tabulation of the total number of species so far listed, and the number of species having a wide distribution:

	Total Species on List	Cosmopolitan	Widespread	Tropicopolitan	Total of 3 Preceding Columns
Thysanura	11	2		1	3
Orthoptera	23	5		7	12
Dermaptera	4		2	1	3
Isoptera	137			1	1
Embioptera	1				
Ephemeroptera	2				
Psocoptera	19	2			2
Trichoptera	12				
Lepidoptera	102	20	6	6	32
Coleoptera	547	66	44	16	126
Diptera	71	3	5		8
Hymenoptera	88	2	5	10	17
Arachnida	41	3	2	—	5
	1058	103	64	42	209

1f6. Keys and their use.

In order to make possible the identifications of the major groups of insects and closely related animals responsible for damage I introduce in this section two keys. Other keys will be given in later sections. It will be seen on turning to the first key that it consists of sets of numbered paragraphs. The paragraphs under a given number contain mutually exclusive groups of characteristics. With the specimen or damage in hand one compares the actual object with the statements made under the paragraph numbered "1". One of the sets of characteristics should agree with the specimen, and to the right of this paragraph will be found either a name or a number. If a name is found, that is the required answer. If a number is found the statements under that number are compared and a new choice made. This process is continued until an answer is obtained. If at any point no choice can be made, that is none of the statements apply completely, then the object in hand is not included in the key, or some error has been made in one of the choices. Partial agreement is not sufficient. If it is impossible to decide between the two sets of statements one may continue as though both were true and at some later point it will probably be possible to decide which is really correct.

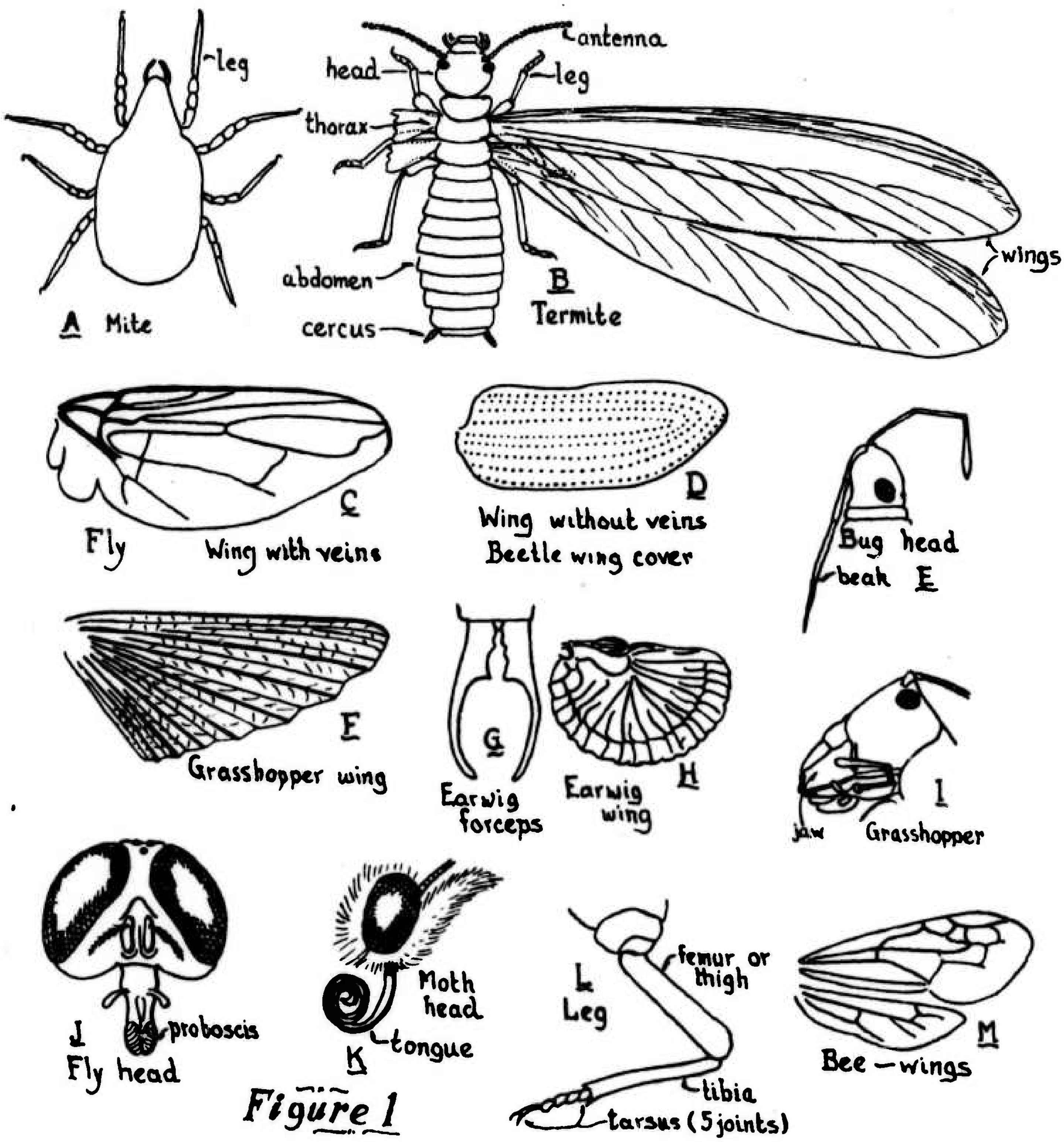

Figure 1

Insect Structures

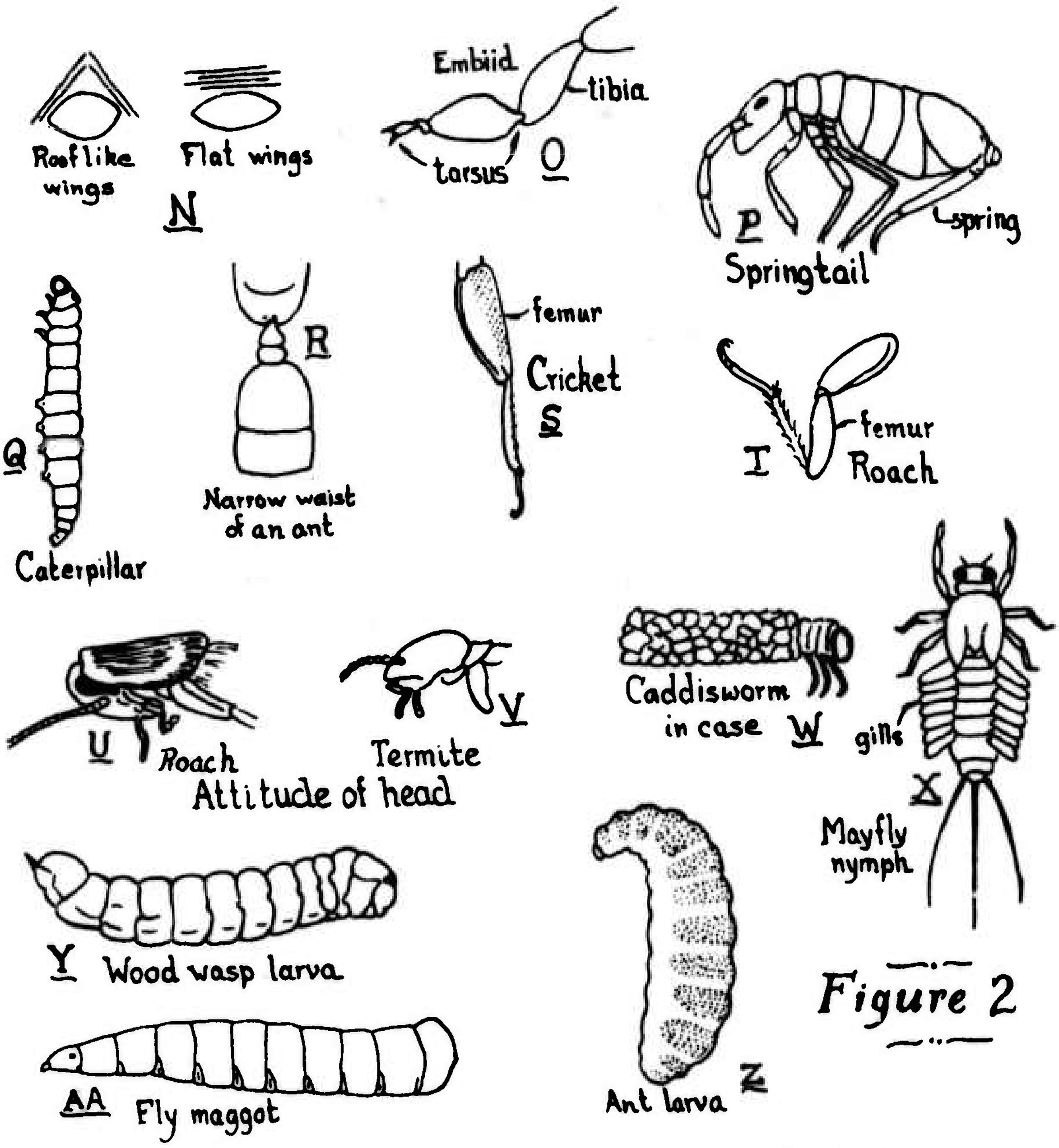

Figure 2

Insect Structures (cont'd)

Key to distinguish the chief groups of insect-like animals.
(All references are to Figures 1 and 2)

1. No antennae; legs usually four pairs, never more; body divided into not more than two regions and often not clearly divided, the leg-bearing region always fused with the head. (fig. A) . . . . . . Arachnida

1'. Antennae present, legs, three pairs or five, or more; body divided into three more or less evident regions 2

1'' Antennae not evident; legs wanting or quite short, body soft, more or less worm-like, regions obscure, even the head may be indistinct. (fig. Q.Y.Z.A.A.) some immature insects (grubs and maggots)

2. Not more than three pairs of evidently jointed legs. (fig. B) . . . . Insects

2'. At least five and usually seven pairs of legs. . certain Crustacea

2'' At least fifteen pairs of legs . . . . myriapods

Key to certain orders of insects
(All references are to Figures 1 and 2)

1. Wings developed 2

1'. Wings wanting. 12

2. The fore wings horny, leathery, or parchment-like, at least at the base, the hind wings, if present, thin, and membranous. 3

2'. The fore wings membranous. 7

3. The fore wings veined. (fig. C). 4

3'. The fore wings veinless, uniformly horny and, at rest, concealing the hind wings. (fig. D) . . 6

4. Mouth parts modified to form a jointed beak for piercing and sucking. (fig. E) . . . . (Hemiptera) bugs

4'. Mouthparts fitted for chewing. (fig. I). 5

5. Hind wings not folded and very similar to the fore wings . . . . (Isoptera) termite

5'. Hind wings folding, fan-like, broader than the fore wings. (fig. F) . . . . (Orthoptera) grasshoppers, crickets roaches

6. Body ending in movable forceps; antennae long, thread-like; fore wings short, hind wings delicate, nearly circular; elongate insects. (fig. G,H.) . . . . (Dermaptera) earwigs

6'. No forceps; antennae various but usually eleven-jointed; forewings usually cover abdomen. (Coleoptera) beetles and weevils

7. With four wings. 8

7'. With two wings; mouth parts forming a proboscis, no tails. (fig. J) . . . . (Diptera) two-winged flies

8. Mouth parts fitted for chewing 9

8'. Mouth parts fitted for sucking and forming a coiled tongue (rarely wanting); body and wings covered with scales; antennae many-jointed. (fig. K) . . . . (Lepidoptera) moths

9. Tarsi usually five-jointed; hind wings smaller than fore wings and lying flat over the body at rest, wings with rather few veins; abdomen usually constricted at base. (fig. M,N,R.) . . (Hymenoptera) ants, bees, wasps

9'. Tarsi 2-, 3-, or 4-jointed 10

10. Wings very nearly equal in size, held flat over abdomen when at rest. (fig. N) 11

10'. Hind wings smaller than fore wings, held roof-like over the abdomen, except when the wings are reduced and thickened. (fig. N) . . . . (Psocoptera) book lice

11. Cerci minute. (fig. B) . . . . (Isoptera) termites

11'. Cerci conspicuous; basal joint of each front tarsus swollen. (fig. O) . . . . (Embioptera) embiids

12. Body more or less insect-like, <u>i.e.,</u> with more or less distinct head, thorax, and abdomen; with jointed legs and capable of locomotion. (fig. Q) 13

12'. Without distinct body regions, or without jointed legs, or incapable of locomotion. (fig. Y, Z, A, A,) 27

13. Living on land, without gills. 14

13'. Immature insects, living in water; usually with gills. (fig. W, X.) 26

14. Very delicate and usually minute insects, mouth parts not evident. 15

14'. Mouth parts fitted for chewing (if body is scaly, see Thysanura) 16

15. Abdomen of 10 segments; body scaly; three tails (Thysanura) bristle tails

15'. Abdomen of 6 or fewer segments and usually a springing apparatus near its tip. (fig. P) . . . . (Collembola) springtails

16. Underside of abdomen without legs. 17

16'. Abdomen with 5 pairs or less of false, unjointed legs; abdomen not distinctly separated from thorax, caterpillar-like larvae. (fig. Q) . . . . (Lepidoptera) moths

17. Antennae long and distinct 18

17'. Antennae very short; larvae; not caterpillar-like. (Coleoptera) beetles

18. Abdomen ending in strong, movable forceps. (fig. G.) . . . . (Dermaptera) earwigs

18'. Abdomen not ending in forceps. 19

19. Abdomen not much narrowed at base 20

19'. Abdomen strongly narrowed at base; segments of thorax not movable on one another. (fig. R) (Hymenoptera) ants

20. Very small (1/8" or less) louse-like species . . (Psocoptera) booklice

20'. Not louse-like, usually larger 21

21. Hind legs fitted for jumping, with enlarged thighs (fig. S.) . . . . (Orthoptera) crickets and grasshoppers

21'. Hind legs not fitted for jumping. (fig. T.). . . . 22

22. Antennae thread-like, many-jointed; cerci present (fig. B.). 23

22'. Antennae usually with eleven joints; no cerci. . (Coleoptera) beetles

23. Cerci with more than three joints. 24

23'. Cerci with one-three joints. 25

24. Body flattened, oval; head turned down and more or less concealed under the front of the thorax (fig. Y). . . . . (Orthoptera) roaches

24'. Body elongate; cerci very short; head horizontal, not turned under front of thorax. (fig. V.) ... (Isoptera) termites

25. Front tarsi not enlarged. (fig. B.). . . . . . . (Isoptera) termites

25'. Basal joint of each front tarsus swollen. (fig. O) (Embioptera) embiids

26. Body in a case made of sand, bits of leaf, etc; animal is somewhat caterpillar-like; sometimes in burrows. (fig. W.) . . . . (Trichoptera) caddis worms

26'. Body not encased in a shell; with external gills; two or three long tails. (fig. X.) . . . (Ephemeroptera) mayflies

27. With a more or less distinct head and chewing mouth parts; body straight or C-shaped . . . . . (Coleoptera) beetles

27'. Head scarcely evident 28

28. Mouth parts fitted for chewing, distinct. (fig. Y) . . . . (Hymenoptera) wood wasps

28'. Mouth parts scarcely evident; body strongly tapered toward the front in most cases. (fig. Z, AA.) . . . . (Hymenoptera) ants, bees, some wasps

and (Diptera) two-winged flies 29

29. Larva in some kind of nest or excavation. (fig. Z.) Hymenoptera

29'. Larva in meat, fruit, cheese, or decaying material. (fig. AA.) . . . . Diptera

1f7. Glossary.

Here are given definitions of most of the important terms used in the present report, and some others which are likely to be encountered in the less technical works on insects. It is not feasible to give a complete dictionary of entomology; however, Torre-Bueno has rather recently published a book defining all of the terms in entomology.

abdomen - the hindermost of the three main regions of the body; it normally consists of six or more segments and bears neither legs nor wings.

antenna - a movable, unbranched segmented appendage, situated on the head; it is usually slender and projecting; popularly called a "feeler".

caterpillar - the long, worm-like larva of a butterfly or moth; also sometimes the similar larvae of such insects as sawflies.

cercus - one of a pair of tail-like segmented structures projecting from the hind end of the body; rarely consists of a single segment.

chrysalis - the pupa of most insects having complete metamorphosis, especially moths and butterflies.

cocoon - the envelope, often largely of silk, which the larvae of many insects form about themselves, and in which they pass the pupal stage.

false leg - a segmented projection from an abdominal segment of a caterpillar, provided at its tip with hooks and a sucking disc, but not with claws; also called proleg.

frass - powdery or sawdust-like material resulting from the chewing activity of an insect.

grub - a thick, worm-like larva, often bent and rather inactive; the legs very short or wanting.

head - the first of the three body divisions of an insect, usually forming a horny capsule; it bears the eyes, antennae, and mouth parts.

larva - the immature, wingless, feeding stage of an insect having a complete metamorphosis.

maggot - soft-bodied, legless larva, usually straight and tapered toward the two ends.

mandible - jaw; more specifically, either member of the anterior pair of mouth parts; in most insects adapted to biting or chewing.

membranous - thin, tough and usually shiny and transparent; often resembling cellophane in appearance.

metamorphosis - an apparent change of form or structure, best seen in those insects which pass through larval, pupal, and adult stages.

mouth hooks - the hook-shaped, horny structures which represent the mout parts in fly maggots.

nymph - a young stage of an insect which possesses gradual or incomplete metamorphosis.

ovipositor - a specialized organ at the hind end of the body for depositing eggs.

palpus - a segmented structure attached to a mouth part, usually serving the senses of taste and touch.

proboscis - an essentially tubular prolongation of the region about the mouth to form a sucking organ. The mouth parts are usually enclosed within it.

pupa - the stage, usually quiescent, between larva and adult in insects having a complete metamorphosis.

puparium - the last larval skin which encloses the pupa in the two-winge flies.

queen - in the social insects, a female actually functioning in reproduction.

rot - in wood a loss of strength which is not accompanied by the obvious removal of substance; more generally deterioration due to the action of microorganisms.

segment - a portion of the body or an appendage enclosed in a horny ring and attached by a joint to one or two similar segments.

stylus - movable, segmented, usually pointed process; one may arise from the attenuation of such an appendage as the mandible.

thorax - the middle region of the body, between the head and the abdomen; it bears the true legs and the wings, if these are present.

2. DISCUSSION OF THE MATERIALS ATTACKED AND NOTES ON THE DIAGNOSIS OF DAMAGE

It is the purpose of this section to indicate under each group of materials (there are 52 such groups) those organisms which are most frequently found as pests and where possible the type of damage for which they are responsible; the distribution and expected intensity of the damage; the significance of infestations of the particular group of materials in relation to infestation of other groups of materials. It is also our intention to show the relation of the infestation to the use of the infested material where use can be made of it; to give clues to enable personnel in the field to determine causes of damage. We will further indicate the general nature of the prevention and cure of infestations.

2a. Food and closely related materials.

The subdivision of the very numerous materials comprised here is a matter of some difficulty, and we must admit at the outset that a completely logical subdivision on the basis of a single principle has not been adopted. Actually account has been taken not only of the chemical nature of the materials but of processes of preparation; the relation of the materials to specific groups of insects; and the fact that certain native produce serves in some regions as a reservoir for food infesting organisms.

2a1. Grain, including rice and buckwheat and its products.

I have included here a very large variety of substances which, although as different in their appearance as threshed wheat and "shredded wheat", have none the less very great similarity in chemical composition especially the high starch content and the gluten content. To be sure grain contains more fat than most of its products. However, the insects associated with these numerous materials are very similar. There is not even a very large distinction evident among the insects associated with the different species of grain, except in so far as particular grains are raised in well defined and limited areas. Corn, for example, has a few pests restricted to the Western Hemisphere and there are similarly a few special pests of rice in eastern Asia, but when these same grains are raised in other parts of the world they have, in general, the pests associated with other grains of the same region. There is more distinction to be drawn between the raw grains and certain of their products. In this connection it is rather striking that the reports of pests associated with cracked grain and with animal feeding stuffs which presumably have been subjected to a minimum of denaturation are more similar as well as more numerous than those reported for the sophisticated dry cereals sold as human breakfast foods.

There are some 246 insects and mites now recorded in connection with these materials. Nine orders of insects are represented mostly by very few species. The table below gives the number of species for the orders of insects and mites.

(Table on next page)

Silverfish	1	Important beetle families	
Crickets and roaches	6	Anobiidae	6
Termites	1	Bostrichidae	7
Embiids	1	Calandridae	4
Booklice	6	Cryptophagidae	9
Moths	39	Cucujidae	7
Beetles	159	Dermestidae	15
Flies	2	Lathridiidae	16
Ants	2	Ostomatidae	5
Mites	29	Ptinidae	16
		Silvanidae	6
	246	Tenebrionidae	30

Damage by Orthoptera is usually not serious since they are not, as a rule, prone to feed on dry and hard materials. There is, of course, considerable doubt about the real significance of the booklice in connection with any vegetable material and it is not unreasonabl to suggest that grain in which they are found is, in any event, slightly moldy or too damp.

The moths of stored grain fall into two main groups. The larger of these consists of insects ordinarily feeding on dry materials. For example, the Ephestias, the Indianmeal moth, the European grain moth, and Angoumois grain moth and the various species of Tinea. The second group includes a few species that feed on grain in the field and may emerge from it after it has been brought into store.

As would be expected, the largest number of species associated with grain is contributed by the beetles and here the relationship to grain itself is even more variable. There are, of course, considerable numbers of species of wood boring families, Anobiidae, Bostrichidae, Lyctidae, and Scolytidae. Next there are some species that seem to have been originally associated with seeds on the plant, such as the Calandridae and probably the Tenebrionidae. Third, there are some species, such as the Cleridae, which were originał at least, feeders upon other grain insects, but which now are either sufficiently frequent in grain to be a mere nuisance because of their presence or, as seems to be true of Tenebrionidae and some of the Dermestidae, have changed from an insect feeding habit to a grain feeding habit to some extent. In the next place we find the Cryptophagidae and Lathridiidae and probably still others whose main interest in the grain is for the molds which may be present. And finally, there are some few scattered species whose significance is unknown. A considerable proportion of grain beetles are now cosmopolitan and perhaps a quarter of them are normally feeders on other substances than grain products.

It is well known that the ability of beetles, especiall to attack sound grain, is variable. The lesser grain borer, the granary weevil and the rice weevil may attack perfectly sound, hard grain but many of the weaker species, such as the saw-toothed grain beetle and certain flour beetles apparently only attack grain that has already been damaged by some other means. As a consequence they tend to be more associated with grain products.

The 29 species of mites associated with grain, so far as we know, are all primarily interested either in molds that may be growing on the grain or its product or in other insects or mites that are present.

The problem of preventing or treating insect infestations of grains is the subject of a large literature. We may conclude that the infestation of grain and its products takes place with great readiness. Grain can seldom be stored under ordinary conditions for any great length of time without acquiring some degree of infestation. Once established such an infestation builds up very rapidly to a peak value and if any grain is added to the bin, this high population of insects is easily maintained. Hence, the prevention of grain infestation is very difficult. It is apparently not possible as yet to store large quantities of grain in insect tight containers, although this, of course, can easily be done for a few pounds of grain.

The best procedure appears to be to fumigate both the bins and their contents at reasonable intervals. This may be done with hydrocyanic acid or with methyl bromide. Although it is not possible to completely clean infested grain of insect remains after a fumigation this is probably not consequential if the infestations do not reach high levels. Heat has also been used and from the point of view of the killing of insects is satisfactory. Not as much may be said for its effect on the grain itself. The disinfestation of flour and other ground products is somewhat less troublesome because most stages except the eggs can be screened out. Insect eggs are difficult to kill even by fumigation.

The ordinary specifications for moisture content in grain and flour permit 13% which is well above the level requisite for the growth of the ordinary beetles. It is not likely that moisture contents above 5½% would be safe against all grain pests in warm regions, although between 6 and 8% would protect against most of them.

The presence of insect infestation is usually made known by one or more definite symptoms and the most frequent of these is the presence of powder derived from the feeding of the insects. It may amount to a considerable proportion of the grain.

The second symptom is the presence of grain which has been partly eaten away or which shows perforation. These symptoms apply to most of the grain pests except the mites. In addition, moths and embiids spin silk as they work which results in an untidy webbing together of broken grains, powder, and excrement. This webbing is usually most conspicuous at the surface of the mass. The only sure way of determining the presence of mites is to find the animals themselves. The finding of insect remains in grain and grain products is not necessarily proof of present infestation. It may merely indicate that the product was derived from badly infested raw materials.

2a2. Meat and fish, fresh or unspecified.

Some 62 insects and mites have been recorded in connection with fresh meat and fish. As might be expected they show a very different distribution among the orders than is true of almost any other material that we shall consider, since this category includes the only moist unprocessed protein foods. The ordinary feeders on starches are almost entirely wanting, as are also the feeders on dry protein, for the most part. The insects which fall here are primarily predators and scavengers; from the standpoint of the blue bottle fly even the freshest meat is carrion. This is true, for example, of the three clerid and four dermestid beetles which have been recorded and it is even more true of most of the 46 flies. We, therefore, turn our attention particularly to this last order. The literature on the pests of meat and fresh fish is very unsatisfactory, but I have tried to list those species which have been actually reared from meat and to ignore those in which only the adults visit meat without evidence that the young may mature in it. With the exception of the cheese skipper all of the flies given are fairly closely related to the house fly. On consulting the appendix it will be found that practically all the records come from four localities, Europe, North America, the Oriental region, and Australia. This does not, by any means, infer that attack on meat will not be severe in any warm or temperate region, but merely that careful studies of the important genus Sarcophaga have been made only in the regions indicated. This genus contains very numerous species in all parts of the world. It can be said with certainty, however, that by no means all of them attack meat. The genera Calliphora and Lucilia will certainly prove also to be of great importance. They are respectively the well known blue bottle and green bottle flies. The cheese skipper is a special case. It appears to be normally a feeder on cheese and smoked meats, but has been reared from fresh meat. More will be said about it in the next section. (p. 112-113)

The ability of some of these flies to find meat quickly is very remarkable. I have myself seen green bottle flies depositing larvae on animals dead less than three minutes, although living animals in the same room were not bothered. Most of these flies hatch their eggs within the body a few at a time and deposit or "lay" young maggots. They do not have to make actual contact with the meat to do this. It was shown many years ago that blue bottle flies would drop their larvae from a height of more than a foot onto meat and that normally they fly above the meat but will not approach it so readily from the side. Hence the general custom of having a fixed top for meat display counters. The prevention of "blowing" of meat by flies consists primarily in preventing access of flies to the meat containers and preferably even to the rooms in which the meat is. This can be done with screening. Infested meat may sometimes be partly reconditioned by trimming.

A few species of ants are especially attracted to meat. These may be handled according to the methods given in section four for ants in general.

The best diagnosis of infestation of meat is based on the actual finding of the insects or their young, but the larder beetles may make fairly characteristic tunnels in the meat and leave behind cast skins.

Roaches	1
Moths	2
Beetles	9
Flies	46
Ants	5
Mites	1

2a3. Dried and smoked meat and fish.

In general the types of insects which attack these substances are the same as those that attack fresh meat, but it will be seen at once that there are many fewer species and a predominance of dermestid beetles. This is to be expected since dried meat more nearly resembles the hair or wool with which we commonly associate such beetles.

In general, the protection of dried and smoked meat or fish consists in preventing the access of insects to it by means of tight packaging or containers. It should be noted that the relative infrequency of meat infesting insects in the United States is probably due to our national habit of keeping all meat even if dried or smoked in refrigerators rather than leaving the bacon or kippers out on the pantry shelf.

The diagnosis of insect damage here is similar to that in fresh meat, but due to the preponderance of beetle attack the tunneling and presence of cast skins will be more frequent.

Silverfish	1
Moths	2
Beetles	16
Flies	2
Mites	2
	23

2a4. Peas, beans, and lentils.

These three groups of seeds are closely related botanically and are placed together to separate them from other related seeds which come into commerce and are to some extent used for human food in various parts of the world. These latter seeds are taken up in section 2a6.

The present group of seeds is particularly liable to attack by seed weevils of the family Mylabridae. Of the 49 species which I have listed more than one-third (17 species) belong to this family and some like the common bean weevil can do tremendous damage to stores of beans, particularly the navy bean. The remaining 16 beetles are for the most part general feeders on seeds or are feeders on materials containing proteins since hide and carpet beetles are listed. The ten moths are general feeders on seeds of many kinds. None of them seem to be especially attached to leguminous seeds. The one remaining insect on the list is an ant which has been taken in association with butter beans, but is probably a predator on other insects.

The diagnosis is similar to that for grain especially in the case of moth attack. The mylabrid beetles seem usually to leave rather little powder around, but their presence is especially marked by perforated beans which may show extensive excavation.

Moths	10	
Beetles	38	of which 17 are Mylabridae
Ants	1	
	49	

2a5. Peanuts

Peanuts are included as a separate section because they are now raised in most parts of the world and have a considerable number of insects associated with them. One would suppose that peanuts being leguminous seeds would be attacked by the same general sort of insects as attack peas or beans, but this is not true. The family Mylabridae which is so prominently associated with most leguminous seeds is here represented by only two species. I presume this is true because the original association of this family with the seeds was based on the laying of eggs on the pods while still on the plants and the pods of peanuts being subterranean were not accessible to this group of beetles. As a consequence the insects of peanuts are to a large extent common and widely distributed grain insects or their close relatives.

Silverfish	1
Embiids	1
Moths	6
Beetles	23
	31

2a6. Other leguminous seeds

Here are included not only a few seeds of legumes such as the soy beans and the chickpea which in some regions are used for human food, but also a considerable number of other seeds such as those of senna and acacia which have medicinal use and a variety of seeds of forage legumes raised in the warm parts of the world. There is no very great difference in the infestation of stored seeds included here from those included in section 2a4 and the remarks made there apply almost equally to this section.

Moths	7	
Beetles	36	of which 28 are Mylabridae
	43	

2a7. Edible nuts.

This section includes not only the edible nuts of the walnut family, but, in addition, edible palm nuts and a few others. No very large number of observations have been made of pests of these foods and, generally speaking, the insects associated with them are those of various miscellaneous seeds. The high oil content of nuts does not seem to be reflected in peculiarities of the insect pests. The only special point to be noticed is the occurrence of some scolytid beetles in palm nuts. I would, however, expect on further investigation to find some infestation by mylabrid beetles.

Moths	13
Beetles	19
Ants	1
Mites	1
	34

2a8. Cacao

The term cacao is applied to the stored seeds from which chocolate is produced. These are raised in large quantities in certain tropical areas and, as seeds, are attractive to insects. There are, however, relatively few insects recorded which are apparently peculiar to cacao. In looking over the list we are struck by the relatively large number of booklice on record, but this arises from the fact that a special study of these insects associated with cacao has been made in England and in all probability similar or larger numbers of booklice could be found associated with any tropical produce that was adequately investigated. In my opinion, the Dermestidae and Cleridae present are primarily predators upon the other insects. Like dates and copra this section is included chiefly to point out the possibilities of infestation of imported materials from a native product.

Earwigs	1
Booklice	6
Moths	9
Beetles	31
	47

2a9. Raisins.

Raisins are remarkably attractive to insects. Twenty-eight forms are listed. Much of this infestation originates in the field and particular care should be taken to secure insect-free stock for packing. I emphasize this point because it seems likely that considerable use will be made of raisins for emergency rations which may remain packed a long time before they are consumed and the ordinary moisture content of raisins is sufficiently high to allow insect development. The chief moths attacking raisins are the species of Ephestia including the tobacco moth, the raisin moth and the

Mediterranean flour moth. The dried fruit moth and the Indianmeal moth are also recorded. The most important group of raisin pests is the beetles. Here are included several scavengers and certain of the grain beetles, such as the saw-toothed grain beetle and the two common species of flour beetle.

Booklice	1
Moths	9
Beetles	24
Flies	2
Mites	1
	37

2a10. Dates.

Dates, being fruit, are attacked by a number of the ordinary fruit insects; chiefly moths, such as, the almond moth, raisin moth and by a few fruit beetles, notably the corn sap beetle. We find listed 12 moths and four beetles. Three of the moths are not listed in connection with any other material. The main reason for treating dates separately is that they are a native source of food - infesting insects in North Africa and the Middle East. Unless caution is exercised they could result in infestation of imported materials when dates are obtained locally for subsistence.

Moths	12
Beetles	4
	16

2a11. Copra.

Like dates, copra is a native source of food-infesting insects likely to be present in regions where military operations are or will be undertaken. The important insects associated with copra are beetles, of which I have a record of 19 species. Here are included not only some of the fruit beetles as well as two dermestid beetles which are normally associated with animal matter. The red-legged ham beetle is so attached to copra in the Orient that it is often known as the copra beetle. It is evident then that the copra may be a source of infesting insects for meat as well as fruit and grain.

Booklice	1
Moths	3
Beetles	19
Mites	2
	25

2a12. Other dried fruits.

The 67 insects and mites listed under this heading include the major share of all fruit infesting insects and in addition a number of general feeders like the cigarette beetle and Ptinus tectus. It has been pointed out that packaged dried fruit can be protected by heating to 125°-130°F for one hour after the packing and sealing is completed. Generally speaking, the moisture content of dried fruits is not low enough to prevent the development of insects.

It is probable that the mites, seven in number, recorded in connection with dried fruits are chiefly significant if the fruit is allowed to become moldy or has been seriously damaged by insect attack.

It is well known not only in connection with miscellaneous dried fruits but also with raisins that a considerable share of the infestation begins in partly dried fruits in the field and that it is kept alive from year to year by means of culls and windfalls which are permitted to remain on the grounds in the orchards. Hence, to a large extent the prevention of infestation goes back to the housekeeping methods of the orchardist.

The general remarks made in previous sections about diagnosis hold here also, but the attack is often more vague and unfortunately does not lend itself well to photography; I am, therefore, not including copies of any of the available illustrations. The large number of moths listed is probably in part due to the softness of fruit and the fact that it normally has a high moisture content, even when dried.

Crickets	1
Booklice	1
Moths	22
Beetles	39
Mites	6
	69

2a13. Other miscellaneous seeds.

Under this head I have included particularly oil seeds, cottonseed and its products, and the seeds of oil palms. This heading is to round out the account of seeds and aside from the fact that some of these seeds are commonly raised and stored in most parts of the world, they have but little connection with the materials used by the Quartermaster Corps, except in so far as they, like some other foods, may act as sources of infestation. We may notice here especially the reappearance of the family Mylabridae. Some of the species are especially associated with oil palm nuts, a few attack some of the seeds included here rather accidentally being normally pests of leguminous seeds and, one, Mylabris bixae, is only known as a pest of annatto seeds. One of the scolytid beetles, Coccotrypes dactyliperda, not only attacks raw vegetable ivory but as well buttons made from it, and in some places is known as the button weevil.

Crickets	1
Booklice	1
Moths	18
Beetles	54
Ants	1
Mites	10
	85

2a14. Dried vegetables.

The number of insects so far reported attacking dried vegetables is surprisingly small and most of them are either rather general feeders or have long been known in association with dried plants, generally. I believe that further investigation will considerably increase the list. It is noteworthy, for example, that neither the cigarette beetle nor the drug store beetle is recorded, so we must regard the information here given as quite incomplete. I would expect the damage to consist either of the characteristic moth webbing with destruction or perforation by beetles associated more or less regularly with accumulation of powdery detritus.

Crickets	1
Booklice	1
Moths	9
Beetles	5
	16

2a15. Fresh potatoes.

The present section includes primarily fresh white potatoes, but a few insects known to infest stored fresh sweet potatoes are also included. Of these the most frequent is a true weevil, Cylas formicarius. The moths listed are, for the most part, pests of growing white potatoes which carry over into storage. Beetles on the other hand are about equally divided between rather general feeders and wood-boring types which have abandoned wood in favor of softer materials. It is quite certain that the presence of moldy or rotten potatoes would serve to attract insects and mites.

Moths	6
Beetles	11
Flies	1
Mites	2
	20

2a16. Spices, condiments, etc.

The substances included in this section are of extremely varied nature; seeds, roots, leaves, some dried and ground, others preserved in various ways and as a consequence the insects associated with them are also extremely diverse. However, they fall on the whole into two main groups; those which are able to attack dried plant materials or seeds and a smaller group which is attracted to moist preserved materials, sometimes due to the presence of alcohol. A good many spices contain starch, either naturally or as an addition, and this helps in making them available to seed-eating insects.

Roaches	3
Earwigs	1
Moths	2
Beetles	37
Flies	7
Mites	1
	51

2a17. Oils, fats, waxes, edible or inedible.

In general, oils and fats are not much attacked by insects. This is, in part, purely physical. The insects tend to be trapped by the material if they do not actually avoid it because of its softness. However, there are a few insects that are specifically attracted by animal fats. These are the clerid beetles and the ants which are listed.

Undoubtedly one could secure a considerable series of insect remains from fats. I have myself seen saw-toothed grain beetle bodies in a sample of commercial hydrogenated cooking oil, but so far as I could determine all of the specimens were dead and had not been actually feeding on the material.

Silverfish	1
Roaches	2
Moths	1
Beetles	7
Flies	1
Ants	5
Mites	1
	18

2a18. Dried eggs.

It is surprising that there should be only two insects recorded from dried eggs, but it is not surprising to find that those two are, to a large extent, feeders upon dried protein substances. In my laboratory it was observed that the confused flour beetle would feed, at least to some extent, on egg powder and I have no doubt that many other insects will do so when the material is available to them.

2a19. Dried milk.

The few insects associated with dried milk fall into two groups. First the beetles which are, with one exception, protein feeders and have been found in connection with the finished product. Second, the flies which have been recorded from plants producing dried milk. It is not certain that they would feed on the finished product although their remains might easily be found in it.

Beetles	5
Flies	3
	8

2a20. Cheese.

The insects attacking cheese are in certain respects very similar to those attacking dried meat. The two important groups are the protein feeding clerid and dermestid beetles and 8 species of mites. The latter are probably associated with the molds used in the manufacture of cheese. Among the flies we may mention the cheese skipper which has long been known as a pest of cheeses. It will cause a certain amount of damage to the surface of the cheese although it does not penetrate into it very deeply. The type of damage done by cheese insects is similar to that caused to dried meat, and cheese may sometimes be reconditioned by trimming. On the whole it should be protected from the eggs of the insects by storage in tight containers or in thoroughly screened rooms. That is, it should be handled with the same precautions that would be used in handling meat.

It may be noted as an oddity that in one part of Germany a special mite cheese is produced and apparently both the cheese and dead and living mites are eaten without ill effects.

Roaches	1
Beetles	10
Flies	3
Mites	8
	22

2a21. Chocolate

In spite of the rather large number of insects that infest cacao only a relatively small number have been found infesting prepared chocolate. It is by no means out of the question that prepared chocolate is too oily a material to attract many of the food insects. On the other hand powdered chocolate is occasionally seen infested with the Indian meal moth.

It has been pointed out that candies containing nut meats are not subject to infestation by moths, while the chocolate coating is fresh, but when it becomes somewhat stale the moths start to work on it. This may be a matter of the physical state of the coating.

Moths	5
Beetles	5
	10

2b. Equipment and supplies and their raw materials.

I have included under this heading, in general, all those items which a soldier would carry with him except food, but including most of the materials used for food packaging. In other words, textiles of all kinds, leather, and other similar animal products, paper and similar materials, rubber, and a few minor items such as pastes and finishes so far as they could be separated from the materials on which they are used. I have postponed to heading 2c all consideration of metals, in spite of the fact that they have some vogue in food packaging.

2b1. Textiles and other materials from natural cellulose fibres.

In this subgroup are included, so far as possible, all materials in which natural cellulose fibres appear as such. It should be pointed out that this subgroup includes, in effect, all of the plant fibres. It is not important whether they are seed hairs or bast fibres.

We may divide the relation of insects to textiles into 3 major parts:

a. Attack upon the fibre material itself where it serves as actual food for the organisms.

b. Primary attack on the sizes and finishing substances which, in many cases, leads to more or less severe damage to the fibres. I regret that we cannot, in all cases, make a complete separation between primary attack on fibres and primary attack on finishes.

c. A rather numerous group of instances in which cloth or fibre is damaged without any part of it serving as food to the insect. This involves perforation of cloth either to secure access to food or to escape from a container and in several instances the use of the damaged cloth purely as a shelter.

It must be noted here, as well as in some of the subsequent sections, that cloth which is soiled with materials of animal origin may be damaged on that account when clean cloth of the same kind would not be touched. It will perhaps be most useful to consider the significance of each of the orders of insects listed in the table below.

The silverfish apparently attack cloth only to obtain some sort of added substance, frequently finishing material. They are undoubtedly led to do this because they ordinarily feed by scraping and the thinness of the layer is no deterrent. This may continue to the point where fibre damage is done.

Crickets and their relations apparently attack soiled cloth but not, as a rule, clean cloth. The exception is one species of Gryllacris. The detail of this attack will be found in section 3a2.

Roaches apparently resemble silverfish very strongly in their attack. It is quite familiar to librarians that roaches attack bindings of books, rasping away the surface which is heavily sized.

So far as I can learn damage to cloth by the European earwig resembles that of crickets.

It is most remarkable that there seem to be in the literature only two species of termites actually reported to damage textiles. This is probably because the whole emphasis in the study of termite damage has been placed on timbers. I have no doubt at all that many species of termites, in each of the known families, would do serious damage to textiles if opportunity offered. I myself had no difficulty in securing such damage in the laboratory by the eastern subterranean termite and have seen a few cases in the field where the same species had attacked cloth on the ground. I would assume, however, that damage by dry wood termites, from the nature of their habits, would be relatively unimportant.

The 6 species of caddis-worms included are known in northern Europe to cause more or less serious damage to the nets of fishermen. Naturally this damage occurs only to nets submerged in fresh water. Damage by the next two orders, moths and beetles, is normally of the type referred to under c above, but in some cases, at least, may be due to soiling of the cloth by some attractive material.

The one instance of fly damage is certainly almost completely accidental.

The ants listed attack a great variety of materials many of which are completely inedible to them and I suspect in many instances the attack is in the nature of an exploration. They are led to believe that there is food on the other side of the cloth.

We must not overlook the well known fact that clothes of cellulose fibre or of reconstituted cellulose are occasionally attacked by clothes moths and other feeders on wool, when they are adjacent to wool or because the cloth is mixed cellulose and wool. Such attack, however, does not seen to be invariable and there are some cases on record in which the insects took great care to select the edible wool fibres and leave the inedible cellulose behind.

Silverfish	3
Roaches and Crickets	6
Earwigs	1
Termites	2
Caddis-worms	6
Moths	2
Beetles	9
Flies	1
Ants	5
	35

As an aid to diagnosis of damage I include a table by Dr. Harvey L. Sweetman of Massachusetts State College which will give some clue to the insects which may be involved. Termite damage can be normally diagnosed by the methods given beyond under wood.

1. Threads snagged: pulled, looped, or broken; if broken, ends tapered or frayed. One or several threads injured with no trace of injury to neighboring threads. . . . . Mechanical injury
   Not as above. 2

2. Round or irregular holes that partially or completely penetrate the fabric; surface or ends of individual threads charred . . . . Burns
Not as above 3

3. Tubes and cases of silk, or burrows lined with silk in or on fabric 4
No traces of silk in or on fabric 6

4. Portable silk cases usually containing larvae on fabric; empty cases usually some distance above injured fabric. Fabric, unless loosely woven and thick, injured on surface only; if loosely woven, cases may be in fabric . . . . .Casebearing clothes moth
Attached silk tubes and webs on or in fabric 5

5. Attached silk tubes and webs on fabric; largely surface injury; tubes may enter thick, loosely woven fabrics . . . . Webbing clothes moth
Silk lined burrows in fabric; some attached tubes on surface; occasional loose portable tubes on fabric . . . . .Tapestry moth

6. Large irregular holes, 3/8 of an inch or more in diameter, penetrating fabric; only slight surface injury 7
Holes small; mostly surface injury, often penetrating fabric 8

7. Irregular areas eaten away largely from edges of fabric . . . . House cricket
Irregular holes eaten through any exposed portion of fabric . . . . .Field crickets and roaches

8. Minute scales on injured fabric; not readily visible to naked eye . . . . Silverfish
Not scales on fabric Brass and carpet beetles

2b2. Paper and books.

Although the list of species here is a little different from that given under the preceding subgroup, the relations of the organisms to the material are essentially the same and so we will say rather little about those groups which have already been taken up. We may, however, again emphasize the small number of actual termite records in comparison with the undoubted ability of that group to attack paper. My own observations show that the eastern subterranean termite can attack not only paper and fibre board, but in the laboratory, in any event, vegetable parchment.

The two booklice listed probably are interested primarily in molds which may grow on starch paste or other similar sizing.

We cannot, at this point, refrain from saying a word about bookworms. First, there is no such thing as The bookworm. It is merely one of several species of anobiid grubs and so far as I know none of them are appreciably concerned with the cellulose in the paper, but are feeders on the pastes and glues used in the binding of the book. It is fairly characteristic that damage is most marked close to the binding.

It has been observed that there is less insect attack generally, on those papers which contain a large share of mechanical pulp. It is assumed that this is due to the lesser degradation of the cellulose in such pulps.

Silverfish	5
Roaches and crickets	8
Termites	4
Booklice	2
Moths	4
Beetles	25
	48

I give here, to assist diagnosis, another key by Dr. Sweetman which covers, as far as possible, paper, book bindings, cellophane and similar materials. Unless the insects responsible can themselves be obtained the diagnosis is frequently quite uncertain.

1. Smooth holes or burrows chewed or eaten in materials 2
   Irregular holes; surface or edge feeding or chewing 3

2. More or less round or elliptical holes or burrows of variable size frequently reaching the surface exposing openings; small bits of chewed material in burrows or near holes; no excrement and earth cemented together lining burrows. Look for continuation of burrows in surrounding wood. Largely accidental infestations in paper, etc.. . . . . Wood borers
   Many burrows lined with excrement and earth cemented together; seldom or never reaching surface and exposing openings; burrows enter soil or surrounding woodwork . . . . Termites

3. Injury largely due to feeding on surface 4
   Injury at edges, corners, and folds 5

4. Minute scales, resembling fish scales on injured surface; not readily visible to naked eye . . . . Silverfish
No scales on surface 7

5. Individual tooth marks 0.5 mm. or more wide producing irregularities on chewed edge; tooth marks in pairs 6
Mandible marks not noticeable to naked eye or much finer than above; scratches from mandibles next to chewed edge frequently visible with magnification 7

6. Individual tooth marks about 0.5 mm. wide; fecal pellets 3 to 8 mm. long. . . . . Mice
Individual tooth marks about 1 mm. wide; fecal pellets 9 to 20 mm. long . . . . Rats

7. Larger fecal pellets 2 to 4 mm. long . . . . Larger roaches (American, Australian)
Larger fecal pellets less than 2 mm. long 8

8. Larger fecal pellets not more than 1 2/5 mm. or less than 1 mm. long . . . Smaller roaches (German, banded)
Larger fecal pellets 3/5 mm. or less in length. . . . . Silverfish

2b3. Artificial silk and rayon.

There are comparatively few reports of damage to these materials by insects under natural conditions, although experimentally it has been found that a number of insects will, at least, perforate rayon. Most of the damage appears to be due to silverfish and here it seems very likely that the finishing materials are what the insects are actually after. However, I see no reason to doubt that any insect which will perforate cotton cloth will also be able to perforate artificial silk and similarly any insect which feeds on cellulose should be able to derive nourishment from these synthetic fibres.

Silverfish	4
Crickets	2
Moths	1
Beetles	2
	9

2b4. Cellophane.

This material has been but little investigated and only 3 insects have been reported as damaging it. It is by no means impossible that the smooth surface would make it temporarily resistant to most forms, although they would have no difficulty at the edges of the sheets. I do not find any ascertainable records of attack on cellulose acetate or on ethyl cellulose.

Silverfish	1
Beetles	2
	3

2b5. Wool, fur, and feathers.

We find here, as is often the case, that the reports refer to a variety of situations. In the first place, we have clean wool or woolen cloth and prepared fur and feathers in the condition in which these materials will be actually used. These are capable of being attacked by a considerable variety of moths mostly related to the clothes moths and by about the same number of beetles of the family Dermestidae which may be collectively referred to as carpet beetles. Then we find a few insects capable of perforating such materials but not necessarily attracted to them as food. Lastly, a few records are based on the raw wool, in which presumably the attractive material is wool grease and whatever other organic substances which may be enclosed in it. It is very probable that there exist numerous other species of insects in the tropics which are capable of attacking wool and fur.

Roaches and crickets	4
Earwigs	1
Booklice	1
Moths	23
Beetles	31
Flies	1
Ants	1
Mites	1
	63

As an aid to diagnosis I include another of Dr. Sweetman's keys.

1. Silk threads, tubes, or cases in fur; hairs cut at or near base exposing base hide. . . . . Clothes moths
(See also 4 and 5 under 2b1)
No traces of silk in fur. 2

2. Skin or hide badly damaged loosening and freeing patches of fur; relatively small amount of hair cut off without injuring hide
. . . . .Larder, hide, cadaver, meat, and cabinet beetles

Skin or hide not at all or only slightly damaged; large amounts of hair cut off at base near skin, or tips of hairs cut or eaten away. 3

3. Hairs cut or eaten near base leaving hide bare; relatively little hide injury . . . . Black carpet beetle
Tips of hairs cut or eaten away leaving uneven surface . . . . Anthrenus species

2b6. Leather.

Because of the method of preparation leather is not especially attractive to insects, although when greasy, in any event, some do make use of it. It is also perforable by at least a few species that do not use it for food. This is the reason for the inclusion of the lesser grain borer.

The inclusion of the big termite in this subgroup and the next is certainly also a case of purely accidental attack on a non-food material.

Roaches and crickets	2
Termites	1
Moths	1
Beetles	13
	17

2b7. Hides.

Although the number of species recorded from hides is not remarkably large the amount of damage which they are able to do is very great. The two chief groups of insects attacking hides are certain clothes moths mostly of tropical types, and the carpet beetles and larder beetles. Damage from the latter is extremely frequent in hides of tropical or south temperate origin and the insects may easily spread to other appropriate materials from infested hides. Apparently the only good protection commercially resides in careful handling and extremely thorough and prompt salting of the hides. The damage by beetles consists chiefly in burrows either within the hide or just above it in the hair and is, therefore, of great importance in the production of sheepskins for fur.

Termites	1
Moths	8
Beetles	17
Flies	1
	27

2b8. True silk.

Fourteen out of 19 insects on the list are beetles and eleven of those are hide beetles or carpet beetles or other members of the same family. This, of course, is reasonable in view of the composition of silk. It is not certain that all of these insects can attack processed silk and a few are specifically recorded for raw silk. The casebearing clothes moth is also recorded. The remaining insects are distributed among 5 orders, one species each. They are firebrat, European earwig, the American fire ant, all of which are destructive to a great variety of substances, and the big termite (Mastotermes darwiniensis). The attack by this termite is probably purely incidental

It must not be overlooked that processed silk contains other substances than silk and the presence of sizes or finishes may be the determining factor in attack by such insects as the firebrat and the fire ant, especially.

Silverfish	1
Earwigs	1
Termites	1
Moths	1
Beetles	14
Ants	1
	19

2b9. Natural sponges.

Natural sponges consist of a material which is chemically very similar to silk. However, the fibres are much coarser and seem, on the whole, to be highly resistant to insect attack. Appropriately enough the insects known from sponges are protein feeders.

Beetles	4

2b10. Starch, pastes and finishes.

Almost all the damage which has been ascertained to such substances is caused by silverfish and roaches, and it must be recalled that such attack very frequently entails damage to the material which carries the finish, although such material may be indigestible to the insect. It is also noteworthy that these insects are mostly types which obtain a good share of their food by abrading it from surfaces. The diagnosis, on the whole, rests on the damage to underlying material and for this and the two following sub-groups I refer back to the keys given under 2b1 and 2b2.

Silverfish	4
Roaches	4
Beetles	1
	9

2b11. Glue and casein pastes and finishes.

The materials here considered are proteins and hence more attractive to insects than the starches. We, therefore, find included not only a silverfish and a roach to which groups doubtless other representatives will be added, but as well two moths, one of them a well known clothes moth, and several beetles, half of which are dermestids. There is no doubt that any insect capable of feeding on wool or hides would attack glue or casein when possible.

Silverfish	1
Roaches	1
Booklice	1
Moths	2
Beetles	9
	14

2b12. Plastic and resin pastes and finishes.

The information available for this subgroup is very unsatisfactory. It does seem to be clear, however, that ureaformaldehyde resins are not known to be subject to insect attack, but the people who know which resins are attackable have proven rather reticent. Mr. Secrist tells me that the silverfish will attack casein but not casein-formaldehyde resin.

Silverfish	1
Beetles	1
	2

2b13. Vegetable ivory.

The two beetles here recorded apparently are both associated primarily with the raw nuts but are able to carry over into the manufactured buttons.

Beetles	2

2b14. Rubber.

Most of the information on damage to rubber is based on damage to electrical equipment and it seems very certain that the damage is not in any way connected with using the rubber, as such, for food.

One ant, Monomorium latinode, is on record as attacking almost all articles made of rubber, except tires. Unfortunately, the most comprehensive article on insect attack on rubber has not yet been received in this country.

Termites	2
Beetles	1
Ants	5
	8

2b15. Felt.

The two available records, both African, seem to involve only the penetration of the felt by termites, presumably to get at underlying wood. I see no reason, however, why felt might not be attacked by a variety of wool-feeding insects. It is commonly stated that piano felts are attacked by clothes moths, although I have never seen an instance of it.

Termites 2

2b16. Photographic emulsions.

Only one record is available, which is silverfish damage from Australia. However, I see no reason why any insect which will attack glue or casein used as a finish should not occasionally attack the gelatin of photographs.

Silverfish 1

2b17. Nylon.

It has been shown experimentally that the casebearing clothes moth can, to some extent, use nylon in place of natural proteins, although it is not known to attack it very readily. It would not, therefore, be surprising if other protein feeders should also attack nylon. The list of species given under true silk would be a fairly good guide.

Moths 1

2c. Materials of construction.

I here include the materials whose primary significance is in connection with the construction of buildings and semi-permanent installations, although wood naturally has a great variety of other uses. The metals are separately taken up under heading 2d.

2c1. Wood and wood products, including plywood.

The present subgroup is intended to include those wood products in which the wood has not been broken down structurally or chemically. The small number of reports of insect attack on plywood doubtless refer to older types in which the binder was glue or casein and the wood was not impregnated. Generally speaking, I have confined my attention to those insects which are able to attack wood that is sufficiently seasoned for use. I have included some records of damage to almost green wood in actual use.

It is extremely difficult, evidently, to draw any line between seasoned and unseasoned wood. The insects, as a whole, do not draw any such distinction and we may even find that an insect, for an example the locust borer (Cyllene robiniae), apparently only initiates its attack in living locust but has been known to emerge after a long time from quite thoroughly seasoned wood. Some few insects, as pointed out later on, respond definitely to the presence of bark and are not concerned with the state of seasoning. It is, of course, perfectly obvious that small species may survive much of the preparation of wood without injury. Powder post beetles, for example, commonly infest logs or timbers in yards and I have seen instances where the infestation remained alive through all the processes of planing and building the wood into a house and the adults finally emerged by perforating the varnish used as finish.

Wood is attacked by animals for a variety of reasons. In the first place, it may represent food, or food and shelter. In the second place, it may represent apparent food. This is true of the American porcupine which will attack wood that has been soiled with salt or grease, although I am sure the porcupine derives no appreciable nourishment from the wood itself, unless it is very green. In the third place, wood may merely represent permanent or temporary shelter. This is true of ants and bees, although the wood wasps actually feed on substances in the wood. A considerable number of beetles drill shallow holes into wood for the purpose of pupation.

It must not be supposed that all of the insects which attack wood are capable of utilizing the cellulose, although apparently they all use carbohydrates in wood primarily rather than the lignins. As a consequence the material discarded by the insect in its excrement may be extremely bulky because only relatively small amounts of hemi-celluloses have been abstracted. In section 1e I have given a classification of the relations of insects to materials infested. We may point out here that the insects infesting wood fall into six groups. (1) Permanent pests, termites, many beetles and ants; (2) bark pests, many beetles; (3) one generation pests, many beetles and some wasps; (4) secondary pests which attack wood only after it has been damaged in some other way, may beetles, a few ants, some roaches and some wasps; (5) temporary pests, carpenter bees and a few other wasps whose use of the wood as a nesting place occupies only a part of their life cycle; (6) accidental pests, a number of beetles which may use other materials for pupation and several miscellaneous insects. If we now turn to the orders of insects which have been reported damaging wood we find two crickets among the Orthoptera. These are probably both accidental pests.

The most celebrated of all the groups attacking wood are the termites. In section 3a4 will be found the necessary account of their biology, including a discussion of habitat types, but we may point out that the distinction of habitat types depends in part on the condition of the wood. Subterranean termites, for example, being able to persist in sufficiently damp wood without a ground connection and similarly the distinction between dry wood and damp wood termites is primarily dependent upon the moisture content of the wood.

The family Kalotermitidae characteristically produces excavations of fairly limited extent since the colonies are rather small, but more than one colony may occupy the same piece of wood. Each excavation has usually one or more external openings which are normally kept blocked but which are opened for the ejection of fecal pellets and for the escape of the winged forms. Some of the species do not eject the pellets.

The two families Mastotermitidae and Rhinotermitidae produce very extensive workings not only in one piece of wood but often in several adjacent pieces so that we ordinarily assume, in the case of the eastern subterranean termite, that all damage in any one building is due to a single colony.

The family Termitidae commonly produces an external nest constructed of paperlike or cementlike material and from this nest passageways run into the wood. It appears that even among closely related species of this family some attack wood and some do not.

The four caddis-worms included are known to burrow into submerged wood in fresh water in Northern Europe and there is one record of the same sort of damage from the Great Lakes.

It will be seen from the statement of the classification of wood-infesting insects just given that 5 of the 6 categories are occupied wholly or in part by beetles. In fact one can scarcely make any useful generalization about wood infesting beetles since they do practically anything that any other sort of insect is able to do.

The deathwatch beetles (family Anobiidae) are partly permanent pests such as the furniture beetle, partly bark pests, for example Ernobius mollis, and partly more or less accidental pests as in the case of a few species which have mostly gone over to other food materials. The false powder post beetles (Bostrichidae) are, on the whole, more important particularly in the tropics than the deathwatch beetles and a large proportion of the species listed are permanent pests. Here also are included a certain number of species chiefly in the genus Dinoderus, which are primarily pests of bamboo but will attack wood or other materials stored adjacent to bamboo.

The longhorned beetles or round headed borers (Cerambycidae). This immense family chiefly comprises beetles boring into living trees but a certain number of species have been able to shift and attack partly or wholly seasoned wood in which they make rather large burrows.

The true weevils (Curculionidae). There is still a certain amount of mystery surrounding attack on wood by weevils. We know that it occurs and we know that occasionally the damage is serious, but we are by no means certain of the predisposing causes. It is my personal opinion, however, that wood attacked by weevils has already been damaged by decay and that we are dealing here with a selection of species which have adopted decayed wood as a particular habitat.

Powder post beetles (Lyctidae). Most of the representatives of this family attack the seasoned sap wood of broad leaved trees. Compare here the biological remarks in 3a10. Because these beetles are small they are relatively easily spread in commerce and several of the species have become cosmopolitan, a phenomenon which is not overly common among wood boring insects. They are capable of doing a very great deal of damage, partly because of the value of the wood which they attack.

The family Oedemeridae. The few species of this family recorded from wood seem always to occur in very wet wood and, in the case of the Dutch wharf beetle, in wood within a few inches of sea water. They are, consequently, to be expected chiefly in bridges and wharves.

The engraver beetles (families Platypodidae and Scolytidae). Although these two families differ somewhat in structure and in the details of their biology, they agree at least in utilizing their bore holes in wood for the raising of fungi upon which the young feed and characteristically, therefore, the walls of their holes are stained. It is probable that none of these species can initiate attack in thoroughly seasoned wood, although they may do so in partly seasoned wood. The Scolytidae are a very large family most of whose members do no damage of interest to us since they work mostly between the bark and the cambium or within the latter layer, but a few species which I have listed produce long radial burrows and can, therefore, weaken the timber. Probably in all cases the bark must be present.

The bees and wasps fall into 3 of the classifications given above, Eriades, Lithurgus, Stigmus and the carpenter bees being temporary pests. The wood wasps (Sirex) apparently are all one-generation pests which actually use the wood for food and the ants are permanent pests utilizing the wood only for shelter.

Each of the agencies injuring wood causes a reasonably distinct effect. The ease of diagnosis depends on the extent of the injury and whether or not a single organism is involved. Numerous sorts of animals, for example, make use of well-rotted wood for one or another purpose but are not able to use sound wood.

Aside from mechanical or chemical injury to wood, which may be caused by fire, acid, heating, etc., it will be useful to consider briefly the effect on the wood of the action of the following groups of organisms: fungi, teredos, crustaceans, insects, and rodents.

Fungi are responsible for various changes in wood which range from discoloration to complete breakdown to powder. The loss of strength in wood which is not accompanied by the obvious removal of substance may be called rot. It may be safely said that every piece of wood which is used for building or packaging is already infected by fungi capable of causing rot. These fungi may remain dormant for long periods. Exposed to favorable conditions of warmth and moisture, the fungus becomes active. These conditions are: the presence of oxygen, temperature above 40°F. and below 115°F, moisture above about 20%. Evidently the action of fungi is very low near these limits.

There are only two effective means of preventing decay of timber. (1) Keep the moisture content of the wood below the critical level. (2) Seal the timber by the application of hot creosote under pressure.

Damage due to teredos occurs only in wood submerged in sea water and consists of long gradually enlarging, circular burrows which are lined internally by a deposit of lime. It is commonly stated that no matter how closely crowded these holes may be they do not intersect.

There are a few crustaceans, rather distant relatives of shrimps, that are also able to attack wood submerged in sea water. So far as I know this damage consists in boring shallow holes entering the wood at a slight angle to the surface. The damage seems always to be quite superficial extending at the most perhaps 1/4 inch in from the surface. As the injured wood breaks away the borings continue inward.

Insect injury involves the eating away of portions of the wood to form tunnels or cavities. These spaces may be clean and empty or filled with one or another material. The various main groups of wood destroying insects may be identified from their work. I give first a key which has been modified from one devised by Dr. E. G. Linsley of the University of California and following that a few notes on other insect damage which he does not include.

1. Colonial, more or less ant-like, usually wingless insects, making large irregular galleries in wood; without round external openings 2
   Usually solitary insects making tunnel-like burrows; often with circular or oval external openings 3

2. Galleries open, clean, without frass or pellets, frequently running across the grain. . . . . Carpenter ants (And a few other ants)
   Galleries often rough, lined with excrement or partly filled with excretal pellets or a plaster-like mixture of earth and excrement; usually running with the grain . . . . Termites

3. Large round burrows from 3/8 - 5/8 inch in diameter in exposed wood; burrows enter at right angles to

the surface then turn and run with the grain; burrows partitioned off into cells by plugs of wood powder and shreds, cells containing pollen or young bees. . . . . . Carpenter bees
Smaller burrows less than 3/8 inch in diameter without partitions, cells or pollen but often well filled with frass or a mixture of frass and pellets. 4

4. Burrows round or oval, averaging about 1/4 inch in diameter, tightly packed with boring frass. 5
Burrows round or oval, 1/8 inch or less in diameter 7

5. Burrows usually in wood of broad leaved trees, especially in panels, plywood, etc. . . . . Some false powder post beetles
Burrows in coniferous woods; the larvae in the burrows are elongated legless grubs about an inch long, with a sharp point near the tip of the abdomen. . . . . Wood wasps
Burrows usually in coniferous woods, especially in studs or heavy timbers, the larvae are usually legless grubs, straight and with a point near the end of the abdomen 6

6. Burrows usually round in section, walls without minute curved grooves; larvae straight and segments behind head rather slightly enlarged so that the body tapers evenly toward the rear . . . . . Round-headed borers
Burrows flattened oval in section, walls with minute, curved, concentric grooves; larvae straight, legless and segments just behind the head much broadened and flattened . . . . Flat-headed borers

7. Burrows not filled with frass, frequently branched, walls stained, usually black. Engraver beetles
Burrows filled with frass or pellets, walls usually unstained 8

8. Burrows 1/16 inch in diameter, filled with fine, flour-like frass, in sap wood of broad leaved trees . . . . Powder post beetles
Burrows up to 1/8 inch in diameter filled with tightly packed frass or frass and pellets 9

9. Burrows winding or running largely with the grain; frass somewhat adhesive and mostly without pellets. False powderpost beetles

Burrows running with or across the grain frequently intersecting and filled mostly with loose pellets . . . . . . Deathwatch beetles

The work of the true weevils consists, in the few instances which I have seen, of minute burrows running largely with the grain, empty with somewhat irregular walls more or less roughened, perhaps with excrement. As far as I know the burrows of oedemerid beetles are largely empty and about 1/8 inch in diameter.

The nesting burrows of various solitary wasps resemble those of carpenter bees but are on a much smaller scale. The cells at the ends of the burrows containing either more or less dead insects or well grown grubs or pupae of the wasps. Occasionally this habit of storing insects in the cells leads to an allegation that the stored insects are the cause of the damage.

Wood injury due to rodents is characteristically recognized by the paired tooth marks. The individual marks will vary in width from about 1/20 of an inch to about 3/8 of an inch and the damage is obviously done from the outside of the piece.

Crickets	2
Termites	136
Mayflies	2
Caddisworms	4
Beetles	209
Bees & wasps	25
	378

2c2. Compo board and wallboard.

There is very little information on these materials. About all one can say is they will be attacked by termites if they contain sufficient unpoisoned cellulose and that almost any of them if soft could serve for the pupation of beetles or could be perforated by ants. The diagnosis would follow that given for wood.

2c3. Concrete.

I have no detailed information on the few records of damage to concrete which are in the literature. However, it is fairly well ascertained that the eastern subterranean termite can eventually penetrate mortar which contains more than 10% of lime and it is highly probable that tropical species of the family Rhinotermitidae with much more abundant secretions from the frontal glands should be able to work more rapidly. I have no idea how the one recorded ant attacks concrete but the species in question has remarkable powers of penetrating unexpected materials.

Rats are also able to gnaw their way through concrete and the latest recommendations which I have seen on rat proofing of outbuildings call for a concrete floor at least 4 inches thick.

Termites	2
Ants	1
	3

2c4. Asphalt.

Very few insects seem able to penetrate asphalt or tar at all. This is probably due to its physical nature. However, the lead cable borer has been recorded as penetrating a 5-ply built-up asphalt roof and 2 African termites penetrating felt heavily impregnated with tar.

2d. Metals.

I have attempted to include here such records as are available of injury to metals of any kind by insects. It may be said at the outset that we have no evidence that insects derive any nourishment from metals or even ingest them. They are, however, able to perforate thin and soft metals.

2d1. Lead.

Since lead is the softest common metal it is not surprising that a fairly long list of insects are known to damage it. In some cases the damage is due to perforation by beetles or bees attempting to emerge from wood which has been covered with lead. In other cases lead is used as a place of pupation by beetles which would ordinarily bore into branches or other wood. Probably most termites damage lead only when they encounter it in the course of making their galleries. I am told, however, that in parts of Australia buried electrical cables are seriously damaged by termites during the dry season, apparently because of condensation of moisture near the cables. Lead is soft enough so that considerable thicknesses may be penetrated, probably a quarter of an inch without great difficulty.

Termites	3
Beetles	27
Bees, ants wasps	4
	34

2d2. Aluminum.

Three moths are on record as perforating very thin aluminum sheets or foil. Probably many other insects could do so if they come in contact with the metal.

Moths	3

2d3. Copper.

The two beetles known to damage copper are both noteworthy for their ability to bore into hard substances, and apparently even copper foil is proof against attack of the vast majority of insects.

Beetles	2

2d4. Tin.

Tin is sufficiently soft so that at least tinfoil of unstated actual composition has been perforated by several insects.

Moths	3
Beetles	3
Wood wasps	1
	7

2d5. Other metals.

The only actual record of damage to other metals is an old one from Strasbourg of a wood wasp penetrating the 1/2 inch steel plates of a safe. Personally, I am greatly inclined to doubt this record.

The larder beetle has been tested against several metals and it was found that while it could penetrate lead and tin it could not penetrate zinc, aluminum or brass. The main thing to be learned from our point of view from these various records is that lead at least is no cure for damage to packages by insects. A reasonable thickness of a quite hard metal is necessary.

2e. Houses and storage buildings, etc.

I have included under this heading a large number of insects, some of them accounted for elsewhere under specified food materials, but many of them without precise food records. Although one could expand the list almost indefinitely, I have tried to restrict it to those insects whose near relatives are known to cause definite damage. We may, therefore, reasonably assume that any insects which appear only in this list will, under appropriate conditions, do damage.

Silverfish	5
Crickets & roaches	8
Earwigs	1
Booklice	12
Moths	3
Beetles	46
Flies	6
Ants	46
Mites	2
	129

2f. Miscellaneous.

The present section is included largely to complete the classification of the available records of the activities of insects elsewhere included and to take into account a certain number of substances of relatively little importance to the Quartermaster Corps but about which inquiry might be made.

2f1. Drugs.

I have not attempted here to abstract the special literature dealing with insect infestation of drugs, but merely to bring together a list of insects that were encountered in connection with other materials. It must be kept in mind that all of these records apply to galenical drugs, mostly in the raw state. The ability of insects to feed on such drugs as opium, nux vomica, aloes, and henbane, has long been a source of wonder, although it is perhaps scarcely more remarkable than the ability of some of the same insects to live readily on a diet of cayenne pepper. The answer seems to be that the insects in fact feed largely on the starches present and do not absorb into their systems the alkaloids.

Moths	1
Beetles	18
Mites	1
	20

2f2. Animal substances.

There were enough records of unspecified animal materials to make it worth while to bring them together. The only specified materials included here were dead insects and dung and I believe that every insect listed has some definite food assigned to it in some other part of this report.

Silverfish	1
Earwigs	1
Termites	1
Booklice	1
Moths	7
Beetles	37
Flies	1
Ants	6
Mites	3
	58

2f3. Plant substances.

This subgroup was included not only to take care of unspecified records but also to include the insects known to attack tobacco and derris. The latter, as is well known, is the source of rotenone, one of the most potent insecticides of plant origin. It is of great interest to an entomologist that stored derris root should be attacked by a respectable number of insects. An added reason for including this subgroup was that it gives a little clearer picture of the potention abilities of a considerable number of species which we have ordinarily considered to possess quite limited choice in foods.

Silverfish	1
Termites	1
Booklice	1
Moths	15
Beetles	66
Flies	1
Ants	15
Mites	9
	109

2f4. Miscellaneous.

The contents of this subgroup is sufficiently indicated by the notes which have been added after the several species.

Termites	1
Moths	1
Beetles	1
Flies	2
Ants	5
Mites	1
	11

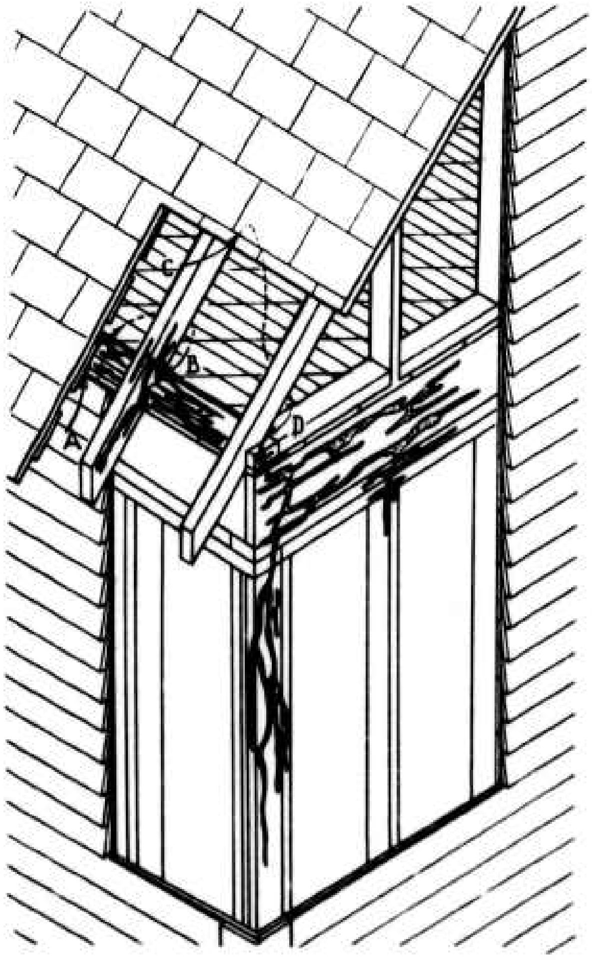

Figure 3: Diagram of the excavations made by two colonies of the common dry wood termite. The lines ab and cd represent the routes of entry. The two colonies are not interconnected.

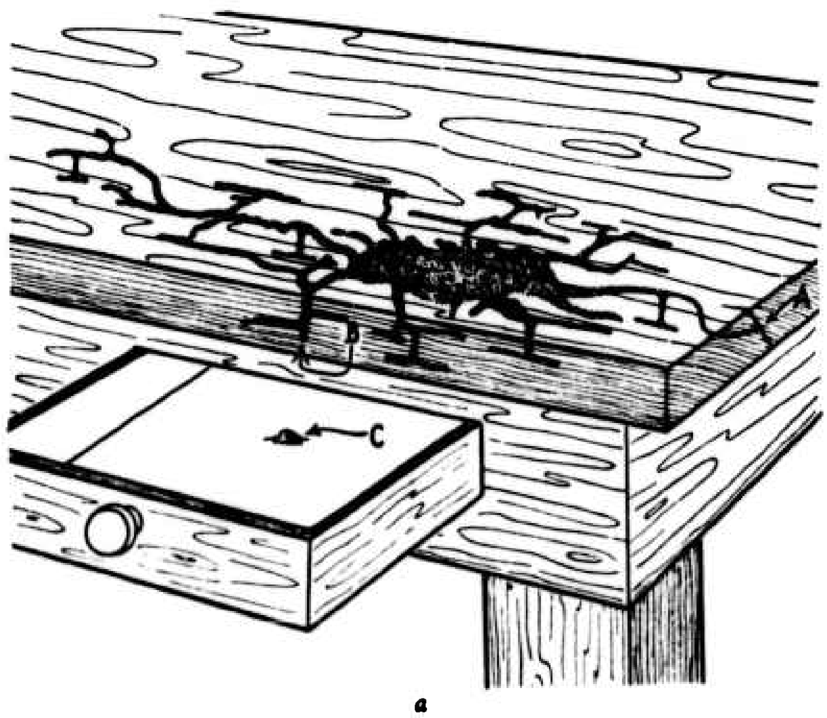

Figure 4: Diagram of the excavations of a powder post termite in a table top. The colonizing pair entered at a, fecal pellets are ejected at b, and have accumulated in the drawer to form the pile marked c.

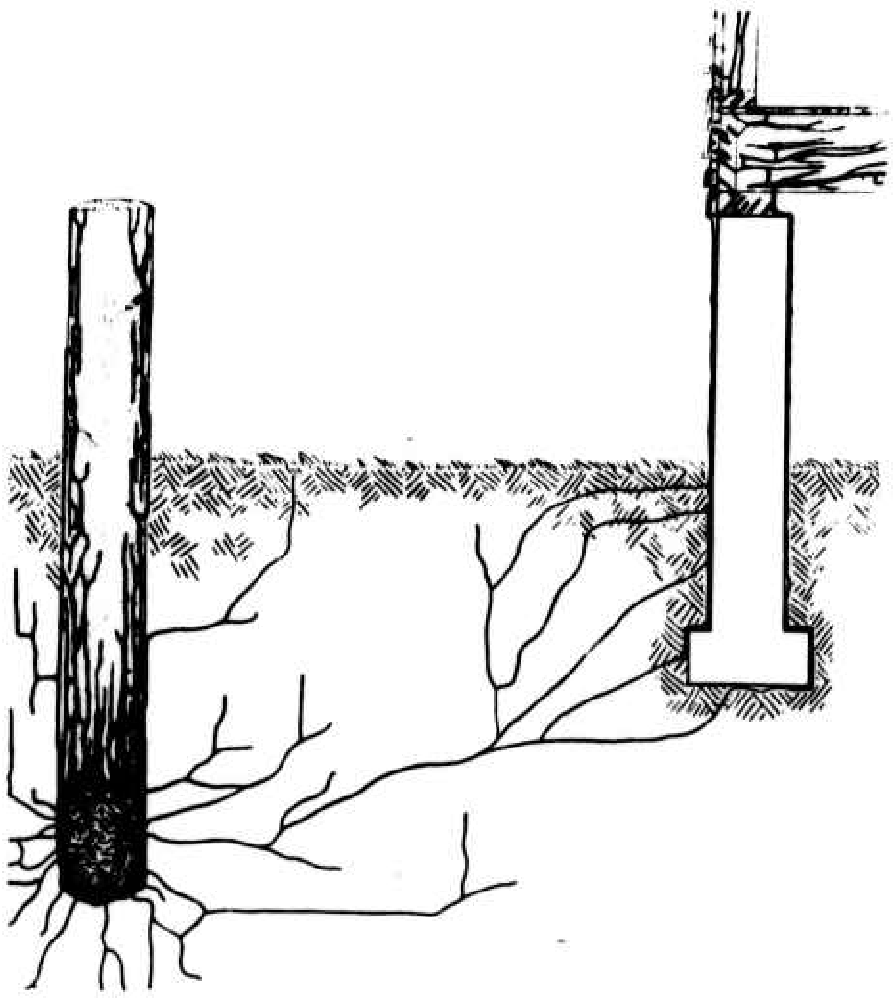

Figure 5: Diagram of the nest and workings of <u>Coptotermes</u> <u>formosanus</u>. The nest is in the bottom of the post at the left. The post has been partly excavated and runways extended to the foundation of the buildings at the right and covered galleries up both sides of the foundation to the wood above.

Figure 6: Damage by <u>Coptotermes</u> to a book. Many live termites are shown together with frass.

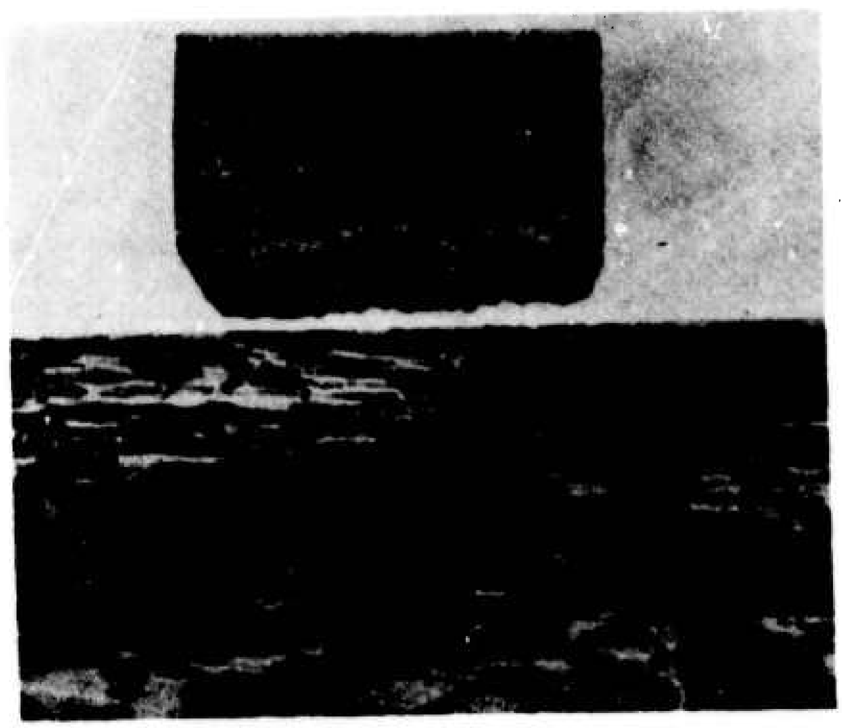

Figure 7: Work of a subterranean termite in the sill of a house in California. The section above shows how the galleries follow the annual rings. The surface view below shows the galleries and plaster used to seal the wood fast to the ground.

Figure 6: Damage to a stored corrugated pasteboard box by subterranean termites.

Figure 9: Ear of corn showing the characteristic loose webbing left by the caterpillars of the Indian-meal moth. This moth rarely attacks sound grain, but, as is shown here, frequently attacks grains already injured by other grain pests. Such webbing as is here shown develops only when corn and other grains are left undisturbed for some time.

Figure 10: Pressed cut smoking tobacco showing burrows of grubs and exit holes of adults of the tobacco beetle. These holes are about one-sixteenth of an inch in diameter.

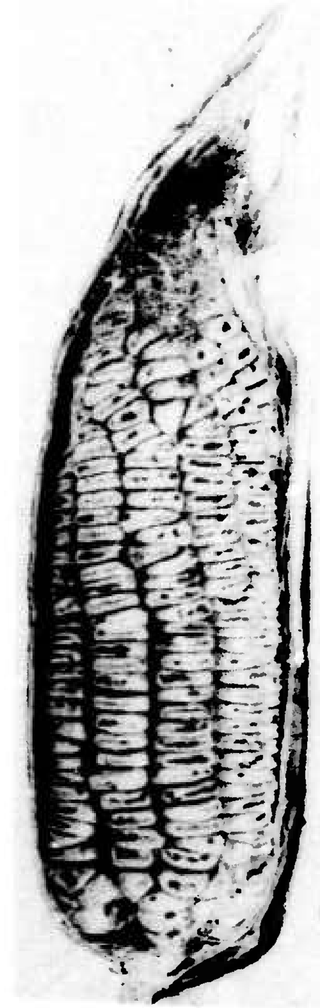

Figure 11: An ear of corn badly damaged by rice or black weevils. This ear has been hit against a table to jar loose the powdery substance, sometimes called the farinaceous material, and so reveals the great damage done by the weevils.

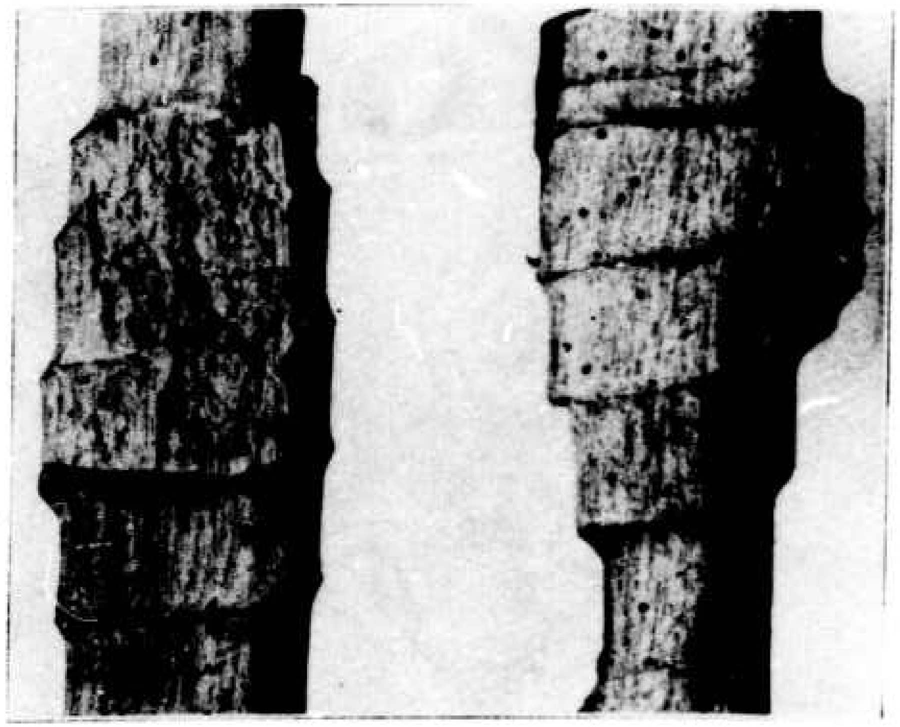

Figure 12: Hardwood blocks showing damage by powder-post bettle (Lyctus sp.). The example on the left shows the internal damage to the wood while that on the right shows the exit holes made by the beetles. The exit holes are about one-sixteenth of an inch in diameter.

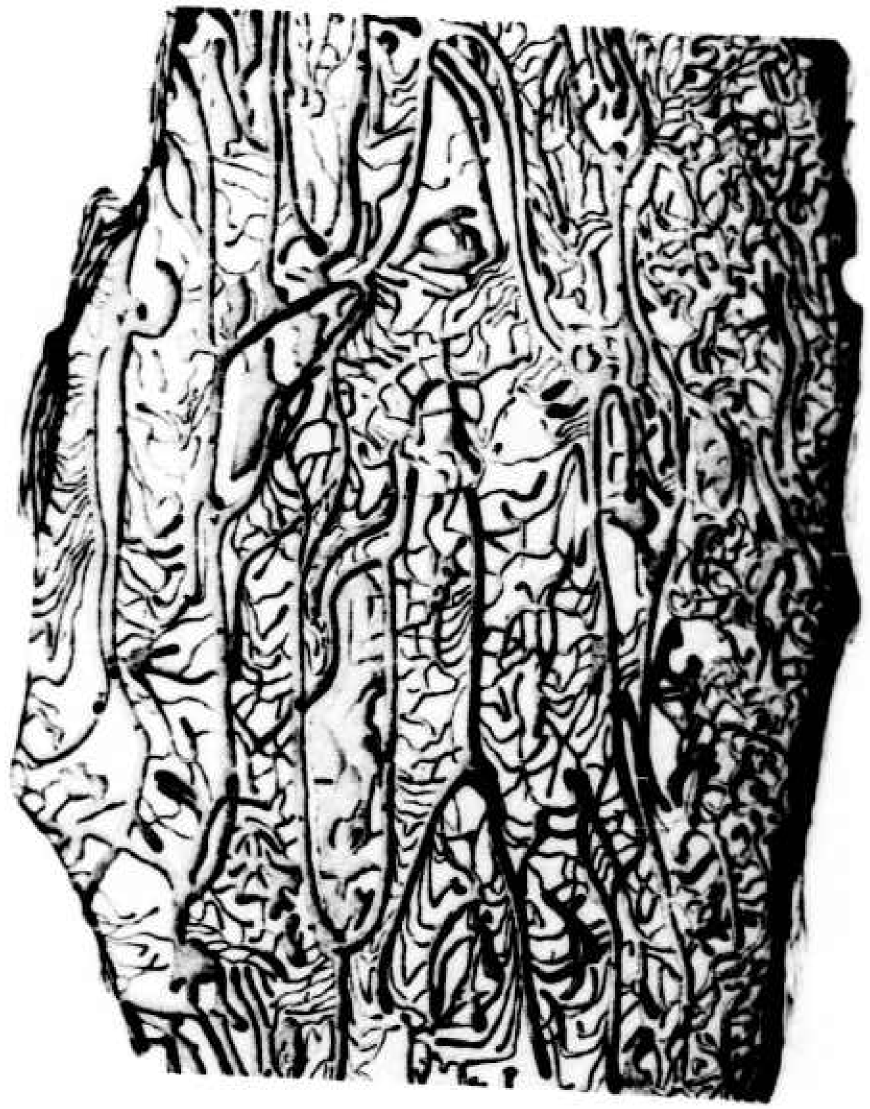

Figure 13: Egg and larval galleries of Tomicus longifolia, Steb., in inner bark of Pinus longifolia. North-West Himalaya.

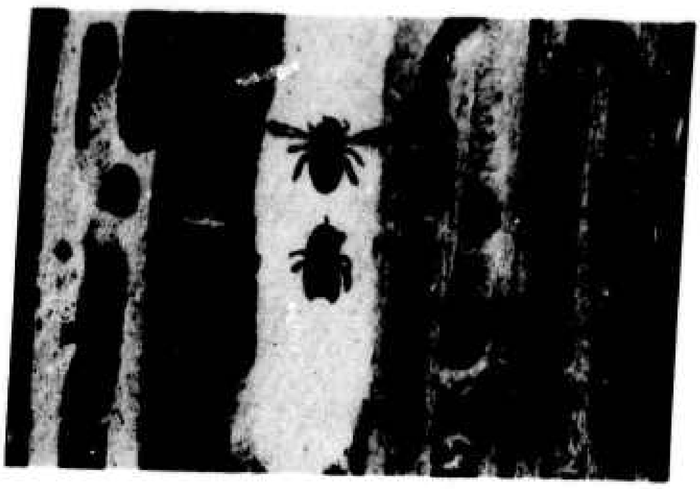

Figure 14: Mountain carpenter bee. In the center are two adults. At the sides the nest burrows. This small carpenter bee is only about 1/2 inch long.

FIG. 9 (BELOW)

Half section of part of a pole worked by carpenter ants. The true height of this specimen is 11 inches

Figure 15

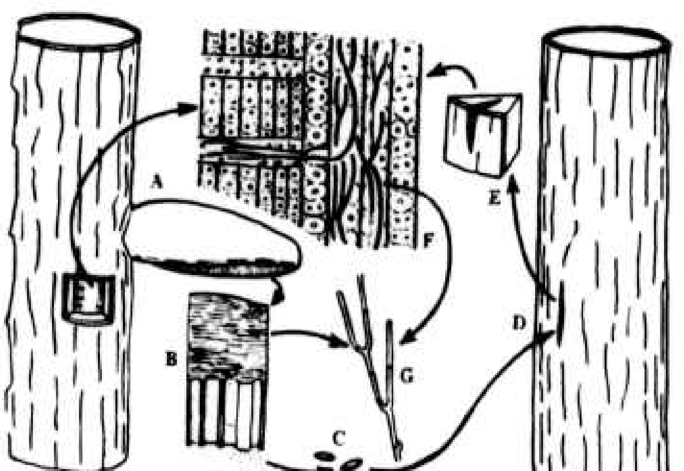

FIG. 2

Life history of a bracket fungus. A. The fruiting body on a tree. The window in the tree shows where the vegetative threads are hidden. (F shows these threads in a wood section, very highly magnified.) B. A vertical section through the fruiting body (magnified) to show the flesh above and the tubes below. Each tube is lined by a spore-producing surface from which the spores fall. C. The spores very highly magnified. D. The spores enter the deep check shown here and give rise to a new set of vegetative threads. E. Part of the same check as in D to show that it extends through the bark and into the wood itself. F. The vegetative threads in a wood section. G. The threads isolated from the wood and more highly magnified

Figure 16

3. SYSTEMATIC DISCUSSION OF THE ANIMALS

In this section the organisms considered are arranged in what a biologist considers systematic order. This means that those forms most nearly related structurally are gathered into categories whose rank depends on the nearness of relation of the contained categories. It is not my purpose to give a lengthy account of systematics, however, we may point out that the four groups designated by letters in the table of contents represent three of the primary divisions of the animal kingdom.

1. The Arthropoda.

This division (phylum) includes insects, spiders and their relatives, crabs, lobsters, centipedes, and thousand-legged worms as well as many lesser known animals. It is the largest major group in the animal kingdom, comprising some 650,000 kinds of animals, or about 3/4 of all the known species.

2. The Mollusca.

This division includes oysters, clams, snails, slugs. We are concerned only with the moderate number of species of teredos or ship worms which are really peculiar clams.

3. The Chordata.

This division includes all those animals having backbones and some closely related forms.

Each of these divisions is divided into smaller groups called classes. In the arthropods we consider some of the class of insects and one part of the class of arachnids.

In the mollusks we consider one small part of the class of clams and in the chordates part of the class of mammals.

Each class is in turn divided into orders. Among the insects we take account of representatives of 12 of the orders.

Each order in its turn includes one or more families. I have not invariably used the family as a category in the discussion. In some instances too few families are involved; in others the possibility of distinguishing the families readily is extremely low so that I have only used this category where it offered some actual advantage to do so. The ending --idae is used as the means of distinguishing the family names from those of other categories.

It will be seen on referring to the appendix that the name of an insect consists of two parts. The first, written with a capital letter, is the name of the genus or small group to which the species belongs. The second, written always with a small letter, is that of the species which is the individual entity with which we are concerned. Each species is always designated by the two names together. In a few cases, especially among the ants, additional names are used which are those of categories below the rank of species. In some cases a generic name is followed by the abbreviation sp. or in the plural spp. This means that we are dealing with an unnamed or unidentified species in the genus designated.

Where possible I have given common names in various languages and so far as I have found them in English I have used them in the general text. The Index will enable one to connect these common names with the scientific names. However, I have strictly refrained from coining common names. Generally speaking, I give preference to the names as used in this country where the English use different common names and in addition have followed in almost all instances the official list of common names published by the American Association of Economic Entomologists.

3a. Insecta - the insects.

3a1. The order Thysanura - bristletails, silverfish.

The insects of this order are completely wingless, the body gray, brown or mottled, and scaly. The antennae are long, thread-like, many jointed. The hind end of the body is provided with 3 long, very slender, and many-jointed tails. There is no evident metamorphosis.

There is still considerable debate about the true food of the silverfishes, but they have been recorded as doing damage to a great many kinds of materials, especially those containing starch or protein. Hence, they attack the sizing of paper or cloth and the glue of book bindings. In so doing they may do damage to the underlying cloth or paper, and this damage is sometimes quite evident.

Silverfish require rather warm conditions and hence outside the tropics are not generally found out-of-doors. They also require a rather high degree of moisture. They may be expected to live in the vicinity of stoves and sinks and particularly around bake ovens. They are decidedly nocturnal and generally prefer to spend the day in crevices.

As has been indicated silverfish are to be expected primarily in the tropics and 3 or 4 species have become, through commerce, virtually world wide. One or two more are distributed throughout the tropics but not in temperate regions.

Due to the minute spaces in which the Thysanura are able to live their control by constructional methods is generally impractical. Fortunately they take poison baits based on starchy materials very readily, and formulae for appropriate baits are appended.

Lepisma saccharina - U. S.: silverfish, fishmoth

There are two well-known members of the present order. One of these is the species named above, a shiny gray animal about 1/2 inch long, not counting the tails, which frequently appears in bath tubs. The upper surface of the insect is scaly, but the scales rub off very easily. It runs with very great rapidity. The silverfish is cosmopolitan but outside of the tropics occurs only in dwellings, since it does best at a temperature of about 80°F and prefers a nearly saturated atmosphere. It, therefore, tends to stay around water and this accounts for its being found in bath tubs.

This insect is known to feed on a considerable variety of starchy materials, such as wallpaper pastes, glazed paper, cereals, and miscellaneous dried plant materials, but it also feeds on protein containing substances such as protein-sized paper and freshly dried beef. It is now generally held that it requires some protein in its diet. In addition, it will attack cellophane, nylon, and cloth sized with some of the synthetic resins but not as far as can be learned those containing formaldehyde.

The insect is readily killed at 98°F and at 32°F.

Thermobia domestica - U. S.: firebrat.

The firebrat looks and acts very much like the silverfish. It is, however, marked with brown cross bands which are quite conspicuous if the scales have not been rubbed off. Its very habits are very much those of the silverfish, but it requires still higher temperatures and does not necessarily require as high humidity. The optimum temperature is about 98°F (about the highest on record for any pest insect) and it may develop at humidities as low as 48%.

The food habits of this species are similar to those preceding. It seems, to have a rather special liking for rayon which is probably a question of the sizing used, and it has been noted that rayon containing sulphonated compounds is not very attractive.

The development of these animals is rather slow and there are numerous molts. They are killed at 32°F and about 130°F.

3a2. The order Orthoptera - crickets, grasshoppers, and roaches.

In this order the antennae are many jointed, often long and thread-like. The hind end of the body is provided with two short or moderate tails, usually these are very inconspicuous. The females of many species have at the hind end of the body a conspicuous egg-laying organism, sword shaped or awl shaped. The wings when developed consist of a relatively narrow front pair which is frequently of firmer texture than the hind pair and a broad hind pair which when closed is folded like a fan. However, reduction or lack of wings is by no means uncommon in adults. The metamorphosis is slight. The

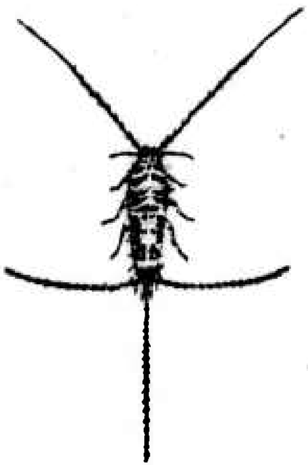

Figure 17: The fire brat. About twice life size.

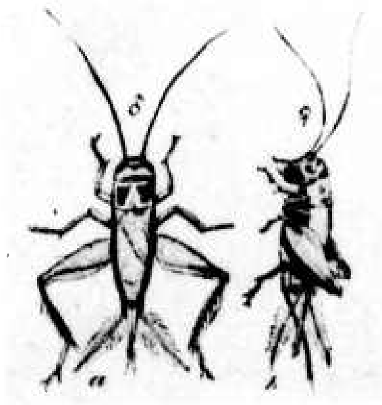

Figure 18: The house cricket. Male on the left; female in side view on the right. The photographs are about natural size.

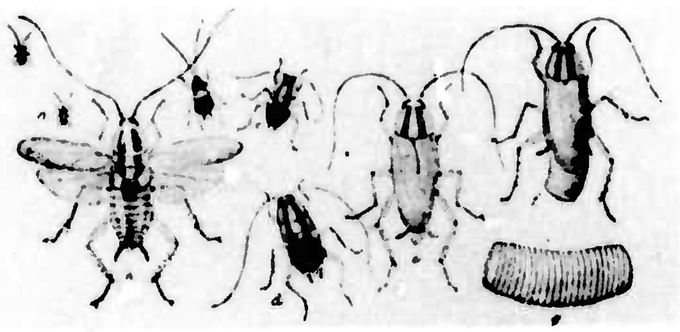

Figure 19: German roach. a to d are stages in its growth; e, f & h are adults; g is an egg case. Another can be seen protruding from the female in f. The figures are natural size except g.

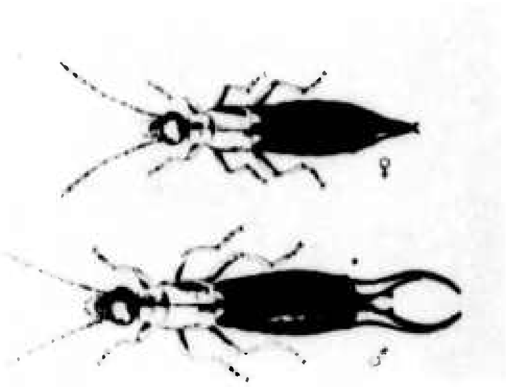

Figure 20: European earwig (Forficula auricularia). This insect is about one inch in length.

young generally resemble the parents very closely except in size.

The Orthoptera include a great variety of insects known familiarly as grasshoppers, locusts, katydids, crickets, roaches, stick insects, leaf insects and mantises. So far as we are concerned there are two groups to consider, the crickets and the similar gryllacrids on the one hand, and the roaches on the other.

The first group have the hind legs much lengthened and the thighs enlarged, hence they are able to leap.

Of Gryllacris sechellensis Vesey-Fitzgerald says "adults and nymphs cut holes in paper and cloth with the object of making a shelter by folding over the cut piece and sticking it down". This family is a fairly large one found throughout the tropics. Similar damage may occur elsewhere although I have found no other reports.

The cricket family is a large and cosmopolitan one, of which several members are known to cause damage. The list of materials attacked is cloth including artificial silk and wool, clothing, leather, wood, flour, bread, dough, fruits, vegetables. One or more destructive species may be expected anywhere in the habitable world, and in temperate climates crickets are rather prone to invade houses in the fall, apparently seeking warmth.

Mr. R. J. A. W. Lever, the Government Entomologist at the Fijis, writes me that crickets and grasshoppers are probably the most serious group attacking cloth in the Pacific area.

The general control of crickets is by means of poisoned baits which generally have a cereal base and molasses for flavoring. Formulae for these baits are given in another section. Any procedure which will tend to keep out roaches will also, of course, tend to keep out crickets and grasshoppers.

Gryllulus domesticus - U. S.: house cricket; German: Heimchen, Hausgrille.

This is the only cricket or grasshopper which seems to have achieved a world wide distribution, doubtless because it particularly likes to invade buildings. It has been recorded as feeding on a variety of textiles including wool and artificial silk and would probably damage any textile which had been soiled with animal materials. In addition, it feeds on paper and various vegetables and bread stuffs.

The life cycle is comparatively long, extending over nine to eleven months, and in most parts of the world we would expect but one generation a year. Some work has been done on the control of the house cricket, mostly through the use of poison baits.

The roaches are so familiar that a definition is almost unnecessary, but we point out that the hind legs are not modified for leaping and the wings are frequently wanting. Through commerce a number of species have become domesticated cosmopolites; these are all of tropical origin and there are rather few species native to temperate regions.

The usual household species are stated to be omnivorous, but they actually show a tendency to prefer materials containing starch or dextrin particularly bookbindings. In addition, damage to cereals, bread, clothing and other fabrics, watercolor paints, cheese, meat, and old leather is on record. All cases except the last three probably involve starchy substances primarily.

In spite of the very large number of roaches which are known from the tropics (100 or more species in several different regions) most damage by roaches even in the tropics seems to be due to the relatively few cosmopolitan and tropicopolitan insects which I have listed in the appendix.

Roaches may be controlled by three general chemical methods: (1) the use of poisoned baits which are commonly dry mixtures of cereal and powdered poison; (2) by spraying with oily insecticides, a procedure which is excellent provided the marksmanship is good; but the mere mist of spray in the air is of almost no significance, and similarly, deposits of the spray on walls or floors are not sufficient; (3) by fumigation: as will be shown later fumigation to be effective takes a building out of use for some time; it requires a tight building and it is no protection against reinfestation, that is, it functions only while the gas is in the building, and in the tropics reinfestation with roaches is to be anticipated since our familiar household species can exist out doors.

Blatta orientalis - U. S.: Oriental roach; German: gemeine Küchenschabe, Kakerlak; English: black beetle

This cosmopolitan species is likely to be familiar to anyone who has eaten in dubious restaurants near the water front or traveled on cargo vessels. It is typically the ship roach. The two sexes are rather different in appearance, the male being very dark brown with long wings and capable of flight. The female being nearly black, almost wingless, and broader and heavier than the male. It is sometimes stated that roaches in general will eat anything they can chew but their jaws are not remarkably strong and they are hence restricted to reasonably soft materials, such as human food and to eroding the surface of cloth and paper for the sizing. There is rather little information on the life cycles of roaches except that the development is relatively slow. In the present species it may be as long as a year. The eggs are laid in capsules, 1/2 inch or so in length, from which a considerable number of young emerge. The young are nearly colorless during the first and perhaps second stages.

Blattella germanica - U. S.: German roach; German: Franzosen, Russen.

This roach is perhaps the most generally distributed of the household roaches of North America since it is easily carried by the grocer boy in his basket and about 9/10 of the individuals are females. It runs with great rapidity but does not, properly speaking, fly. It merely volplanes down to the ground.

There is rather little information about the normal food of this species, but it is probably whatever the animals can find around the kitchen. They will also invade food processing plants and some will go to garbage dumps. The species is especially prone to damage bindings of books for the sizing in them and it has been recorded once attacking water color paints, presumably also for the contained mucilage.

This species is rather peculiar among roaches in carrying its egg capsule projecting from the hind end of the body until the eggs are ready to hatch. Each capsule contains some 30 to 60 eggs.

3a3. The order Dermaptera - earwigs

In this order the antennae are rather slender, many jointed. The abdomen is armed at its tip with a pair of strong forceps. The forewings, if present, are short and leathery. The hind wings, if present, broad, rounded, and membranous. The metamorphosis is slight. The members of this group can be told at once by the forceps mentioned. There are only a very few other insects so armed, and the others are smaller in general and wingless. Earwigs have strong biting mouth parts.

Although earwigs feed on a great variety of substances, they prefer, on the whole, insects and growing plants. There are a few references of damage to stored products and to cloth.

The metamorphosis is gradual, and the life history is chiefly remarkable in that the females remain in attendance upon the eggs until they hatch and even take care of the newly hatched young.

Earwigs remain in concealment during the day under bark, stones, or in similar dark places, and come out at night to feed.

One species of very wide distribution is known to attack a variety of stored products much as roaches do, although it prefers animal food. Another very widely distributed form may do minor damage to cotton and silk. Like the roaches and grasshoppers the earwigs are capable of ejecting from the mouth a dark fluid which is known to rot cloth. At least two species are capable of drawing blood with the forceps if roughly handled, and this is probably true of a number of others.

Hebard refers to the tropicopolitan Prolabia arachidis as a "disgusting greasy household pest of the sub-tropical and tropical regions which has been carried around the world by commerce". As to this species, I have no specific information on the damage that it does.

There are fewer than a thousand species of earwigs, mostly found in the tropics. There are several native European species and a very few native to North America. I have found indication of damage but by three species; one I have referred to, one of the others is cosmopolitan, and the last one has been introduced pretty much throughout the temperate regions of the world.

I am told by Mr. Hardenbrook that although he is familiar with earwigs in the tropics, he has never seen any damage from them. This agrees with the literature essentially, and we need not anticipate any extensive damage.

It seems very certain that precautions taken against roaches would also operate against earwigs.

3a4. The order <u>Isoptera</u> - termites

This order contains social species living in large communities composed of winged and wingless reproductive individuals together with a large number of wingless sterile forms, some with modified heads. The winged individuals are ordinarily dark in color; the wingless individuals ordinarily pale brown or cream color. The mouth parts are adapted for biting or are degenerate. The wings, when present, are two very similar pairs, longer than the body and rather transparent. There are strong veins toward the front margin of the wing and at the rear weaker longitudinal veins and a net work of small veins. The wings are capable of being shed at fracture lines near the base. The juncture between thorax and abdomen is broad. The cerci are short or very short; the metamorphosis is slight.

<u>Food</u>. The chief food of termites is cellulose. It is of no consequence to the termite, as far as I can learn, whether this material is obtained from wood, paper or glue. The other substances in wood are scarcely digested at all. A large number of tropical termites cultivate certain species of mushroom-like molds which they eat. The latter termites, in general, do not attack wood although they do great damage to grass and herbage. All the termites with which we are concerned are directly or indirectly feeders on cellulose.

<u>Colony Structure</u>. As has already been stated termites are social insects, and this implies not a random assembling of individuals but a definite organization of the group. A given colony takes its origin from a reproductive pair which are commonly called the king and queen. These may or may not have originally possessed wings, and they may or may not have founded the colony with the aid of certain sterile individuals. In any event all of the termites in the colony are the descendants of this king and queen or of their immediate ancestors. In a developed colony most of the individuals function as workers and are not reproductive. In most of the families these workers are actually sterile adult individuals which are uniformly wingless. They are entirely responsible for the excavation of the dwelling place, for the chewing up of the wood or other food, thereby rendering it available ultimately to the entire colony. They

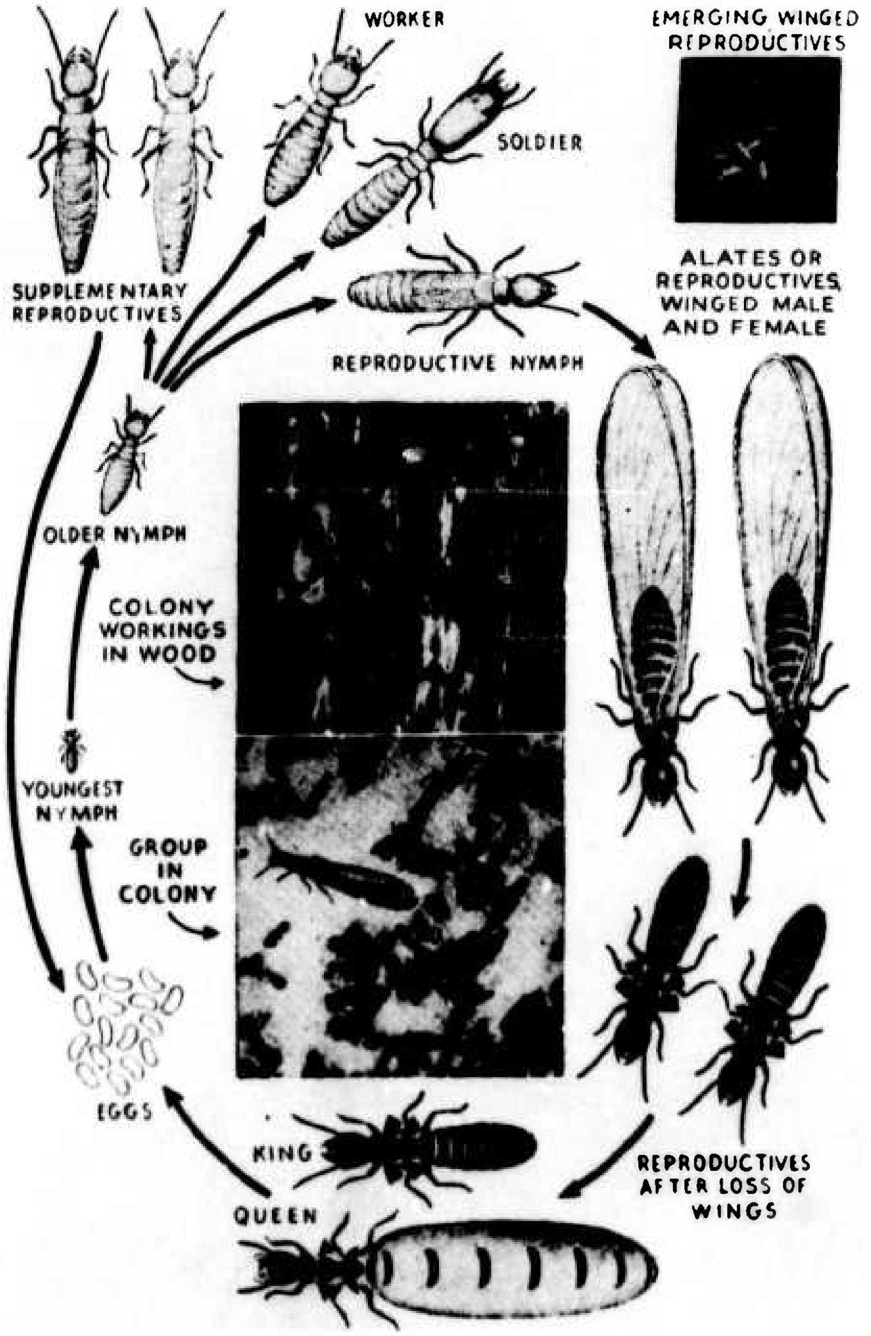

Figure 21: Life history and characteristic work of the western subterranean termite. The forms ordinarily seen in a termite colony are the worker and the soldier.

also take what care is necessary of the eggs and young. In almost all species of termite there are, in addition, a certain number of sterile individuals called soldiers. They may either be provided with abnormally enlarged jaws or may even practically lack jaws, in which case the head is provided with a greatly developed gland whose secretion is said to be protective. There is no doubt that the soldiers are protective individuals, but they seem also to have a certain regulatory function in the colony. To discuss this latter point would lead us too far into theory. In any event the occurrence of two or more wingless types (castes) is the usual situation in a termite colony. In the drywood termites and their near relatives, all in the family Kalotermitidae, the place of the workers is taken by young reproductive individuals. There is no special point in discussing here the precise details of the caste arrangement of termite colonies. It suffices to point out that there are three reproductive castes each represented by both sexes and a maximum of three soldier castes which may differ among themselves only in size or as well in structure. This colonial organization entails certain peculiarities. In the first place, members of the colony recognize one another by odor. Second, they have a very marked tendency to maintain extremely close contact with other individuals of the colony, and in addition usually also with more than one solid surface. This seems to account for the extremely constricted nature of the ordinary passageways in the colony. In the third place, and most important, the food made available by the workers is passed along in partially or even completely digested form to the non-feeding individuals, soldiers, younger nymphs, and reproductives who are therefore dependent upon the continued existence of these feeding individuals.

It is commonly stated that to control a termite infestation it is necessary to kill the queen. In the first place, infestations are constantly being controlled without killing the queen at all which in very many cases would be entirely impossible; and in the second place, eliminating the queen or king and queen will by no means assure the elimination of the colony because it is comparatively easy for the colony to replace sexual individuals through the young sexual individuals which are almost always present, and in some instance at least, by the sexual maturing of soldiers. This last has been obtained in the laboratory, and we have reason to suspect that it may occasionally occur in nature.

Habitat Types. We may distinguish six habitat types among the species in which we are interested.

a. Dry Wood.

Excavations of a single colony are relatively limited and occur entirely within a piece of wood. The galleries are opened temporarily at a few points for the discharge of fecal pellets and at the appropriate season for swarming of the winged individuals. The colonies of dry wood termites number at the most a few thousand individuals.

b. Powder Post.

The powder post termites are closely related to the dry wood forms. The colonies are of the same general composition but usually larger. The workings are more extensive and may ultimately destroy all of the wood except a very thin outer shell. The fecal pellets and other frass may not be discharged from the galleries.

c. Damp Wood.

These are also termites mostly closely related to the dry wood species. They work, however, only in wood which is evidently damp or even rotted and hence they are not commonly found far above ground. This habitat type is largely restricted to North America.

d. Subterranean.

In this type the excavation of the colony is partly in wood and partly in the soil nearby. The colony is apparently always started in wood which is in contact with ground but may later extend to wood not in contact by means of shelter tubes (see Section 5). Generally speaking, the subterranean termites are capable of causing the greatest amount of damage since they are dependent on cellulose for their food and the colonies are often of considerable size, some hundreds of thousands of the individuals. Many of the species fill unused parts of the excavation with a plaster composed of earth, feces, and other material. The presence of this plaster is diagnostic of their work.

The subterranean termites proper do not form a definite nest in which the reproductive individuals occur, but queens will be scattered about through the extent of their workings.

e. Semi-subterranean termites.

I am using this term for the genus <u>Coptotermes</u>. The work of this genus differs from that of the ordinary subterranean termite in that a definite nest of plaster or similar material is produced. This may be either in the ground or in wood. For that reason some species of this group have been introduced in regions to which they are not native. In addition, it does not seem to be so dependent upon contact with the soil as the true subterranean forms. Their colonies have been found on more than one occasion in the timber of ships. The best known species <u>Coptotermes formosanus</u> makes very extensive passages through the soil. One which was examined in Hawaii had a length of more than 165 feet and in places descended 10 feet into the ground.

f. Foraging termites.

The species of this group come above ground sometimes even by day to gather grass and leaves to take back to their nests as food for fungi and at least some of them have been reported to attack wall-paper and they might attack cloth on or very near the ground.

<u>Nests and Covered Passages</u>. The colonial habits of the termites seem to necessitate a comparatively great centralization of the activities of the colony and in many forms this involves the formation of a specialized nest which is composed of earth, more or less, mixed with other substances and may be of almost cement-like hardness. These nests vary in size from the bulk of one's two fists to huge mounds several feet in height and diameter. These mounds are, in some parts of the world, a conspicuous feature of savanna landscapes.

Figure 22: Covered galleries or tubes of subterranean termite on vertical concrete walls of a warehouse. The substance of these galleries is the same as the plaster which may be found within the workings in wood.

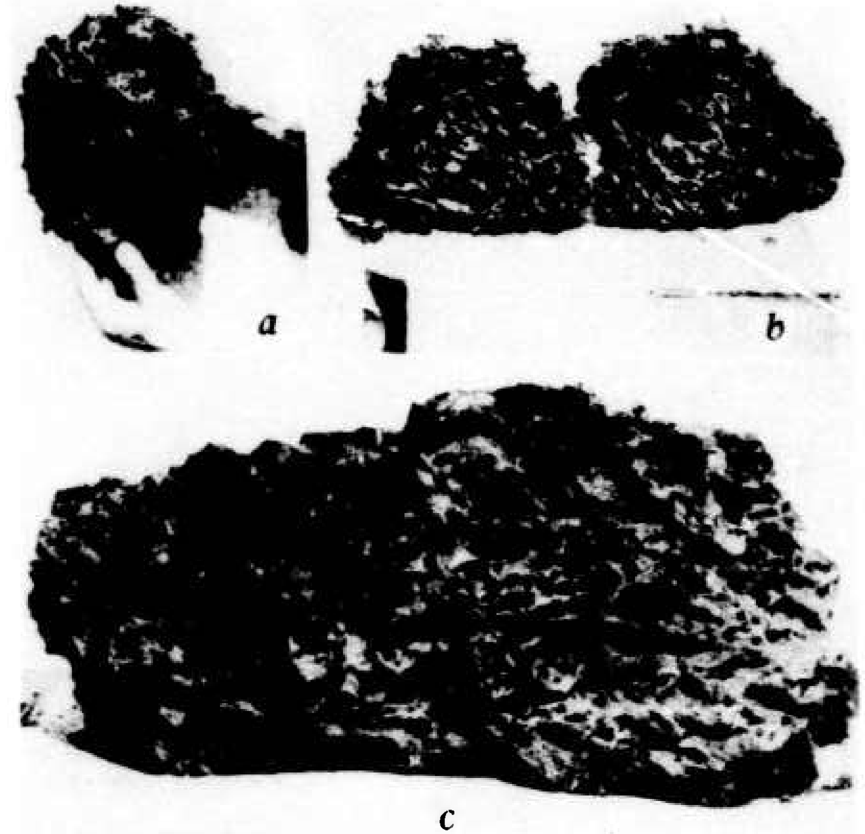

Figure 23: Nests of _Coptotermes formosanus_. _a_ and _b_ are paper like: _c_ is mostly plaster.

The nests of termites occur when they are strongly centralized in three situations, projecting above the ground, in the ground, sometimes in wood which has been hollowed out by the termites, and sometimes simply in the soil, and finally above the ground in a tree or on a pole or building. These latter nests are generally known in the West Indies as "nigger heads". Their height above the ground depends in part on the habits of the particular species of termites and on the support which is available. They have been found in Australia more than 100 feet above ground. Since termites are with very few exceptions strongly dependent on a slight amount of water but on a continually moist atmosphere, they very rarely appear in the open. It might be assumed that whatever communication they have from wood to ground or from one piece of wood to another would be entirely under cover, but this is not necessarily true even in some of those cases in which they nest on trees. They have a very considerable power of constructing covered passageways from the same sort of material of which the nests are made. There these passageways may run exposed for long distances and over all sorts of objects. Although, therefore, in North America subterranean termites would be discouraged by the interposition of rather moderate heights of concrete foundation, the same cannot be said of tree-nesting termites of the tropics which are used to building such passageways to very considerable heights, even a great many feet, and more positive methods of protection must be employed.

Damage. The most familiar form of termite damage is, of course, the attack on wood and here, as has already been pointed out in section 2cl, it is customary for the majority of the passageways to follow the rings of the wood, the spring wood being excavated, and the summer wood left largely untouched. For this reason termites in Australia are sometimes popularly called "ringants". But in addition to this termites will attack, as has already been pointed out, almost any material containing cellulose, although we have very little information about their attack on highly-treated cellulose materials, such as ethylcellulose. The hardness of the material seems to be of relatively little consequence. In addition to that, termites will penetrate a most considerable variety of completely inedible substances - asbestos pipe coverings, lead, asphalt-impregnated felt, electric insulation, and a certain number of perhaps edible substances such as wool fabrics. Since section 2 was written some additional information on this point has come to hand which could not be included there or in section 8.

I have had the opportunity to actually watch termites feeding, and two actions seem to be used in concert - in the first place, a prying up of an appropriate amount of the material. At this point the animal braces itself strongly against a firm surface and by working the head up and down and from side to side loosens a piece of material which is of a convenient width to go between the jaws. Then the jaws are slowly and strongly forced into the material with more pulling and tugging, and eventually a piece is separated off which is then carried away, held by the other mouth appendages but not apparently by the jaws. Beyond this I have not seen, but suppose that this bit of material is still further chewed up and swallowed. We do know that in the intestine wood occurs in the form of microscopic fragments. It seems quite certain on the other hand that although these same actions might be gone through with inedible materials that the fragments of the material would not be swallowed, unless its separation from edible substances was impossible.

Distribution. Although it is true for termites as for most other organisms that there are more in the tropics than in cooler regions, the distribution of the various habitat types is not by any means uniform so far as our present knowledge goes. It may be roughly stated that termites are found from 50° N. to 50° S. Lat. which indicates a fairly great extension of a few members into cool regions. In the cooler parts of the northern hemisphere almost all termite damage is done by subterranean species which in Asia and North America do a large amount of damage. The same thing is true to some extent for Europe, although the number of species and the amount of damage reported is rather less. In the cooler parts of the southern hemisphere, on the other hand, it is the dry-wood termites that show an important extension into temperate regions.

Taking first the dry-wood termites, we find that the greatest amount of damage from them is to be expected in the American tropics from Mexico to Brazil with somewhat less damage in the West Indies. The next region of high damage is northeastern Australia. The number of dry-wood species in southern continental Asia and in Africa is relatively restricted, and so far, at least as tropical Africa is concerned, it seems safe to conclude that there really are rather few dry-wood species. The islands off southeastern Asia from the Philippines to Java, Ceylon, and Madagascar possess moderate numbers of dry wood termites. The subterranean termites show a somewhat more uniform distribution, but again they are surprisingly uncommon in tropical Africa, and there is a very high likelihood of damage from southeastern Asia to Queensland, a likelihood which is matched only by the probability between Mexico and British Guiana, although in this region the number of subterranean termites is less than the number of dry wood forms. The distribution of foraging termites which might conceivably do damage, and under this head I am thinking of the very large family Termitidae, reaches its peak in central tropical Africa. In this family certainly very few species do much damage. Lesser areas of danger are India, Malaya, and Queensland.

So far as the smaller Pacific Islands are concerned, they usually possess a rather few dry wood species and one or two subterranean species, but as is usually the case the number of species occurring is roughly in inverse proportion to the size of the island.

Control. Most of the information on the control of termites will be given in section 4, particularly 4b, c and d. At this point, however, I want to present a list of termite-resistant woods. Certain cautions are necessary in using this list. First, it must be recognized that so far as untreated wood is concerned, there is no such thing as a termite-immune wood known. We can merely say that some woods are more resistant to attack than others. Second, the woods included in this list have not been tested against very many types of termites, in some instances only against a single abundant species, and it is, therefore, not certain that even in the regions named the woods would be uniformly resistant; and it is well known that woods resistant in one region are not resistant in other regions necessarily. This is true, for example, of jarrah, one of the best-known termite-resistant woods of Australia. Third, the resistance of a given species of wood is subject to some variation - not only because different trees of the same species differ in their rate of growth and therefore in the relative hardness of the wood, but as well because sapwood is on the whole much less resistant than heartwood. In the following list I have arranged the woods alphabetically under their scientific names and divided the list into sections each of which represents the area in which the given wood is known to be resistant. As far as possible I have given the native names in various languages. In some sections, at least, there are notes on non-resistant woods which elsewhere are resistant.

It must be further recognized that resistance to termite attack bears no relation to resistance to other insect damage or to decay, and some of the woods here listed are known to be subject to decay.

UNITED STATES

Sequoia sempervirens - U. S.: redwood
Western United States

EASTERN UNITED STATES

Callitris robusta - cypress pine
Queensland

Chamaecyparis lawsoniana - Port Orford cedar
N. W. United States

Chamaecyparis nootkatensis - yellow cypress
N. W. United States

Juniperus sp. - juniper
United States

Libocedrus decurrens - incense cedar
Western United States

Nectandra rodiaei - bebeeru; English: greenheart
Northern South America

Shorea robusta - Indian: sal
India

Tectona grandis - Malabar: tekka; English: teak; Dutch East Indian: djatti
Burma, Malaya, Java, Sumatra, Siam, India

Thuja plicata - western red cedar
Western United States

CALIFORNIA

NOT RESISTANT

Thuja plicata - western red cedar
Western United States

PANAMA

Sequoia sempervirens - U. S.: redwood
Western United States

PUERTO RICO

Anomis grisea - ausú
Puerto Rico

Bowdichia brasilensis - sapupira
Brasil

Brosimum paraense - muirapiranga
Brasil

Buchenavia capitata - granadillo
Puerto Rico

Bucida buceras - ucar
Puerto Rico

Caryocar villosum - piquiá
Brasil

Cedrela odorata - West Indian cedar, cedro
Cuba, Haiti, Brasil

Coccolobis grandiflora - moralón; ortegón
Puerto Rico

Cordia goeldiana - freijo
Brasil

Euxylophora paraensis - pau amarillo
Brasil

Guarea guara - Guaraguao
Puerto Rico

Homalium racemosum - Caracolillo
Puerto Rico

Manilkara nitida - Ausubo
Puerto Rico

Montezuma speciosissima - West Indies: maga
Puerto Rico

Pithecolobium racemosum - Angolim rayado
Brasil

Platymiscium ulei - Macacahuba
Brasil

Rhizophora sp - Mangrove
West Indies

Stahlia monosperma - cóbana negra
West Indies

Swietenia mahogani - English: mahogany
Neotropics

Swietenia sp - English: mahogany
Origin unstated

Taxodium distichum - southern cypress
Southern United States

Vouacopous americana - acapú
Brasil

Zanthoxylon flavum - aceitillo
Puerto Rico

Zanthoxylon sp - West Indian satinwood
West Indies

Zollernia paraensis - pau santo
Brasil

BARBADOS

Eperua falcata - English: wallaba
Origin unstated

Swietenia sp - English: mahogany
Origin unstated

TRINIDAD

Eschweilera subglandulosa - Trinidad: guatecare
Origin unstated

Guarea trichilioides - Trinidad: redwood
Origin unstated

Hieronymea caribaea - Trinidad: tapana
Origin unstated

Manilkara bidentata - Trinidad: balata
Trinidad (scarce)

Mora excelsa - Trinidad: mora
Trinidad

Paraclethra macroloba - Trinidad: bois mulatre
Origin unstated

Tabebuia serratifolia - Trinidad: poui
Trinidad (scarce)

NOT RESISTANT

Tectona grandis - Malabar: tekka; English: teak; Dutch East Indian: djatti
Burma, Malaya, Java, Sumatra, Siam, India

WEST AFRICA

Khaya senegalensis - Senegal mahogany; dry zone mahogany; Sudan: bandoro, bogu, bele; Arabic: homraya
French Sudan to Cameroons and Uganda

CENTRAL AFRICA

Cynometra alexandri - Uganda ironwood; Muhimbi
Uganda, Belgian Congo

UGANDA

Markhamia platycalyx - Trade: nsambya
Uganda, Kenya, Tanganyika

SOUTH AFRICA

Adina galpini
South Africa

Brachylena discolor
South Africa

Combretum porphyrolepsis
South Africa

Olea laurifolia - S. African: black ironwood; Swart Ysterhout, Native: Gqwanxi
South Africa

Ptaeroxylon obliqunm - S. African: Sneezewood; Nieshout
South Africa

RHODESIA

Baikiaea plurijuga - S. African: igusi, redwood; Rhodesian teak; Rhodesian: iGusi, mKusi; Angolese: umPapa
Rhodesia, Angola to Bechuanaland

Erythrophloeum africanum
Rhodesia

Marquesia macroura
Rhodesia

EAST AFRICA

Afzelia quanzensis - S. African: pod mahogany; Rhodesian mahogany; Rhodesian: muKamba; Mozambique: Chanata omPow; Swahili: mGoberere, mBemba koti
Angola, Moçambique, Kenya-Transvaal

Juniperus procera - S. African: African pencil cedar; Kenya: muTarakwa, olTarakwa, tarakuet, muRara; Uganda: tolokyo
Ethiopia to Nyasaland, Uganda, Tanganyika

Lovoa browni - nkoba; Uganda walnut
Uganda, Tanganyika

Pterocarpus angolensis - mlombwa, bloodwood; Rhodesian: mVagasi, muLombi
Angola-Moçambique, s. to Transvaal

INDIA

Cedrus deodara - Indian: deodar
India

Tectona grandis - Malabar: tekka; English: teak; Dutch East Indian: djatti
Burma, Malaya, Java, Sumatra, Siam, India

Mesua ferrea - Malayan: penaga
Malaya

CEYLON

Hopea odorata - Burmese: thingan; Siamese: mai takien
Burma, Siam

Sequoia sempervirens - U. S.: redwood
Western United States

MALAYA

Artocarpus lanceaefolia - Malayan: keledang
Malaya

Balanocarpus heimii - Malayan: chengal
Malaya

Burseraceae (sp.) - Malayan: bebras
Malaya (rare but remarkably durable)

Callitris sp. - Australian: native cypress, cypress pine, Murray pine
Australia

Cassia siamea - Malayan: jahar
Malaya

Cotylelobium lanceolatum - Siamese: kiam
Siam

Eusideroxylon zwageri - Malayan: belian
Sumatra

Fagraea gigantea - Malayan: tembusu
Malaya

Heritiera minor - Burmese: kanazo
Burma

Hopea nutans - Malayan: giam
Malaya

Hopea odorata - Burmese: thingan; Siamese: mai takien
Burma, Siam

Intsia spp. - Malayan: merbau
Malaya

Isoptera borneensis - Malayan: sengkawang
Malaya

Lagerstroemia speciosa - Malayan: bungor
Malaya, India

Lumnitzera littorea - Malayan: teruntum
Malaya

Madhuca utilis - Malayan: betis, belian
Malaya

Nectandra rodiaei - bebeeru; English: greenheart
Northern South America

Ochanostachys amentacea - Malayan: petaling
Malaya

Pentacme siamensis - Burmese: ingyin
Burma

Shorea ciliata - Malayan: kumus
Malaya

Shorea glauca - Malayan: Damar laut
Malaya

Shorea materialis - Malayan: balau
Malaya

Shorea spp. - Malayan: serai, nemesu
Malaya

Shorea spp. - Malayan: resak; sama rupa
Malaya

Shorea utilis - Malayan: Damar laut
Malaya

Sloetia sideroxylon - Malayan: tempinis
Malaya

Tectona grandis - Malabar: tekka; English: teak; Dutch East Indian: djatti
Burma, Malaya, Java, Sumatra, Siam, India

Terminalia tomentosa - Burmese: taukkyan; Indian: laurel
Burma, S. India

Urandra corniculata - Malayan: dedaru
Malaya

Vatica spp. - Malayan: resak, sama rupa
Malaya

Vitex pubescens - Malayan: leban
Malaya

Xylia dolabriformis - Burmese: pyinkado; Burma ironwood
Burma

Xylocarpus granatum - Malayan: nyireh batu
Malaya

NOT RESISTANT

Eucalyptus marginata - Australian: jarrah
Australia

Shorea robusta - Indian: sal
India

FORMOSA

Chamaecyparis formosensis
Formosa

Cunninghamia lanceolata
Formosa, China

Libocedrus macrolepis
Formosa, West China

Lithocarpus spp.
Formosa

Melia azedarach - Chinaberry
Formosa, S. Asia

Nephelium longana - longan
Formosa, India, S. China

Podocarpus spp.
Formosa

Quercus spp. - English: oak

PHILIPPINES

Callitris glauca - Australian: cypress pine
Australia

Intsia bijuga - Philippine: ipil
Solomons, Philippines

Tectona grandis - Malabar: tekka; English: teak; Dutch East Indian: djatti
Burma, Malaya, Java, Sumatra, Siam, India

Vitex parviflora - Philippine: molave
Philippines

AUSTRALIA

Callitris sp. - Australian: native cypress, cypress pine, murray pine
Australia

Eucalyptus marginata - Australian: jarrah
Australia

SOLOMONS

Calophyllum inophyllum
Solomons, Tropical Asia

Guettarda speciosa
Solomons, Palaeotropics

Intsia bijuga - Philippine: ipil
Solomons, Philippines

Thespesia populnea
Solomons, Tropical Asia, tropical Africa

Family Hodotermitidae

This family contains a relatively small number of species distributed through most of Africa, India, and southwestern Asia to Turkistan. The species are not to any extent wood eaters. Typically they cut grass and low vegetation and carry the pieces to their nests. They will, however, invade houses and are destructive to thatch and all paper. Damage by members of this family is mostly reported from south Africa.

Family Kalotermitidae

The rather numerous species in this family are dry wood and damp wood termites. Only one species approaches the habits of the subterranean termites. The colonies are, for the most part, of only moderate or even small size. It is not uncommon, however, to have several colonies at work in the same piece of timber and they are consequently able to do great damage. The dry wood members of the family differ from other termites in making temporary openings to the outside through which they eject fecal pellets. These pellets are somewhat elongate and ordinarily marked by a series of longitudinal grooves. I know of no other wood boring insect which produces exactly similar pellets. The family is well represented in most warm or tropical regions except the Mediterranean Basin where but two or three species occur. It is represented in cooler regions, for the most part, only by damp wood species, although the only native termites of Tasmania and New Zealand are dry wood termites. Because the colonies are small and restricted to the wood in which they occur they are relatively easily transported and a few of the species have become rather widely introduced through the tropics. On the smaller Pacific Islands dry wood termites are to be expected almost to the exclusion of any other type. It is only necessary that there shall be some wood for them to eat.

Kalotermes brevis - U. S.: powderpost termite; Spanish: polilla, carcom

This extremely destructive species is best known in Central America and northern South America, but it has been reported from a few places in the Old World and is, at least, well on its way to invading the whole of the tropics. It is often recorded in the literature as Cryptotermes brevis. In the western hemisphere it appears to be entirely a house termite not found out-of-doors in logs but only in buildings and furniture. This species rapidly reduces the wood to powder leaving only a thin outer shell. It does not eject all of the frass or fecal pellets from the workings. It will attack a number of substances other than wood, such as dry goods, books, and stationery and has been recorded damaging masonite pressboard. Rather interestingly, it has been found that this species avoids glazed paper, apparently because it cannot get its jaws into the material and a layer of glazed paper has been used to protect wallboard.

Kalotermes snyderi

This is the important dry wood termite of the southeastern United States. It has been much confused with various other species under the specific name of marginipennis. It ranges from Georgia and Mississippi southward along the east coast of Mexico into Central America and in eastern Mexico, Light considers it common and economically important. It occurs in poles as well as in buildings.

Family Mastotermitidae

This family contains only one living species, the most primitive and one of the largest of the termites. The winged forms are distinguished from all other termites by a broad lobe projecting at the rear of the base of the hind wing. The only species is discussed below.

Mastotermes darwiniensis - Australian: big termite

This remarkably destructive species is named for Port Darwin Australia, and is widely distributed in the drier parts of tropical Australia, chiefly the Northern Territory and north Queensland. It is not known from coastal localities with high rainfall nor from the Atherton Tableland, Queensland.

This species has been recently discussed at length by Gerald F. Hill and I quote some sections of his work:

"There is no record of a nest of this termite ever having been found in virgin country, but it is reasonably certain that they are invariably situated below or very little above ground level in a stump or the bole of a tree. It is in such places as these, and in the base of poles and fence posts, that nests have been found in occupied country. The nest is constructed almost entirely of vegetable matter moulded to form tier upon tier of relatively large, horizontal cells, the whole mass conforming to the dimensions of the wood destroyed. Nothing is known regarding the location of nests in certain residential and industrial areas in which large masses of wood are not available as nesting places. In some such localities there are numerous relatively small colonies located in nests at the butt of fence posts and other small masses of timber; in other localities the enormous number of insects to be seen indicates the presence of a large nest, which may be located in buried timber or in or below the flooring or foundations of buildings. There is an authentic record of an enormous colony having become established in the space between the boards of a double partition wall and in the adjacent hardwood flooring in a large disused concrete industrial building. It is known that a very large number of winged adults was reared in this nest for several successive years.

The numerical strength of colonies varies very greatly, from several thousands in small nests in fence posts, etc., to probably several millions in very large colonies. (It has been recorded (Hill, 1921, p. 11) that approximately 1,100,000 soldiers and workers were trapped and destroyed in one of two adjoining infested rooms without exhausting the supply of termites)."

The eggs of this species are remarkable in being cemented together in clusters somewhat like the eggs of roaches. Hill believes that a large proportion of the colonies arise by a process of swarming from already established colonies, a phenomenon which is common also in the family Rhinotermitidae and which I suspect has something to do with subterranean habits and the peculiar arrangement of the reproductive castes in the present family and the one just mentioned.

"The subterranean runways of Mastotermes usually are from 6 to 12 inches below the surface of the soil, but often are much shallower or deeper. They have been intersected at a depth of 14 feet during quarrying operations, Some of these runways are known to exceed 100 yards in length, which probably is well within the normal feeding range of the species.

Mastotermes is by far the most destructive Australian termite and probably has caused more economic loss than any other insect in the northern part of the continent. Not only has it acquired a taste for many substances essential to man's welfare and progress, but it has acquired almost unbelievable resourcefulness in overcoming his efforts to protect his property. The completeness and rapidity with which Mastotermes can, and usually does, carry out its work of destruction is a source of wonderment to those familiar only with the activities of the incomparably less destructive southern termites.

Amongst the substances known to be destroyed by this termite are all kinds of timber structures, fences, poles, lead sheathing of electric cables, bitumen, paper, bone, ivory, horn, leather, hides, ebonite, asbestos, jute, cotton and other vegetable fibre, silk, woolen fabrics, stored grass hay, sugar, bagged pickling salt and flour. Accumulations of human excreta and the dung of herbivorous animals also are invaded by these termites. In addition to the trees previously mentioned, citrus, soursop, pineapple, vines, cassava, banana, paw-paw, melon, pumpkin, carrot, potato, tomato and many kinds of shade and ornamental plants are very subject to destruction by

Mastotermes. In some low-rainfall localities it is practically impossible to produce domestic supplies of the ordinary kitchen garden crops owing to the ravages of this pest, whilst in the Burdekin district of Queensland it has become a major pest of sugarcane (Jarvis, 1923, p. 372; 1926, p. 13; 1927, p. 11; Bates, 1926, p. 4)".

In addition to the damage to structural wood this species also is a serious pest of living trees of many species, although a few, such as the species of figs, are immune to it.

"Extensive damage or total destruction by Mastotermes of farm buildings, stockyards and fences is commonly to be seen in many parts of north Australia, particularly where durable timbers such as Callitris intratropica and Pithecolobium monoliferum are not available for building purposes. The practical impossibility of maintaining efficient fences on some runs has led in its turn to serious difficulties for the stockbreeder.

The life of a wooden building constructed without precautions being taken against the entry of termites may be a matter of a few years, and even when precautions have been taken frequent inspections are necessary, as it is doubtful if any building containing wood or other material attractive to Mastotermes can be regarded as permanently immune from visitation. The provision of effective metal barriers between timber and other susceptible material and the soil is very important in building construction in Mastotermes-infested districts. In practice it will often be found difficult to maintain these barriers in a satisfactory condition and to prevent the ingress of the termites at some unsuspected point. A woody creeper, a tubular metal stanchion, or a piece of timber temporarily in contact with the ground and with the building may provide a means of access to a building otherwise reasonably immune from attack. Having established communication between the ground and the timber above, no part of the building or its contents are beyond the reach of these termites. In disused buildings covered-ways, sometimes an inch or more in width and many yards in length, may be built on walls, ceilings, steel roof girders, and on fabric-covered wire to facilitate approach to such objects as wall plugs, electric light brackets and sockets, leather belting, and accumulations of cinders, dust and oil at the bearing of overhead machinery. These runways may take the shortest route from the point of entry into the building to the object of attack, but often meander for 100 feet or more and end far from any possible source of food supply.

As previously mentioned, asbestos sometimes is damaged by Mastotermes, as for example when such material is used as insulating for boilers and steampipes. In one instance the termites entered the asbestos around a long line of overhead steampipes by tunnelling up one of the supporting trestles, and from there excavating in the insulating material for a distance of 50 yards to a point where the pipe rested on a girder in an adjacent steel and concrete building. A runway, constructed almost entirely of asbestos, was then built along the girder for a distance of several feet, where it terminated. This building contained no woodwork and was impregnable at all other points.

There are numerous records of damage to subterranean electric cables, resulting in "faults" and consequent interruptions to services. In Townsville these interruptions became so frequent in one locality that it was considered expedient to relay the cable along an indirect route so as to avoid what was regarded as a particularly badly infested area. Lead water pipes have been similarly pierced. Failures in the electric light services in Darwin have been traced to the penetration by Mastotermes of the bitumen filling in the jointing boxes of the subterranean cables."

Family Rhinotermitidae

This family is somewhat smaller in number of species than the Kalotermitidae but is represented in my files by somewhat more economic species. Almost all of its members are subterranean termites. The only exception of consequence being the genus Prorhinotermes. This last genus is considered as a damp-wood group and is found very close to the ocean in the warm parts of the world, particularly in the Pacific Islands. The colonies of Rhinotermitidae are usually of considerable size and capable, therefore, of doing very extensive damage, but because of their dependence on soil moisture they are relatively readily controlled in new construction and they are difficult to introduce from one region to another, although such introduction is known to have occurred in 2 or 3 instances. The family is especially well represented in the new world and in Australasia and surprisingly poorly represented in tropical Africa. One of the genera, Reticulitermes, is the chief genus of termites in the temperate regions of the northern hemisphere, occurring as far north as extreme southern Canada, central Japan and China, and southern Europe. It is not found at all in the south temperate zone and, in fact, the family as a whole is not well represented south of the tropics. The most destructive genus in the family is Coptotermes which contains about 40 species found throughout the tropics and it is probable that any of these species are capable of doing great damage. It is also rather readily introduced since it tends to make definite nests, frequently in wood, and to survive fairly readily apart from the soil if there is adequate moisture. At least one species has even been found infesting ships.

Coptotermes formosanus - Hawaiian: subterranean termite

I have already discussed, to some extent, the genus Coptotermes of which this is one of the best known species. It occurs commonly along the south coast of China, perhaps as far north as Shanghai, in Formosa and in southern Japan (recorded from Kagoshima, Maragame), the Riu-Kiu Islands, Hawaii, and south Africa. It may already have been introduced elsewhere in subtropical regions.

This species, like others of its genus, is capable of doing very great damage to wood in contact with the ground or which can be gotten to by means of shelter tubes. It will also attack books and paper and the animals can work their way through brick walls, presumably through cracks in the mortar which they enlarge. It has also been recorded as attacking asphalt, lead, and other unspecified materials overlying wood work. The passageways which it makes in the ground are very extensive and the nests are usually somewhat away from buildings (commonly in Hawaii in the base of poles) and Ehrhorn mentions that the species spreads from the waterfront along city streets from one pole to another.

Reticulitermes flavipes - U. S.: eastern subterranean termite

The present species occurs primarily in forested regions in eastern North America. Its northern limit is an irregular line running from Newcastle, Maine, through West Concord, N. H., Bellows Falls, Vt., and thence westward touching extreme southern Ontario and ending at the edge of Great Plains. From this line it ranges southward east of the Great Plains to the Gulf of Mexico and into northeastern Mexico. Its colonies are extensive and contain very many individuals. They are not, however, found on all soils. It has been possible to work out, to a certain extent, the real limits of distribution of this species. The minimum temperatures required are an average of 21°F in winter and 65°F in summer. Both of these minima must be met. The species also requires for its nesting a well drained and somewhat loose soil. The animals push their way through the soil rather than excavating passageways the way the true ants do. It is, therefore, found in soil types which are sandy, gravelly or stony and is not found in the northeast, in any event, in true loams or heavier soils. In addition, it has certain fairly definite requirements as to the chemical composition of the soil. I have been able to determine, experimentally, that it survives well in soils with an acidity, expressed as pH, from 3.2 to 8.2. This species appears to be particularly affected by the quantity of magnesium carbonate in the soil and I have not had good survival above 2.5% of this salt. This percentage represents in my tests just about the upper limit of alkalinity, but other tests with magnesium sulphate suggest that this is also close to the magnesium limit. It also does not survive in the presence of more than 7½% of calcium carbonate. I mention these details mainly to suggest that the local distribution of termites elsewhere in the world will probably eventually be linked to similar soil factors, but as yet almost nothing has been done to examine them. It is known in Malaya that one of the mound-building termites occurs only on laterite soils and a closely related species only on other soils.

The eastern subterranean termite will attack a large variety of native woods, preferring, of course, the sapwood to the heartwood and in some cases, for example red cedar, scarcely attacking the heartwood at all. I have also records of its attack on numbers of non-native woods, mostly rather similar to native species. In addition, it readily attacks pasteboard, paper, vegetable parchment, and cellophane, as well as cotton cloth. It does not consume material with very great rapidity. Although I have not made any measurements on the consumption of wood, I have been able to determine in the case of paper that at room temperatures the rate is .002 cu. mm. per termite per hour. This might lead one to guess that a colony of 300,000 individuals would destroy about 2 cu. ft. of wood per year. The colonies in this species are longlived. In at least one of these I found evidence for the continuous infestation of a building for at least 17 years. In addition to these obvious cellulose-containing substances, this termite will attack, incidentally, various other materials such as electric insulation and lead foil. In the laboratory I have secured damage to paper backed with tinfoil of a thickness of .0008", but the rate of destruction was about 1/5 that of paper of the same total thickness. In this instance the tin was identified chemically.

At least in the cooler parts of its range this species retreats into the ground in the winter in eastern Massachusetts from early November to early April. However, in heated buildings it will work 12 months in the year. Although this species probably can, to some extent, damage mortar, it does not attack good concrete and on the outer face of foundations will not ordinarily build up to wood for a distance of more than about 8". Where, however, there is protection such as on inner faces of foundations, it will build up for considerably greater distance, probably more than 3 feet. It should be pointed out that most of the tube building of this species is done (a) to establish new ground connections from the wood, or (b) for the emergence of winged reproductives.

I personally adhere to the view that the spread of colonies is mostly through the migration of supplementary reproductives (short winged) accompanied by groups of workers. These supplementary reproductives are not able to establish new colonies without the aid of workers.

Although pressure-treated creosoted wood is immune to this species for a long period, a properly installed metal shield is the best permanent protection for new construction.

In connection with my other work on the relation to soil composition, I have some indication that this species does not survive an admixture of 1/4% of common salt in the soil nor about 1/10% of borax. Either of these substances might, therefore, be used to obtain cheap but very temporary protection.

Family Termitidae

This family includes about 3/4 of the known kinds of termites but of these 1200 or more species only about 50 are of any interest to us. They are the relatively few species that utilize wood either fairly directly as food or as a material upon which to grow fungi. Almost all of them are tropical and most of the damage caused by them is recorded from Africa. The members of this family are quite variable as to habit. Some species make no very obvious nest, simply burrowing into the ground like members of the preceding family. Many others including part of the great genus Nasutitermes, tend to build nests

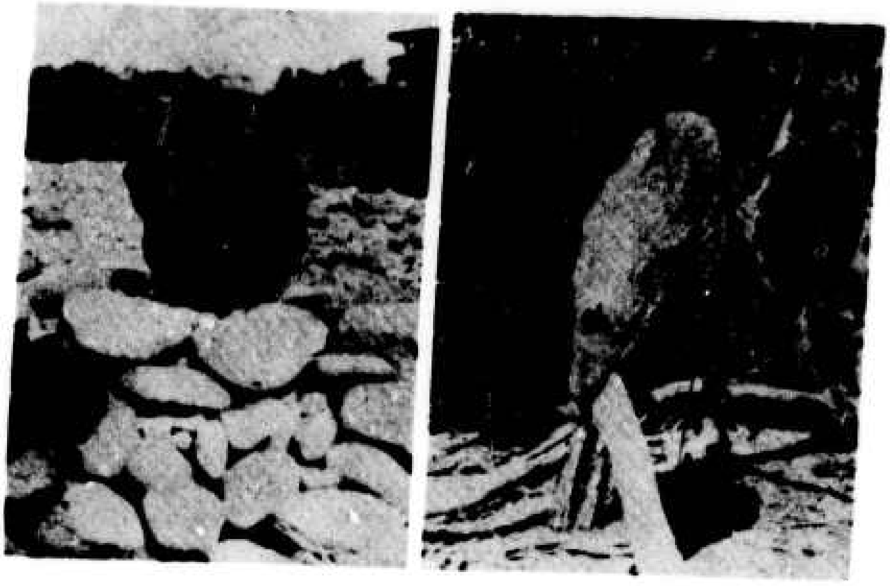

Figure 24: Niggerhead nests of a species of *Nasutitermes*.

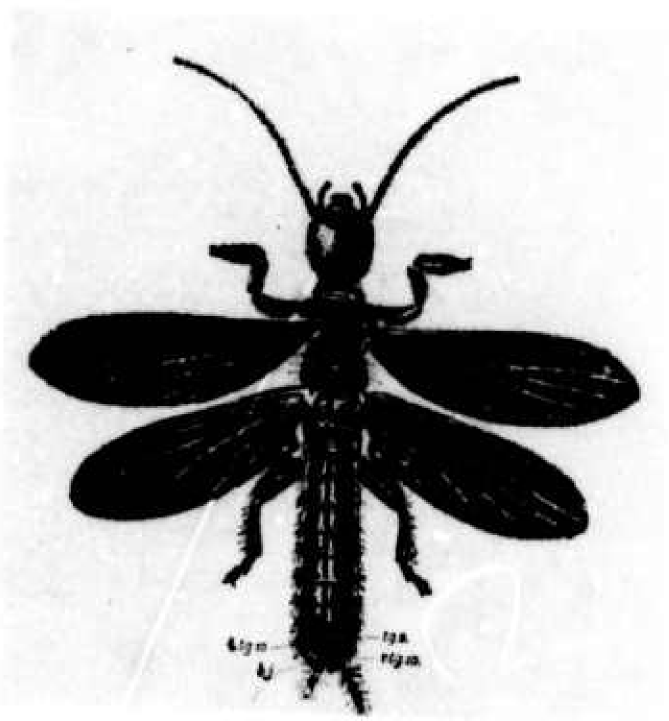

Figure 25: A male embiid. The adults are about one inch in length.

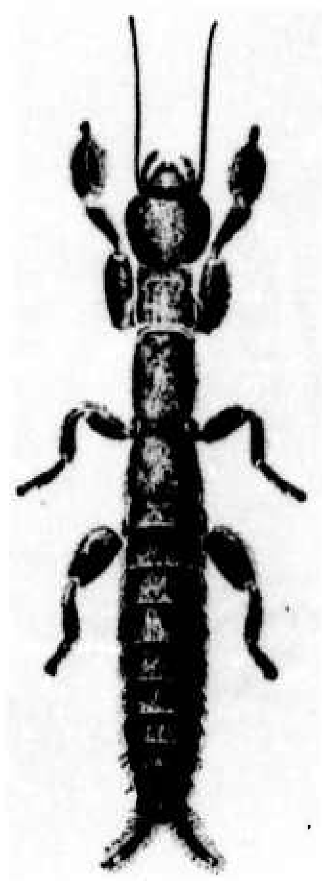

Figure 26: Female of an embiid. Note the absence of wings.

of cement, wood and earth well above the ground. Another large group builds mound nests of a cement-like material. The colonies are frequently of very great size, perhaps a million or more individuals, and they are, therefore, capable of doing a great deal of damage if they attack wood. In addition, the mounds of some of the mound-building species are of economical significance. They interfere with agriculture and in some regions with the construction of airplane landing fields. However, the substance of the mounds may be crushed and used as road metal. This has been done for years in tropical Africa and in Australia.

3a5. The order Embioptera - embiids

These insects are generally small and tend to live in groups in silken tunnels. The antennae are rather long and thread-like. The insects are all dark in color, including the wings if they are present. The young resemble the adults very completely. The silk is spun from an enlarged joint near the tip of the first pair of legs.

There is almost no certain information on their food which is probably both vegetable and animal.

A considerable number of species are known, practically all of them being found in the tropics. They live, on the whole, in damp and dark places.

I have found reference to damage caused by one species in Senegal. In this case stored cereals and peanuts were injured, not apparently by feeding but by the webbing of the embiids and by fermentation.

It seems certain that this unimportant source of damage to food can be controlled by keeping the materials dry.

3a6. The order Psocoptera - booklice and barklice

These minute and often wingless insects could be readily confused with mites. The antennae are thread-like and many jointed. The wings, if present, are usually membranous and with few veins. In some cases the wings are reduced to thickened scales. The first segment of the thorax is noticeably small. There is little metamorphosis beyond the development of wings.

The smaller members of this fairly extensive order are by no means well known. The species of northern and central Europe have been well worked out. Those of the rest of the world have been scarcely examined at all. We can assume large numbers of appropriate species in the tropics, but only a very few economic species have ever been recorded from such regions.

There is still considerable argument over the economic status of this group. A typical book louse infestation in the United States begins from a few weeks to a few months after a house is built

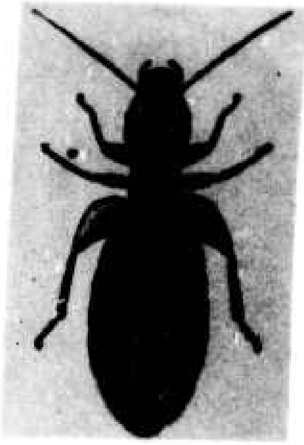

Figure 27: Book-louse or psocid. The adult is about 1/25 of an inch long.

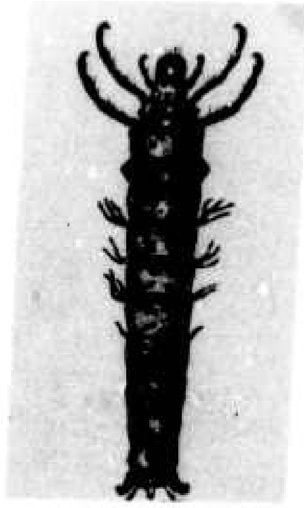

Figure 28: Grub. A typical caddis worm (Anabolia).

Figure 29: The rice moth. a. mature moth with wings spread; b. side view of moth with wings folded as it is seen when resting. The moth is about one-third of an inch long.

and while the plaster is still damp. The place is overrun with them. But within a year or so the plague abates spontaneously unless some special source of food and moisture is present.

Various booklice have been found in connection with grain, cacao, paper, seed, copra, dried animal and vegetable materials generally, starch paste. One school of thought contends that the booklice are feeding only on molds favored by damp conditions. The other claims that while the molds may be important there is actual attack on the substances themselves. My own observations lead me to believe in the reality of this attack at least so far as dried animal matter is concerned. We may, however, think of the booklice as primarily nuisance insects, since they will not cause great damage if proper methods of storage are in use.

Specific control may be accomplished by keeping the materials dry, by heating to a temperature of 140°F., or by fumigation.

3a7. The order Ephemeroptera - mayflies

The adults of this order are the well-known mayflies. The young stages (called nymphs) are elongate, active; the legs are long, the antennae short. There are two or three rather long tails and usually a conspicuous row of gills down each side of the abdomen. The metamorphosis is gradual.

Generally the nymphs feed on vegetable material, chiefly minute water plants. All of the nymphs are aquatic

The only report of damage which I have is from Siam, where nymphs of two species were reported as attacking submerged wood. The damage, however, was sufficient in this case to bring them to notice.

There are probably fewer than a thousand species in this order, but only those of the north temperate zone are well known. They are certainly abundant in some parts of the tropics. However, the fact that only one report of damage seems to be extant suggests that such damage is very rare.

Under the circumstances it does not seem worth while to take any special precautions against mayfly attack on submerged wood.

3a8. The order Trichoptera - caddisflies

These small or moderate-sized insects greatly resemble moths in appearance and color. The antennae are long, thread-like. The wings are covered with hairs rather than scales. The hind wings are broad, usually being partially folded at rest. The larvae are all aquatic and resemble caterpillars to a considerable degree. Usually they provide themselves with cases made of bits of wood, leaves, or sand grains, the material being held together by silk, and they are commonly called caddis worms. The metamorphosis is complete.

The food of the larvae is in some cases vegetable and in other cases animal.

Caddis worms are found in almost all bodies of water, sometimes in considerable abundance. The adults fly freely, often at some distance from water. The habits of the adults are of no economic significance.

There are very few reports of damage by caddis worms. At least one species has been reported damaging submerged wood work in the Great Lakes. No details are available on this case.

In northern Europe about ten species are well known as damaging submerged woodwork or the nets of fishermen. All of these cases are in fresh water, and there are few or no marine species in the group. It has been ascertained that the worms actually cut into the material and swallow the fragments.

There are a considerable number of species, rather more than 2500 known, and many of these occur in the north temperate regions. The scarcity of reports would indicate that damage by them is not very widely distributed or very conspicuous.

It seems very likely that damage by caddis worms in wood could be avoided by the use of fairly hard woods for submerged work and to cordage by tarring. It may well be that the damage is not important enough to warrant the use of special preventive measures.

3a9. The order Lepidoptera - moths and butterflies

Although everyone knows butterflies, the important members of this order are not by any means conspicuous. The adults have two pairs of wings, covered with scales which are easily rubbed off. The hind wings are generally much broader than the fore wings. The mouth parts, when present, consist of a sucking tube which is coiled under the head when not in use. The metamorphosis is complete. The larva is a caterpillar, that is to say, an elongate, cylindrical, somewhat worm-like animal with three pairs of short true legs on the thorax and not more than five pairs of false legs on the abdomen. Each false leg is a short process provided at its end with a number of minute hooks and a sucking disc. These false legs, if present in full number, are found on the third to sixth and the tenth abdominal segments. The pupa is usually enclosed in a silken cocoon which may be produced in the food material or at some distance from it.

The eggs of moths are generally laid on or in the food of the caterpillar. The young caterpillar which hatches out is often extraordinary minute and slender; as a consequence, although they are not generally able to perforate tough materials, they can go through extremely small openings - in one instance .004" in diameter. The length of time required for the completion of larval life is extremely varied depending not alone upon the species but upon temperature, available food, and moisture. The species may even pass

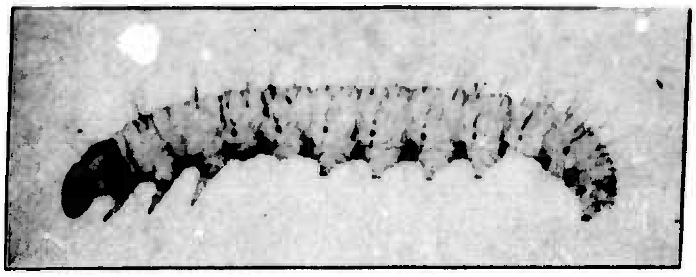

Figure 30: Full-grown caterpillar of the rice moth. The full-grown caterpillar is about one-half inch long.

Figure 31: The tobacco moth. The moth is about one-third of an inch long.

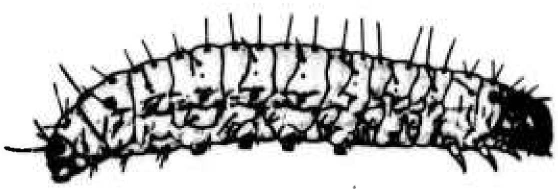

Figure 32: Full-grown caterpillar of the tobacco moth. This caterpillar is about one-third of an inch long.

the winter as a caterpillar. So far as the moths with which we are concerned go, it is probably safe to say that most of them overwinter either as caterpillars or as pupae. Unless the pupal stage overwinters it is usually fairly short. The length of life of the adult is extremely variable but is usually rather short in the pest species.

Since the larva of a moth is equipped with chewing mouth parts, it is able to attack a very large variety of hard and rather dry materials. It seems likely that virtually all of the pest species began as feeders on seeds and from there progressed to the products of the seeds. The group of clothes moths still retain to a considerable extent this ancestral habit and feed, in addition, on miscellaneous materials which may be found in association with seeds, such as hair, and a few species have become almost exclusively feeders on dry protein substances, such as wool, fur, and feathers. A few of the species which I have included, such as the potato tuber moth and the semitropical army worm, are primarily feeders on fresh plant materials which may continue to feed on the same materials after they are brought into store and occasionally on dried materials.

The food of the adults is entirely fluid as is demanded by the structure of the mouth parts, The adults, therefore, are not capable of doing any damage which concerns us except laying eggs. Many of the adults do not feed at all.

Caterpillars are soft bodied and although they do not require very large amounts of moisture in their food they are usually found in places where evaporation is reduced. The pest species tend to be found in, rather than on, the material, although they may not go to great depths in a bin of grain, and many of the species further protect themselves by avoiding the light and by spinning tubes of silk. Consequently, two of the chief control measures against food infesting moths are the provision of abundant light and ventilation. Because of the dependence of the caterpillars of a number of species on their silken tubes, they are also not prone to infest articles which are frequently moved or disturbed.

I have already considered most of the points which are important in connection with the damage done by moths, but we may add that they produce abundant excreta which contaminates much more food than is actually injured by feeding. The excreta of moths are more conspicuous than those of any other pest group, except the roaches. In addition much material is destroyed by the webbing of the caterpillars. Well-grown caterpillars are able sometimes to perforate quite resistant materials such as heavy paper, cloth, and even metal foil, although their powers in this respect are considerably less than those of the beetles or the termites.

The Lepidoptera in which we are interested are mostly rather small species of dull coloration. For these reasons, among others, they are not very well known and I have been able to secure rather scanty information about their near relatives. The preservation of such animals in condition for identification is difficult. The

Figure 33: Cocoons of the tobacco moth spun beneath a floor board of a tobacco warehouse for the purposes of overwintering and pupation. These cocoons are about one-third of an inch long.

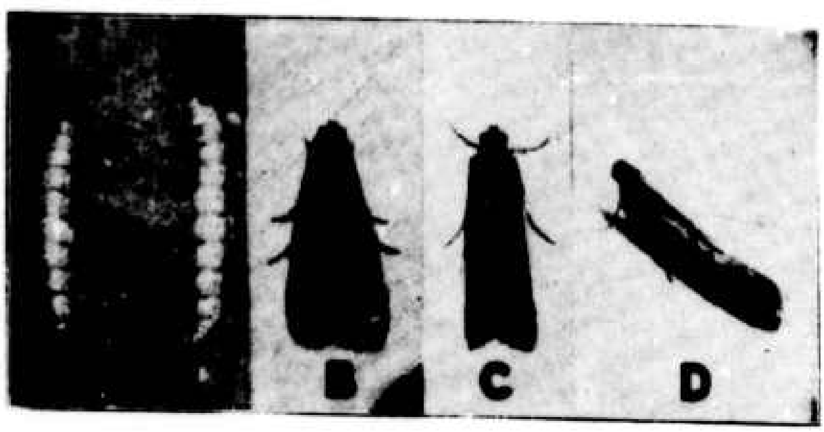

Figure 34: Mediterranean flour moth. A, larvae, B and C, adults, dorsal view; D, position of moth when at rest from side. The adult moth is about one inch long.

moths, as opposed to the caterpillars, are frequently not taken in association with the food of the latter so that expeditions do not bring back many such species with biological information. I can only, therefore, make some rather unsatisfactory surmises with regard to the general distribution of possible pest species. We may note first that practically all of the really important pests are cosmopolitan and several of them have no very close relatives. There are probably a rather large number of seed-infesting species in the tropics. The various sorts of clothes moths seem to be more numerous in the Old World tropics than in the New World. It must be noted especially that in the genus <u>Tinea</u> a very large number of the species are not known to be clothes moths but are feeders on seeds.

The control of moths is largely covered in the various parts of section 4, but it remains to speak briefly here of what is known as moth proofing. This is the treatment of fabrics with various chemicals to render them inedible to moths. There are a very large number of substances which have been proposed for this. Unfortunately, it seems to be quite well established that no one material will protect against all of the types of insects which can injure fabrics. This is particularly troublesome in the attempt to protect against both clothes moths and carpet beetles. It is fairly well agreed that a few material of the Eulan family offer the best protection against clothes moths. This is, of course, not a chemical family, but a trade-mark family; and of these various materials Eulan CN is regarded as the best for permanent moth proofing.

<u>Corcyra cephalonica</u> - U. S.: rice moth or wolf moth; English: rice moth; Dutch: rijstmot

This cosmopolitan moth is usually thought of, as its common names show, as a rice insect. It is not by any means restricted to rice but attacks a variety of seeds and a few other materials. The list of substances includes: rice; corn; leguminous seeds, including peanuts; cacao; copra; dried currants; army biscuits; manufactured chocolate. Although cacao is infested by many insects there are surprisingly few (mostly moths) recorded from manufactured chocolate.

In summer in temperate regions the rice moth completes its development in 28 to 42 days. We may expect five or six generations a year in such regions and perhaps twice as many in the tropics.

The rice moth is killed at 120° - 130°F. Other than this there is no special information on control.

<u>Ephestia cautella</u> - West African: cacao moth; U. S.: fig moth; U. S. official: almond moth; German: Dattelmotte; Australian: dried fruit moth; Dutch: chocolademot

Like several of its near relatives this species is cosmopolitan. It is recorded as feeding on a variety of fruits and seeds. It appears to show a slight preference for oily materials. The various names which have been applied to it suggest that it may have somewhat different habits in different regions. Although the Dutch call it chocolate moth I do not find any record of its actually attacking prepared chocolate. The development under tropical conditions requires about 82 days but there are stated to be 5 or 6 generations a year in the tropics.

The caterpillars can penetrate tinfoil, aluminum foil, and greased paper, but do not penetrate 18-mesh wire gauze. This must, of course, refer to rather well grown larvae.

In the case of copra it has been found that the caterpillars require a moisture content above 5%. Some work has been done in West Africa on the control of this species. The general procedures recommended are scrupulous cleanliness, frequent whitewashing of walls and leaving an alleyway between the store room and the outside walls. It has been found that the moths can be trapped by using a sticky material such as bird lime applied to hanging strands and they may also be trapped in soapy water, six parts of soap per thousand,

Ephestia elutella - U. S. official: tobacco moth; U. S.: chocolate moth; German: Kakaomotte or Heumotte

In spite of its official name this is a dried-fruit moth which has made a name for itself by attacking manufactured chocolate. I find the following foods listed: currants, raisins, and other dried fruit; stored grain; walnuts, cacao, chocolate; tobacco. This species is cosmopolitan.

It has been found that the larvae can penetrate tinfoil, aluminum foil, and greased paper but not 18-mesh wire gauze. These results presumably are based on well grown larvae.

The moth has an optimum temperature of 86-88°F. The minimum temperature for development is said to be 59°-68°F. The lower temperature is more likely. It requires at least 10% of moisture in its food. The development takes 60 days at 75°-80°F. This means a maximum of 6 generations a year. The tobacco moth can be killed at 113°F.

Ephestia kuehniella - U. S.: Mediterranean flour moth; German: Mehlmotte; French: papillon gris de la farine; Dutch: meelmotje. (The correct scientific name of this species is E. sericarium, but I use the name found in the economic literature.)

Like many other important species this one is cosmopolitan. Although best known as a grain and flour pest, its attack on other foods is not unimportant. I find reported: dates, chufa, figs, almonds, nuts, raisins, cacao, chocolate, army biscuits, beans, dried peppers, dried banana, dried vegetables, "jelly cubes", stored potatoes, in addition to grain and meal. The larvae do not penetrate paper but can pass through tiny openings.

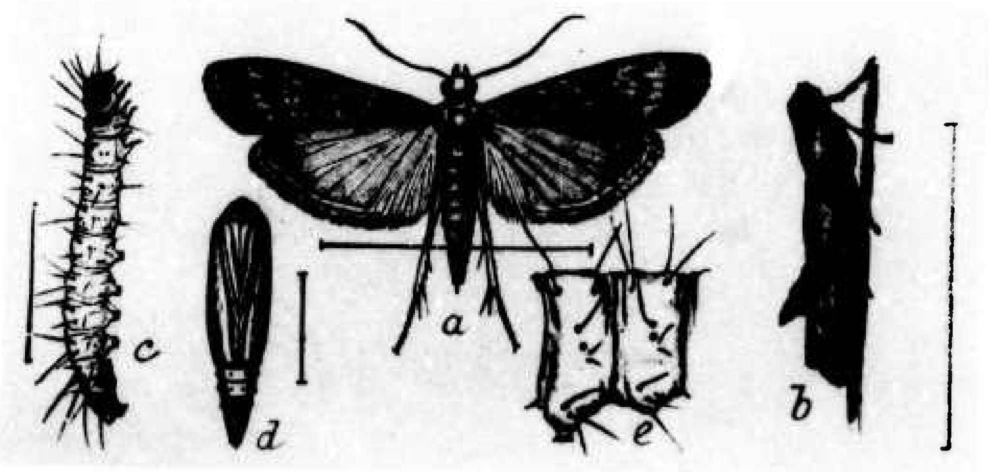

Figure 35: The Mediterranean flour moth.
a. moth; b. same from side, resting; c. caterpillar; d. pupa; e. abdominal joint of grub. The lefthand segment shows a typical false leg. The moth is about seven-eighths of an inch long.

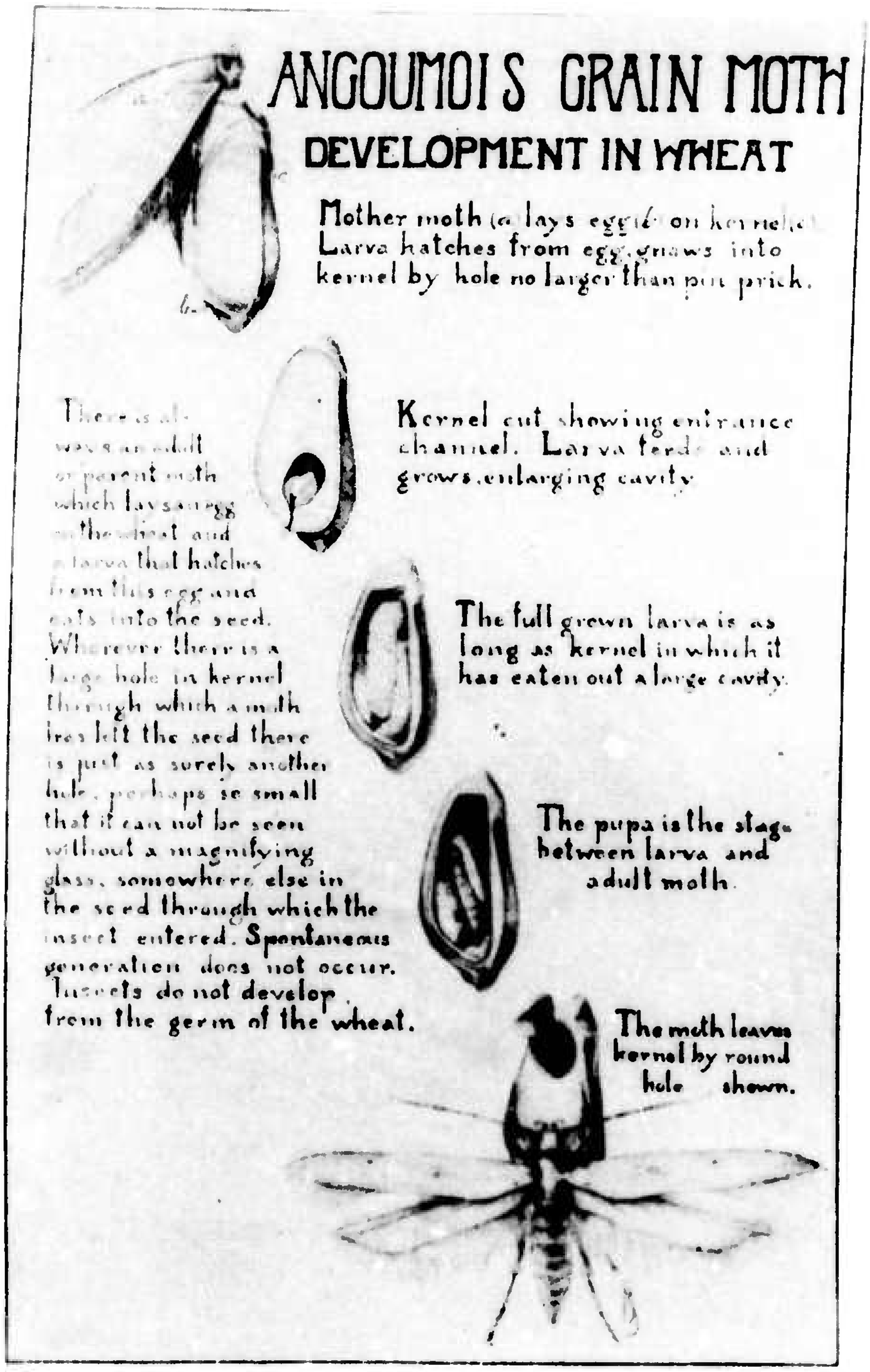
ANGOUMOIS GRAIN MOTH
DEVELOPMENT IN WHEAT
Mother moth (a) lays egg (b) on kernel (c). Larva hatches from egg, gnaws into kernel by hole no larger than pin prick.
There is always an adult or parent moth which lays an egg on the wheat and a larva that hatches from this egg and eats into the seed. Wherever there is a large hole in kernel through which a moth has left the seed there is just as surely another hole, perhaps so small that it can not be seen without a magnifying glass, somewhere else in the seed through which the insect entered. Spontaneous generation does not occur. Insects do not develop from the germ of the wheat.
Kernel cut showing entrance channel. Larva feeds and grows, enlarging cavity.
The full grown larva is as long as kernel in which it has eaten out a large cavity.
The pupa is the stage between larva and adult moth.
The moth leaves kernel by round hole shown.

Figure 36

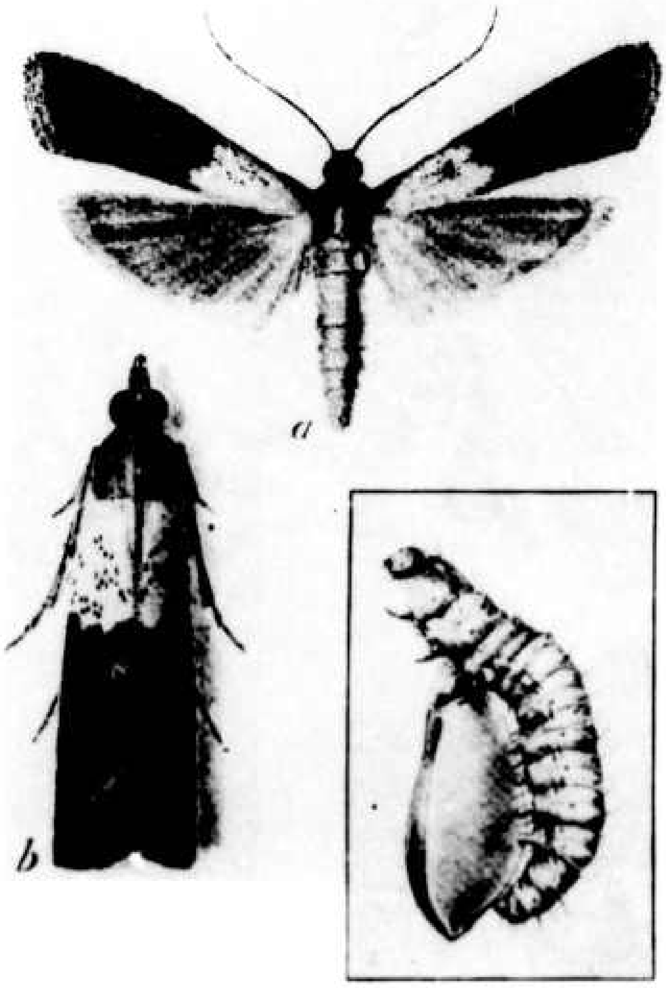

Figure 37: The Indian-meal moth. a. moth with wings soread; b. moth with wings folded as it is usually seen when resting; c. a well-grown caterpillar on a kernel of wheat. The moth is about five-sixteenths of an inch long.

Development requires 8 to 9 weeks in summer.. The eggs hatch only between 53°F and 90°F, although the lowest temperature for development is said to be 46°F. I have found no data on moisture requirements.

This flour moth is killed at 115°F in 3 hours and at 10°-15°F in 4 days, but old larvae and pupae withstand 32°F for several months.

Measures against this moth are: cleanliness, screening of openings, abundant light and ventilation.

Plodia interpunctella - U. S.: Indian-meal moth; English: dried fruit moth; Australian: lesser dried fruit moth; German: Dorrobstmotte; Japanese: noshime-koguga.

This moth is both cosmopolitan and abundant. It infests a wide variety of foodstuffs including corn and other grains and their products; seeds and nuts such as walnuts, cottonseed meal, chestnuts, dried peas, beans, soybeans, peanuts, almonds, coffee; dried vegetables including tea, dried carrots, dried radishes; dried fruits such as dates, currants, dried banana, dried nectarines, prunes, chillies; some drugs; chocolate (see below); nougat; floor dust.

The mature larvae can penetrate tinfoil, aluminum foil, greased paper, walnut shells but not 18-mesh wire gauze. Eulan treated fabrics are not touched.

There are one to six generations a year depending on temperature. The optimum temperature is about 83°F and development takes place between 52° and 89°F. The optimum moisture in the food is 18%.

The adults die at once at 117°F or in 30 minutes at 113°F and at 10°-15°F in 5 days. Dried fruit can be disinfested at 145°F in 10-15 minutes. It has been recommended that packaged fruit be heated to 125°-130°F for one hour after packing and sealing. In Germany the eggs were found to be killed at 1% soft soap solution.

It has been found that a fresh coating of chocolate does not attract the females and a thick coat will protect fruit cakes, marzipan, etc., but an old coating is not protective.

The larvae spoil much more food than they consume by webbing it together with silk as they move about. At the time of pupation the caterpillars crawl up away from the food and by choice seek angles at the top of bins or containers in which to spin their cocoons. In manufacturing and packing plants the thorough cleaning of such places is of great importance.

Sitotroga cerealella - U. S.: Angoumois grain moth; German: Getreidemotte; Italian: vera tignolo del grano; Dutch: rijstmot; Spanish: polilla del trigo or polilla del grano; Mexican: palomilla

This cosmopolitan species first came to notice in southern

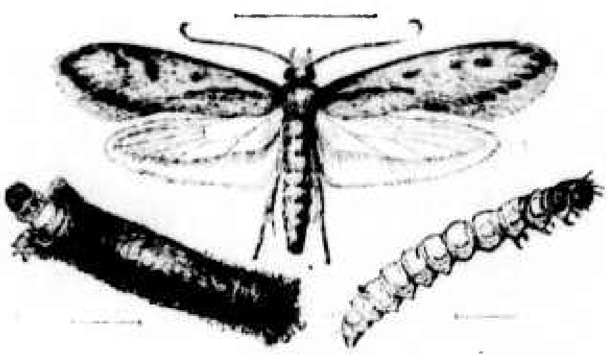

Figure 38: Case bearing clothes moth. a. adult; b. caterpillar; c. caterpillar in case. The adult moth is about one inch long.

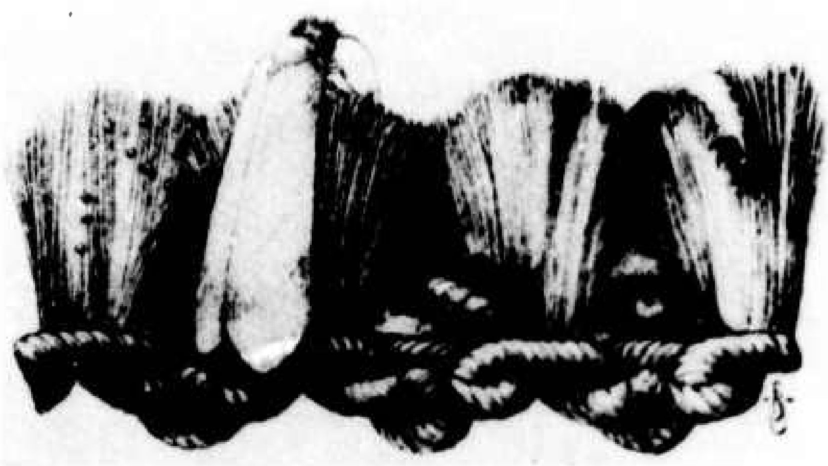

Figure 39: Diagrammatic view of edge of carpet, showing from left to right: eggs of webbing clothes moth on pile of first row; adult moth resting on second tuft; caterpillar protruding from tube constructed on the warp between the second and third tufts and feeding upon the pile of the third tuft; end of pupa in a cocoon built on the warp between the third and fourth tufts; and caterpillar crawling down over the top of the fourth tuft. This moth is about one-fourth of an inch long.

Europe, but it may not be native to that part of the world. It is one of the very serious pests of stored grain, but does not customarily attack other materials. It is recorded from beans and peas. Although is is so well known in stored grain it is also an important field pest and some workers believe that large infestations in stored grain are primarily of field origin. It is, therefore, not unlikely that this would be the chief grain moth that uninfested stored grain would acquire in the tropics. It is also a species particularly likely to be introduced if purchases of local grain are made.

The minimum temperature required for reproduction is about 50°F and the maximum 95°F. Under tropical conditions the development may require as little as 23 days. This insect is relatively resistant to high temperatures. It is killed in 1½ hours by exposure to 140°F and in small samples of grain has been killed in 15 to 20 minutes at 176°F. The amount of moisture required seems to be somewhat high, about 12% in wheat and over 15% in sorghum.

Tineola biselliella - U. S.: webbing clothes moth; English: common clothes moth; German: Kleidermotte; French: teigne des vêtements.

Like many familiar pests this moth has become cosmopolitan. Although best known for its attack on wool, it feeds also on other materials: casein, fish meal, baled human hair, fur, grain, groats, vetch seed. It does not attack clean silk, and wool without fat is not a very satisfactory diet.

It has from one to four generations per year. The optimum temperature is 77°F and, although the larvae will stand temperatures down to 17½°F, development does not occur below 50°F nor above 95°F. The eggs are killed at 32°F and the larvae at 16°F.

The adults fly rather reluctantly preferring to crawl between folds of fabric. The caterpillars spin silken tubes as they feed. Clothing which is frequently disturbed is nearly immune to damage. Newly hatched larvae can pass through openings as small as 0.004 inches in diameter.

3a10. The order Coleoptera - beetles and weevils

This immense group contains about one-quarter of all the known kinds of animals, and it is, therefore, not surprising that it proves to contain more than half of the known insect pests of stored materials; in all more than 500 species.

Beetles are minute-to-large insects, although none of the pest species seem to exceed about 3/4 of an inch in length. The fore wings are modified as horny wing cases which partly or completely cover the abdomen which is normally soft on top. In many beetles the two wing cases are soldered together and the insects are not capable of flight. The hind wings, if present, are longer than the fore wings, membranous, and folded under the wing cases when at rest. The metamorphosis is complete. The larva is a grub, usually with three pairs of short, true legs (sometimes wanting). False legs are exceptionally present. The pupa is either naked or enclosed in some sort of a cocoon which is usually not silken.

The eggs of beetles may be attached to the food, laid loosely among it, or inserted into the food either by way of natural openings or in a perforation made by the female. The grub on hatching often penetrates directly into the food, not appearing on the outside of the material at all. Whether this occurs or not depends on the habits of the particular species. The length of the larval period is perhaps more variable among the different species than in any other of the insects we are dealing with. It may be a comparatively few days, in the case of many beetles attacking foods, or it may extend to several years, in the case of some of the larger wood-boring beetles. It varies for somewhat the same causes that were listed under the moths, although, generally speaking, the length of the larval period in wood-boring beetles is considerable, rarely less than several months.

Since beetles do not ordinarily form cocoons, other methods are used to protect the pupa, and in many species this occurs in the last larval stage, which bores into some material, such as wood, which is not its ordinary food, forming a chamber in which the pupa occurs. The pupal period is ordinarily rather short. Consequently, when overwintering occurs, it tends more frequently to be by means of the grub or the adult.

The pest beetles, taken as a whole, feed on virtually any substance that any other pest insect can feed on. The only real exception is that the beetles do not attack man's own person, other than very exceptionally. But as will be brought out presently, there is a certain amount of specialization in each family.

As would be expected, beetles may occur in almost any conceivable situation, and it is hardly possible to offer any restrictions on the habitats in which they may be expected.

The damage caused by beetles consists, in part, of the actual digestion of material, and, in part, its physical breakdown to powder. In addition, the beetles tend very strongly to permanently inhabit their food, with the consequence that their dead remains may be found in the material. This leads also to attracting various sorts of scavenging beetles which may in themselves do some damage to the original material. The copra beetle and its near relatives are an excellent example, They seem almost certainly to have originally attacked other insects, but they are able to feed on a great variety of protein materials. Since both the young and the adults of beetles have strong biting mouth parts, the grub shows a particular tendency to penetrate a great variety of inedible substances. Almost nothing, except hard metals and concrete, is immune to beetle damage. This is especially serious since beetles go into these inedible materials for a variety of reasons. The material may be perforated by the beetle on emergence from the pupa. It may be attacked to get to food either by the grub or the adult. It may be perforated by the adult for purpose of egg laying; and finally the larva just before pupation does its share of such damage.

It is hardly profitable to generalize on the distribution of possible injurious species of beetles. The order is too large and too varied. However, I discuss below a number of the more important families and have included the possible distribution of other injurious species.

The control of beetles obviously depends on the sort of material infested. So far as those attacking food are concerned the methods used against food insects generally are adequate and those will be described in section 4.

Control of wood boring beetles consists (a) in preventing their access to the wood. In some cases paint or varnish is all that is necessary, but in other cases they will penetrate such finishes and one must use something stronger, such as creosote; and (b) the elimination of infestations already established. This is rather troublesome. Not only are the burrows frequently small, long and tortuous, but the penetration of any poisonous substance, whether gas or liquid, is rendered still more difficult by the frass which largely fills the burrows of the majority of the wood boring beetles. It is rather customary, where possible, to cut away as much as possible of the infested wood and then thoroughly spray the wood with orthodichlorobenzene. This method of treatment is facilitated by the marked preference of the insects for sapwood and has been utilized quite successfully in old buildings where the large square beams had sapwood only at the corner. It is, of course, less feasible in modern construction where many of the boards are entirely sapwood. In such cases complete replacement may well be the only answer to a serious infestation.

The last important situation in which beetles must be controlled is the infestation of wool and similar animal products. In such cases the method of choice is fumigation, but this necessitates, as a rule, not only the fumigation of the material but also the building in which it is contained. This arises from the rather interesting fact that the dermestid beetles which are responsible for practically all such infestation do not, as adults, feed on animal products to any great extent. Instead they seek, on the whole, to escape from the building and to visit nearby flowers. They accumulate, consequently, about the windows of houses. When they are ready to lay their eggs they again reenter the building and seek appropriate material. As a consequence infestation by carpet beetles may arise very easily without the introduction into a building of any infested material. This is, of course, quite different from our North American clothes moths in which the infestation spreads from one source of food to the next. Considerable work has been done in the attempt to find adequate materials for beetle proofing fabric. A very disappointing result of these investigations has been the discovery that a given material acts well against moths or against carpet beetles, but generally not against both. Certain rather fugitive treatments are fairly good against both groups of insects. One of these is sodium aluminum silicofluoride. So far as carpet beetles alone go, Dr. Back of the Department of Agriculture recommends pentachlordioxytriphenylmethanesulphonic acid applied in the dye bath at 2% by weight.

Family Anobiidae - Furniture beetles, deathwatch beetles; German: Pochkäfer

This very considerable family of some 900 species is associated primarily with the sapwood of logs that retain their bark, but a certain number of species have gone over to other habitats, largely sapwood without bark over it, and a few have deserted wood entirely and appear as book worms and as pests of a very large variety of vegetable products. (See beyond under tobacco beetle and drug store beetle.) It is probable that very much remains to be learned of the distribution of this family. The species are mostly small and not very readily reared on account of the nature of their habits. As at present known the relatives of the economic species are predominantly in the north temperate zone and especially in Europe and Asia. The genus _Anobium_ contains about 35 species and is cosmopolitan in distribution. The species are wood borers. _Calymmaderus_, another important wood boring genus contains 60 species which are almost entirely confined to the western hemisphere. The same restriction is true of the nearly 100 species of _Catorama_, a genus which has a strong tendency to invade various plant products such as paper, grain, and tobacco. _Lasioderma_, which contains the tobacco beetle, includes about 35 species of wide distribution. _Sitodrepa_ contains but one species, which is now cosmopolitan. Almost nothing is known of the habits of the species confined to Africa and the Oriental region.

Anobium punctatum - U. S.: furniture beetle; German: Totenuhr, gestreifte Holzbohrkäfer; Dutch: klopkevertje.

This species is the best known of the wood boring anobiids. It is especially prevalent in Europe, but has been introduced widely in other temperate regions. Aside from timber where it generally infests the sapwood, it also attacks books and linen cloth. In Tasmania eucalyptus timber is apparently immune. The development is quite slow requiring from 2 to 3 years.

Lasioderma serricorne - U. S.: cigarette beetle; German: kleiner Tabakkäfer; Italian: tarlo del tabacco; Dutch East Indian: tabaksboeboek.

This cosmopolitan beetle has made its reputation as a pest of cured or manufactured tobacco, but few insects show a wider choice of dried plant foods. The list is remarkable enough to give in detail. Stored tobacco, rice, corn, starch, cacao, cottonseed and cottonseed meal, beans, peanuts, coffee beans, cumin seeds, pumpkin seed, tamarind seed, aniseseed, sugar, copra, dried figs, dried dates, raisins, dried bananas, saffron, cayenne pepper, ginger, curry powder, paprika, nutmegs, turmeric, orris root, opium, liquorice, belladonna, curcuma root, rhubarb root, ergot, stramonium, hyoscyamus, pyrethrum powder, stored

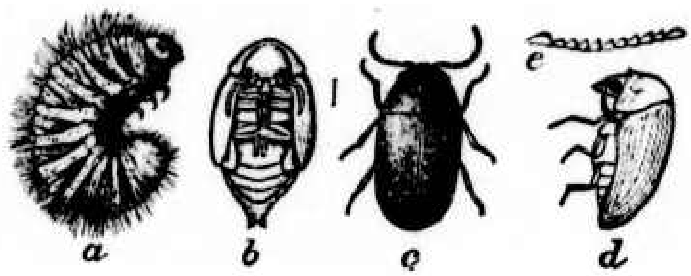

Figure 40: The tobacco beetle. a. larva; b. pupa; c. adult; d. side view of adult; e. antenna. This beetle is about one-eighth of an inch long.

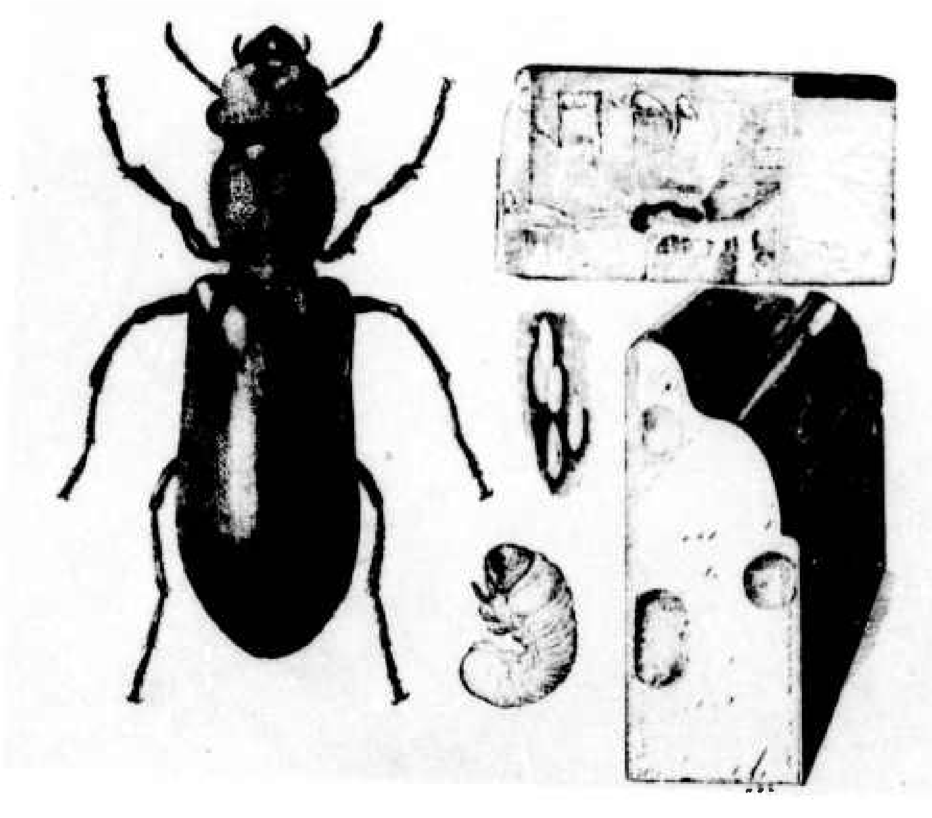

Figure 41: The black polycaon and work in wood. The adult at the left is nearly an inch long. To its right are eggs and a grub.

wax of the suwarie palm (Cocos coronata), dried yeast, dried fish, prepared fish food, cane and rattan work, books, gun wads, upholstery, rugs, tapestries, silk. The moral of such a list is that the introduction of an infested material into a storehouse may lead to the infestation of apparently very dissimilar materials.

The adults will gnaw through various fabrics, including linen, and the young larvae can penetrate twill, packing paper, sisalkraft paper, and cellophane.

The optimum temperature is 90°F and the optimum relative humidity is 75%. Development requires six to seven weeks in the tropics and its minimum temperature is 55°F and minimum relative humidity 30-45%. The minimum moisture content required in cacao is just under 6%.

The insects are killed in 2 hours at 130°F and in 15 minutes at 140°F and also at 25°F in 7 days. They have been controlled in books by keeping the books at 140°-145°F for 6 hours.

Sitodrepa panicea - U. S.: drugstore beetle; German: Brotkäfer.

Like the cigarette beetle this insect belongs to a family of wood borers but attacks almost any dry material except wood. It is now cosmopolitan. The list of substances attacked includes: grain and cereal products including baker's goods and breakfast foods; numerous seeds, among others coffee, beans and peas, various drug plants; pepper, chocolate; ice cream powder; books; cloth containing glue, paste or casein; leather; bamboo, and to a lesser degree, the ivory, of mahjong pieces where the glue was the primary attractant.

The development is rather slow, 66 to 230 days and the optimum temperature is between 79° and 83°F.

Family Bostrichidae - the false powder post beetles.

It will be seen by consulting the appendix that a very large number relatively of species in this family are known to be economically significant since the family includes only about 500 species. The great majority of these species attack more or less well-seasoned wood. Only a rather few have gone over to other food materials, of these the most important is the lesser grain borer, the only species in its genus. The family, as a whole, is best represented in the tropics primarily on continents or large islands and is not well represented in Australia. The false powder post beetles tend to prefer the wood of broad leaved trees, and many of them, like the lead cable borer, are able to penetrate considerable thicknesses of lead. A few species, chiefly in the genus Dinoderus, are especially prone to attack bamboo, and some of these species are also reported from edible roots and from grain.

Dinoderus minutus - U. S.: bamboo borer

The genus Dinoderus is especially prone to invade bamboo and some of its members have taken to attacking a variety of other more or

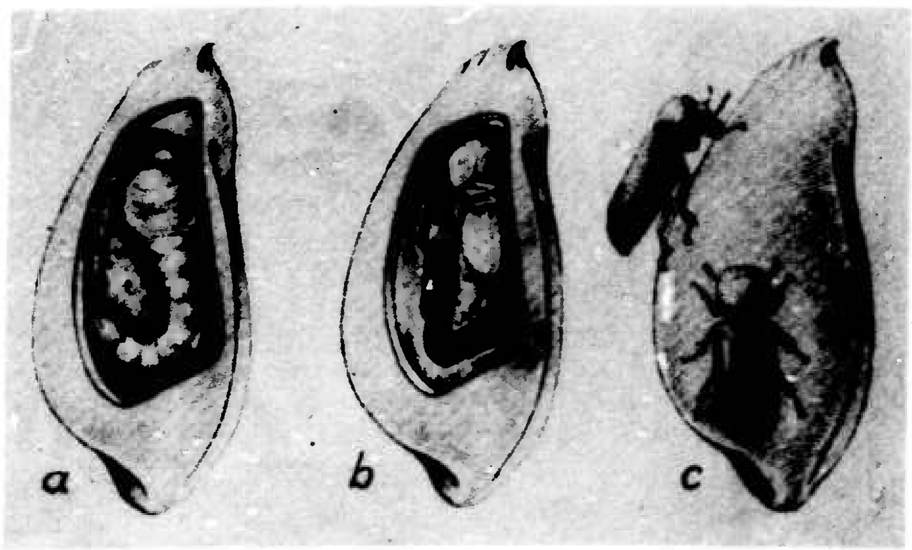

Figure 42: The lesser grain borer in and on wheat kernels: a, The well-grown grub; b, the pupa; c, two adult weevils. Adult borer is about one-eighth of an inch long.

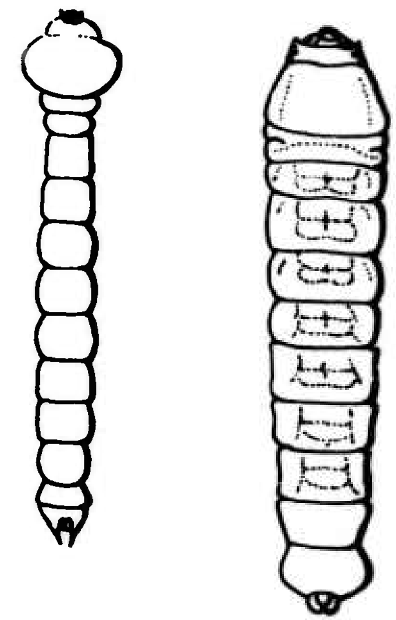

Figure 43: Grubs of wood boring beetles. The one on the left is a flat headed borer of the family Buprestidae. The one on the right a round headed borer of the family Cerambycidae. Both figures are considerably magnified.

less woody materials, particularly stored roots. This species, which occurs throughout the tropics and into the southern United States, is recorded from drugs, spices, tobacco, grain, cacao, chestnuts, dried bananas, and a few other materials. It shows, therefore, a very great tendency to infest seeds. Although it is not considered one of the serious pest insects, it would appear that it might, under appropriate conditions, become quite destructive.

Heterobostrychus aequalis

Several species in this genus have been reported from timber and the one mentioned here is the most widely distributed, having been found in several localities in the Old World tropics and having a marked tendency to appear in commerce. It appears to show a decided preference for imported soft woods, such as those used in box making. It infests the same wood continuously, making burrows about 1/8 inch in diameter. It has also been recorded as boring into tin, presumably in an attempt to escape from wood when mature. It might be expected nearly anywhere in the warmer parts of the Old World.

Rhizopertha dominica - U. S.: lesser grain borer, woodbug; German: Getreide-Kapuziner

This is the most important seed infestant among the false powder post beetles and, in addition to a variety of grains, it also attacks wood, leather, books, drugs, and some other materials of similar character. It has become spread over the whole world although it is much more frequent in warmer regions. Perhaps as a consequence of its grain dwelling habit, the life history is comparatively short, being about one month in the summer. This species has proven to be particularl serious where grain is stored in the open and very large populations may be built up. This was the case in Australia during the first World War and has subsequently been observed in the United States. The beetles require rather high temperatures, but little reproduction occurring below 80°F and the optimum temperature is about 95°F. Correspondingly they do not require much moisture, the minimum being under 8% in grain. It is not always easy to determine the presence of an active infestation. The beetles themselves, if cool or disturbed, take refuge within the infested grains. However, if the grain is put by quietly in a warm place they will again come out and begin to move about. They can be killed in 3 minutes at 122°F.

Family Buprestidae - Flat-headed borers.

In spite of the great size of this family (more than 11,000 species only a comparatively few attack wood other than that of living plants, and I give the family separate mention mainly because the adults are large and brilliantly colored for the most part, and are, therefore, very likely to be seen and perhaps accused of damage to which they are not related. The genera which are known to attack more or less seasoned wood are largely continental in distribution and very widespread. Of the genera that I have listed, only 3 contain more than a handful of species. These are Chrysochroa, with 66 species extending from Eastern

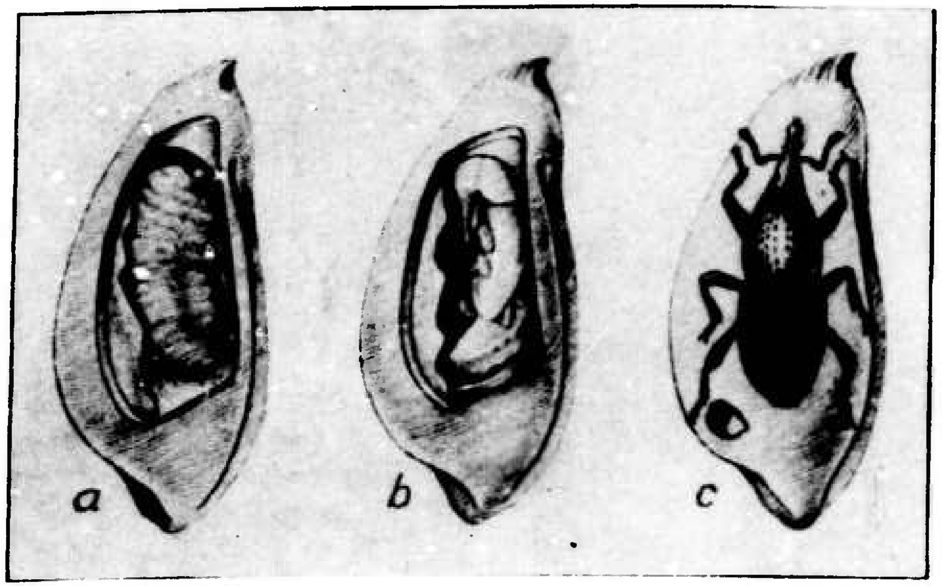

Figure 44: Life stages of the granary weevil in a wheat kernel: a. well-grown grub; b. pupa; c. adult. Note that the development of the weevil takes place within the kernel. Figure c shows the type of injury caused by the weevil in preparation for laying its eggs: note holes. The adult is never more than three-sixteenths of an inch long.

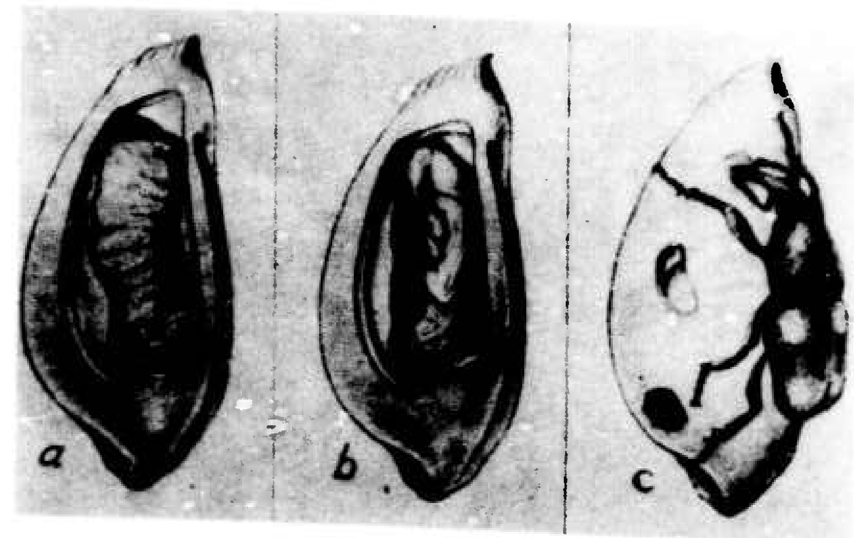

Figure 45: The rice weevil. a. grub in a grain of wheat; b. pupa; c. adult on the outside of the grain and two feeding holes. The lower most hole is an emergence hole. Note the light spots on the wing covers of the adult. Its length is about 1/8 of an inch.

Asia and Indo-Malaya to Amboina; Buprestis, with 79 species which is cosmopolitan except for the Pacific Islands; and Chrysobothris, with 525 species, which has the same distribution as Buprestis.

Family Calandridae.

This rather small family, which is very closely related to the true weevils, seems to contain but 4 economic species. However, two of those, the rice weevil and the granary weevil, are of great importance. As is the case with many of the true weevils, these insects use the long beak for the purpose of boring holes into the food in which the eggs are then inserted. They do not restrict themselves entirely to boring such holes in actual food but may bore them through various materials. In the laboratory I have seen such holes through heavy paper covered with lead foil. Generally speaking, the young undergo their entire development within a single seed, and a grain of wheat or rice is quite large enough for this purpose. Calandra itself is a rather small genus, most of its species being found in the Old World tropics. The only other genus of which I have note is Myocalandra, with 5 species, only two of which occur outside of Madagascar, those being Indo-Malayan to Australian. Most of the other species in the family are found in the Old World tropics.

Calandra granaria - U. S.: granary weevil; Spanish: gorgojo (a rather general term for weevil); German: Kornkäfer.

This is a member of a small family of seed eaters. It has become domesticated to the extent of almost abandoning an outdoor life in favor of stored products, chiefly grains. The species is cosmopolitan. Its foods are: stored grain, rice, buckwheat, acorns, chufa; ginger; currants; figs. The larvae can penetrate kraft paper.

The most rapid development is 29 days; in grain in Germany there are two to three generations a year. The optimum temperature is 77°F and egg-laying occurs between 53½° and 91½°F. No development takes place below 50°F although the adult will live up to 6 weeks at 31°F. The optimum relative humidity is 93% and the larvae do not mature at less than 44%. The minimum moisture required in wheat is 9½% but seems to be more in some other materials.

Egg-laying is probably similar to that of the rice weevil.

The adults can survive a summer in northern Europe without food. They are killed in 30 minutes at 131°F.

Calandra oryzae - U. S.: rice weevil; South African: maize weevil German: Reiskäfer; Australian: common grain weevil.

This species is similar in its habits and distribution to the preceding. The differences in the list of materials attacked as shown in the appendix are not consequential. It does, however, differ in surviving under much drier conditions, the best relative humidity being below 56% and in requiring somewhat higher temperatures, the optimum temperature being 84°F. As a consequence, it does not tend to become established in cool regions. It apparently requires slightly less moisture than the granary weevil, although the difference here is not entirely certain.

Family Carabidae - Predacious ground beetles

Members of this family are certain to be seen anywhere outside of the Arctic regions, but only very few of them have taken to eating anything other than small animals. There are, however, a few hundred species of seed eaters, mostly from the northern hemisphere and mostly attacking seeds in the gound. It is very likely, however, that occasional species will be seen in infested material where they are probably feeding on other insects present.

Family Cerambycidae - Longhorned beetles, round-headed borers

This important family comprises more than 14,000 species, most of which are borers in the wood of living or freshly cut trees, and a few only in other materials, chiefly dry wood. A large number of the species are of considerable size and able to penetrate fairly hard materials so that there are a number of records of the larvae damaging lead. As is the case with the Buprestidae, the adults of this family are conspicuously colored and very abundant, especially in the tropics, and hence many adults will be seen which are in no way associated with economic damage. They are particularly likely to be found on flowers. Those that have been associated with seasoned wood or similar materials are for the most part found in the northern hemisphere with rather fewer species occurring in the tropics. This is probably a defect of our knowledge rather than a real restriction on the activities of the family. The genera in which these economic species occur are mostly of rather moderate size, and, therefore, so far as our present knowledge goes, extensive damage from round-headed borers is not to be anticipated.

Hylotrupes bajulus - U. S.: house beetle, porter beetle; German: Hausbock

Although this beetle is found throughout the cool temperate parts of the northern hemisphere, it is much better known in Europe than in America. In Sweden, for example, it is considered the number one enemy of houses, and in some parts of northern Europe 40% or more of the wooden buildings are infested. It prefers the sapwood of coniferous trees and generally avoids hard wood, particularly oak. In spite of its relative abundance in northern Europe, it evidently requires rather elevated temperatures and it has been shown that it is especially prevalent in roof beams and more likely to occur under a slate roof than under thatch. It may develop in wood with as little as 7½% of moisture and its life cycle requires 4 or 5 years. It has also been reported as penetrating lead. In wood the burrows are elliptical in section and nearly 1/4 inch in greatest diameter. The only region in the United States in which it is reported at all frequently is that of the Middle Atlantic States.

Infestations in northern Europe have been successfully controlled in summer by heating the upper part of the house to a temperature of about 140°F for several hours. This requires an eventual air temperature in the attic of about 170°F.

Family Clerida - Checker beetles

This species with which we are concerned out of this family of about 2300 species are mostly the rather aberrant relatives of the genus Necrobia. Without being too cautious biologically, we may suggest that this general group of checker beetles is adapted to feeding on insects occurring in burrows and from that habit they have to some extent tended to attack the materials on which their original prey was feeding or other animal products. This is especially true in Necrobia. Most of the other species probably do little or no damage, but are fairly frequently found in infested material. Necrobia itself comprises 9 species on the whole cosmopolitan, three of which are already well known as infestants of a great variety of materials. They are for the most part metallic dark blue beetles frequently marked with a small amount of red or yellow. The pupa is somewhat remarkable in being enclosed in a net-like silken cocoon.

Necrobia rufipes - U. S.: copra beetle, red-legged ham beetle;
German: rotfüssige Schinkenkäfer, blaue Schinkenkäfer

Undoubtedly this cosmopolitan beetle was originally a predator on other insects. It still retains this habit to some extent. It seems not unlikely that it may have specialized on dermestid beetles. In any event it now attacks particularly the same sort of materials that the dermestids attack and some other materials that are apparently a peculiar food of the present species. It is, however, difficult to determine whether all of the materials listed in the appendix are truly food of this beetle since the adults, at least, seem to have a strong tendency to wander. Most of the materials which the red-legged ham beetle is known to feed on are more or less oily and it seems to be particularly attracted by rancid fat.

Its development is fairly rapid, a little over one month in warm weather. The larva is rather slender and active and the pupa, unlike the case in most beetles, is enclosed in a net-like silken cocoon. It is evidently important to prevent the access of this beetle to foods rather than to try to cure the infestation after it has become establishe At least two other very similar beetles have been taken in the same general sorts of materials.

Family Cryptophagidae

In Europe especially members of this family are reported with considerable frequency from store houses and deposits of various foodstuffs and some of the species have become fairly widespread. They appear for the most part to be feeders on molds, but they are able to do some damage to grain products and dried fruits. The genera in which such damage is known are predominantly of the north temperate zone, but the species are fairly easily carried about with commerce.

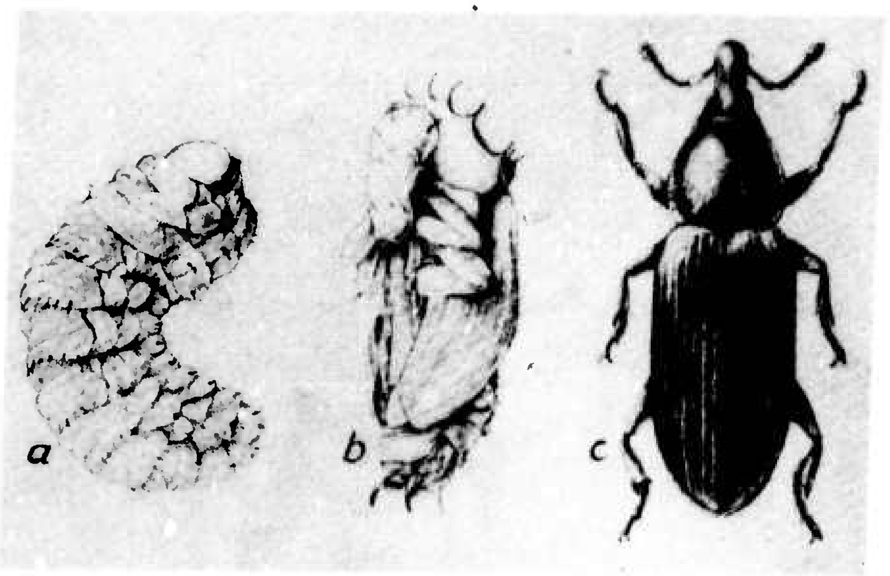

Figure 46:
Adult of the flat grain beetle, showing characteristic long antennae. Body not more than 1/16 of an inch long.

Figure 47: The broad-nosed grain weevil: a, Full-grown grub; b, pupa; c, adult weevil. The adult weevil is slightly less than one-eighth of an inch long.

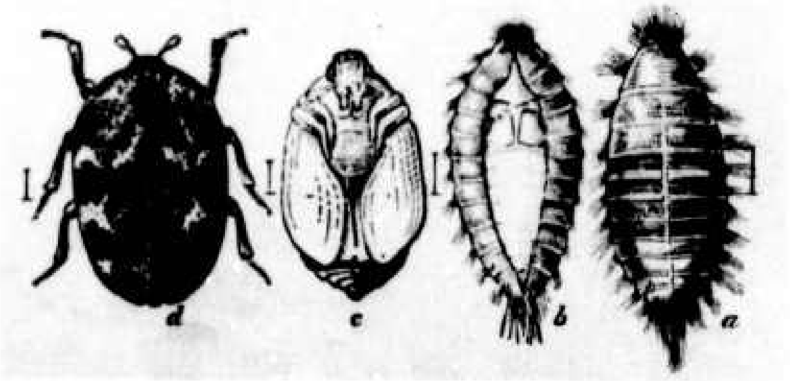

Figure 48: The common carpet beetle: a, grub; b, pupa within the old cast-off skin of the grub; c, pupa; d, adult beetle. The adult beetle is about 3/16 of an inch long.

Family Cucujidae.

Most of the members of this family are of no importance, but one genus Laemophloeus contains a number of species that do more or less damage to grain and a considerable number of other plant products. This genus is cosmopolitan in its distribution and contains about 325 species, so that one might anticipate a considerable amount of damage from this source especially in the tropics. We must point out also that the adults of this genus in a few cases are known to bite man and are for the most part carnivouous, the larvae being scavengers or feeders on injured materials where their habits are definitely known.

Laemophloeus minutus - U. S.: flat grain beetle

This small cosmopolitan beetle is given merely as an example of a number of closely related beetles. These species are probably none of them primary pests of grain. That means they do not attack uninjured grain but require that it be in some way injured, either intentionally or accidentally. One or more of these might be expected almost anywhere in the world, particularly in the tropics.

Family Curculionidae - weevils

In spite of the vast size of this family (about 30,000 species) and its tremendous importance in agriculture, there are relatively few species which attack materials of interest to us. These species fall into three groups: (1) A very few species that normally occur on growing plants and which may carry over to stored material. These species are largely tropical in their distribution. (2) A single species, the broad-nosed grain weevil, which is able to breed both in growing seeds and in stored seed. In addition, it also attacks various roots. (3) A number of species, all closely related to each other and to the broad-nosed grain weevil, which bore in wood. So far as I can make out these species require wood which has been somewhat affected by decay. Those species (of group 3) which have been ascertained to cause economic damage occur, for the most part, in the north temperate zone, but the group as a whole is highly remarkable for the very large proportion of its species which are restricted to islands, especially the Hawaiian Islands, Madagascar, St. Helena, and New Zealand. Some species, however, are known from all of the temperate and tropical parts of the world.

Caulophilus latinasus - U. S.: broad-nosed grain weevil; German: breitrüsselige Kornkäfer

This weevil is widely distributed in the western hemisphere and Europe. It is quite closely related to a considerable group of weevils that attack more or less decayed wood. It feeds on seeds and roots, but as would be expected from the habits of its near relatives, it is not able to attack hard, ripe, uninjured grain. In summer the life cycle requires about one month. It can be controlled by methods applicable to fruit insects generally. None of its near relatives have been reported as damaging foodstuffs.

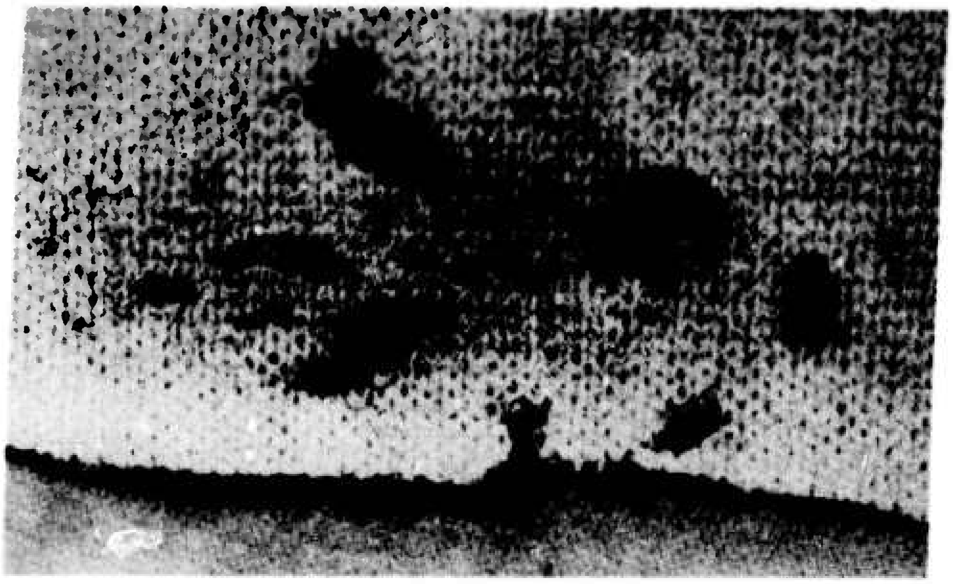

Figure 49: Immature grubs of the common carpet beetle feeding on cloth. The two lighter colored objects on the lower part of the cloth are cast skins. The grubs are about 3/16 of an inch long.

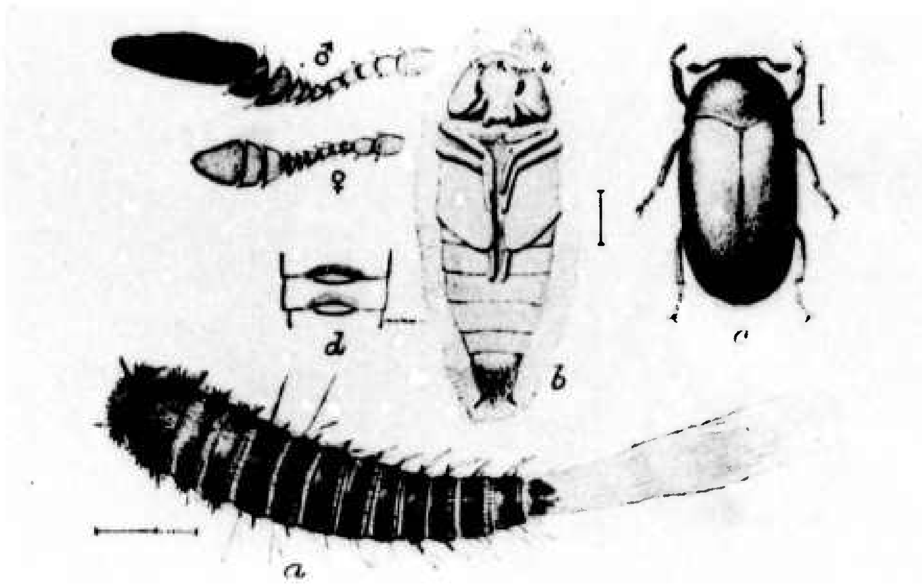

Figure 50: Black carpet beetle. a, grub; b, pupa; c, adult. The adult beetle is about three-sixteenths of an inch long.

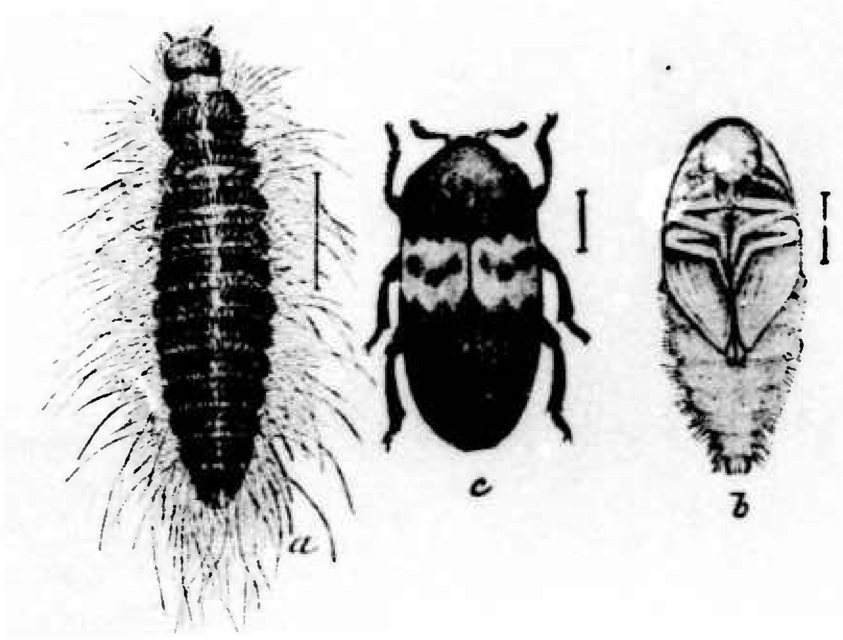

Figure 51: Larder beetle. a, grub; b, pupa; c, adult beetle. The adult beetle is about five-sixteenths of an inch long.

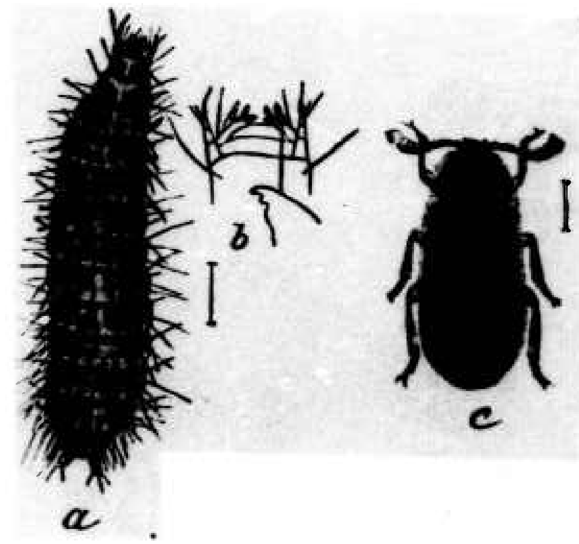

Figure 52: Red-legged ham beetle. a, grub; b, head of same greatly enlarged; c, adult beetle. The adult beetle is about one-fourth of an inch in length.

Family Dermestidae - Carpet beetles, larder beetles, etc.

We ordinarily associate the members of this family with damage to more or less dried materials of animal origin, meat and wool in particular. But they are by no means confined to such foods since a few species have achieved some importance as grain pests, and probably most of the species will attack seeds in default of more congenial food. They also cause a certain amount of miscellaneous damage to wood, in particular through their habit of burrowing into fairly solid materials for pupation. The group is especially well represented in the northern hemisphere, particularly in the case of those genera for which actual damage is recorded. However, relatives of the cabinet beetles of the genus Trogoderma are quite numerous in the tropical parts of the western hemisphere, and some damage might be expected in those areas by species not yet on the list. The family is, for the most part, very poorly represented in Australasia and the Pacific Islands, although Trogoderma itself is an exception, since it provides most of the native species of Australia and New Zealand. . .

Anthrenus scrophulariae - U. S.: common carpet beetle; German: Kabinettkäfer, Teppichkäfer

This cosmopolitan beetle may be taken as a satisfactory example of a very considerable number of species that have become major pests of woolens and furs. The present species is regarded, in most parts of the north temperate zone, as the chief beetle attacking such materials and certainly appears to prefer them to dead insects, which are a usual article of diet of its various relatives. The adults feed little, if at all, on animal materials and are commonly found on flowers where they obtain pollen. However, they lay their eggs on protein materials appropriate for the larvae. Several of the species, including this one, also attack grain products. The life cycle lasts approximately one year. In temperate regions, in any event, the beetles overwinter as pupae or young adults. . .

Attagenus piceus - U. S.: black carpet beetle; German: schwarze Pelzkäfer

This insect, like so many other important economic species, is now cosmopolitan and frequently very abundant. It is perhaps the most usual of the dermestid beetles in eastern North America. It attacks a considerable variety of protein materials, especially heavy fabrics and, in addition, various seeds. It is also of some repute as a bookworm. The larvae are able to penetrate cardboard containers. The species requires from 6 months to 3 years to complete its development. No development occurs below 50°F and the best temperature is about 77°F. Like the preceding species it tends to leave buildings when adult and return to them for egg laying. It is not, however, ordinarily seen on flowers.

Dermestes lardarius - U. S.: larder beetle; German: gemeine Speckkäfer

This species also is now cosmopolitan and regarded in northern Europe as the most common species of its genus. As can be seen from its name, it is especially associated with food stores. It is, however,

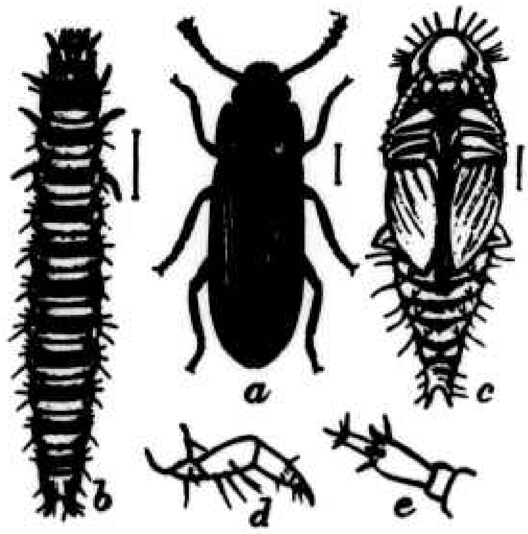

Figure 53: The Mexican Grain beetle: a, beetle; b, grub; c, pupa; d, leg of grub; e, antenna of grub. The adult beetle is about 3/16 of an inch long.

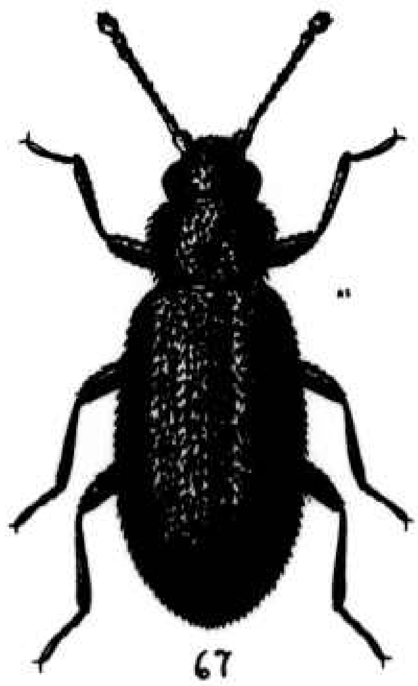

Figure 54: Corticaria pubescens. Adult. Its length is about 1/8 of an inch.

a rather uncommon beetle, as a rule, in the United States. This probably is because of the difference in food storing techniques in the two regions. It is, of course, rather customary in this country to store smoked and salted meat in refrigerators where they are not available to insects, while in Europe such products are stored in pantries and insects can get at them. In the appendix will be found a considerable list of substances in which this beetle has been found. It is one of the very few insects which is able to attack natural sponges. It will also be seen that it penetrates lead and tin rather readily, but not other metals. The genus Dermestes is especially noteworthy for its habit of burrowing into soft wood for pupation and when the beetles are abundant they may do considerable damage in this way. The development requires from 5 to 9 weeks and the optimum temperature is fairly low, about 66°F.

Dermestes vulpinus - U. S.: hide beetle; German: Dornspeckkäfer; South African: skin beetle

This very widely distributed beetle is the one customarily seen infesting shipments of raw hides, especially from South Africa and Australasia. In addition, it is known to attack various other substances. In sheep hides, with the wool on, it has very much the habits of a carpet beetle; that is, each larvae excavates a burrow through the wool, next the skin and when the insects are numerous the wool falls away from the skin in patches when handled. In addition, the skin will be more or less penetrated. The development requires from 5 weeks to 8 months and the optimum temperature appears to be above 80°F. Hides may be protected by storing at 40°F or lower. Investigations in South Africa have brought out that the proper salting of hides is of the greatest importance in their protection. They must be salted strongly and thoroughly and as soon as possible after removal from the animal.

Family Lathridiidae

The present family is only of moderate size, about 500 species, but almost 10 per cent of these species have been recorded as infesting various stored products or occurring in buildings. It seems to be reasonably certain that they are secondary infestants, feeding primarily on molds. Most of the species are no more than 2 or 3 mm. in length. One consequence of this small size is that they are best known from the well-explored north temperate zone, and comparatively few are reported elsewhere in the world.

Family Lyctidae - The powder post beetles

The economic importance of this family is quite out of proportion to the small number of species which it contains, probably not more than 50, since I have record of damage by fully half of the known species Almost all of these are recorded as damaging timber, chiefly the sapwood of broad-leaved trees. This restriction arises from the habit of depositing the eggs within the pores in the wood, but the size of pore which can be utilized is very minute - as yet we do not know quite how small. More or less extensive damage by this family may be anticipated almost anywhere in the world, although it is naturally best known in

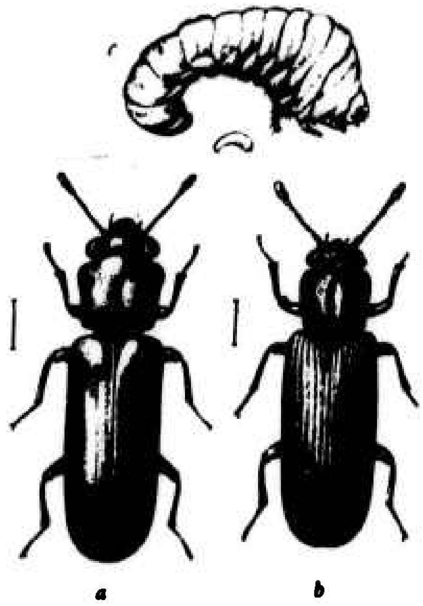

Figure 55: a, Old World powderpost beetle; c, grub; b, European powderpost beetle. The adults are about one-fourth of an inch long.

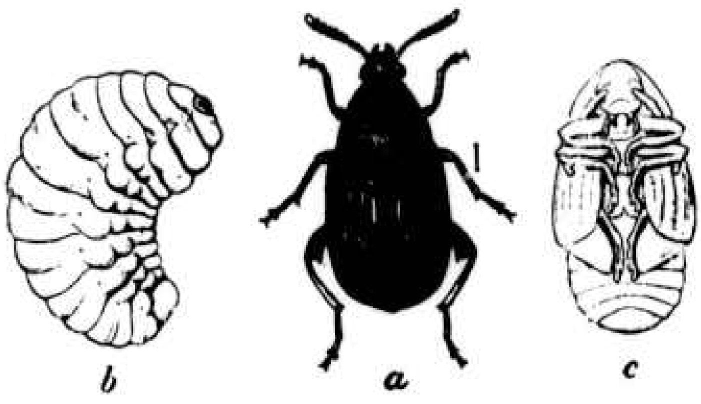

Figure 56: Bean weevil: a, beetle; b, grub; c, pupa. This beetle is about one-eighth of an inch long.

Europe and North America. A few species specialize on bamboo, and have caused much damage in the Orient. A still smaller number of species have other habits, particularly that of burrowing into roots of cassava and derris. Wood is infested continuously by powder post beetles and may, therefore, be very seriously damaged. Egg laying, which takes place at the surface of the wood, can be prevented by plugging the pores with varnish or even with oils. This does not, however, stop the development of those grubs which are already in the wood.

Lyctus brunneus - Brasilian: caruncho da madera

This powder post beetle is cosmopolitan, although not frequent in North America or most of the tropics. Like the other species of Lyctus it attacks seasoned wood of broad leaved trees. It is able to complete its development within the plies of plywood. We also find records of attack on cassava, and on lead and on copper roof plates.

Family Mylabridae

Something has already been said about this family in consideration of the insect pests of peas and beans. The family contains more than 800 species, and so far as their habits are known, they all attack seeds, with particular emphasis on the seeds of legumes. They fall into two general groups: those in which the eggs are laid on the pod during its development and in which fully ripened seeds are not utilized for subsequent egg laying, and on the other hand those species which, while they may use green pods for egg laying, will continue to lay their eggs on dry and ripened seeds. Relatively little has been done on the habits of those species which attack non-leguminous seeds, but it is known that a considerable number of species are associated with the seeds of palms. The headquarters of the family are in tropical America which possesses nearly 350 species. About 200 occur in the temperate portions of the Old World, and another 100 each in the temperate New World and in Africa. Native species are quite rare elsewhere, and apparently wanting entirely in the Pacific Islands. As is so often the case the most important species, like the bean weevil, have become thoroughly cosmopolitan. The control of seed weevils is rendered difficult by the fact that the larva upon hatching emerges through that portion of the egg shell which is firmly in contact with a seed. It consequently does not appear externally until it has completed its development.

Mylabris obtectus - U. S.: common bean weevil; German: amerikanische Speisebohnenkäfer; Italian: tonchio dei fagoli; Argentine: bruquido del poroto.

This species is undoubtedly of North American origin but it has become very completely cosmopolitan. It is usually thought of as a pest of beans like the navy and kidney beans (Phaseolus vulgaris) but it occurs also in lima beans and cowpeas, as well as sometimes in common peas, field peas, Windsor beans, lentils, chick peas, and seeds of Lathyrus sativus.

The development requires from 25 days to 6 months, in Italy there

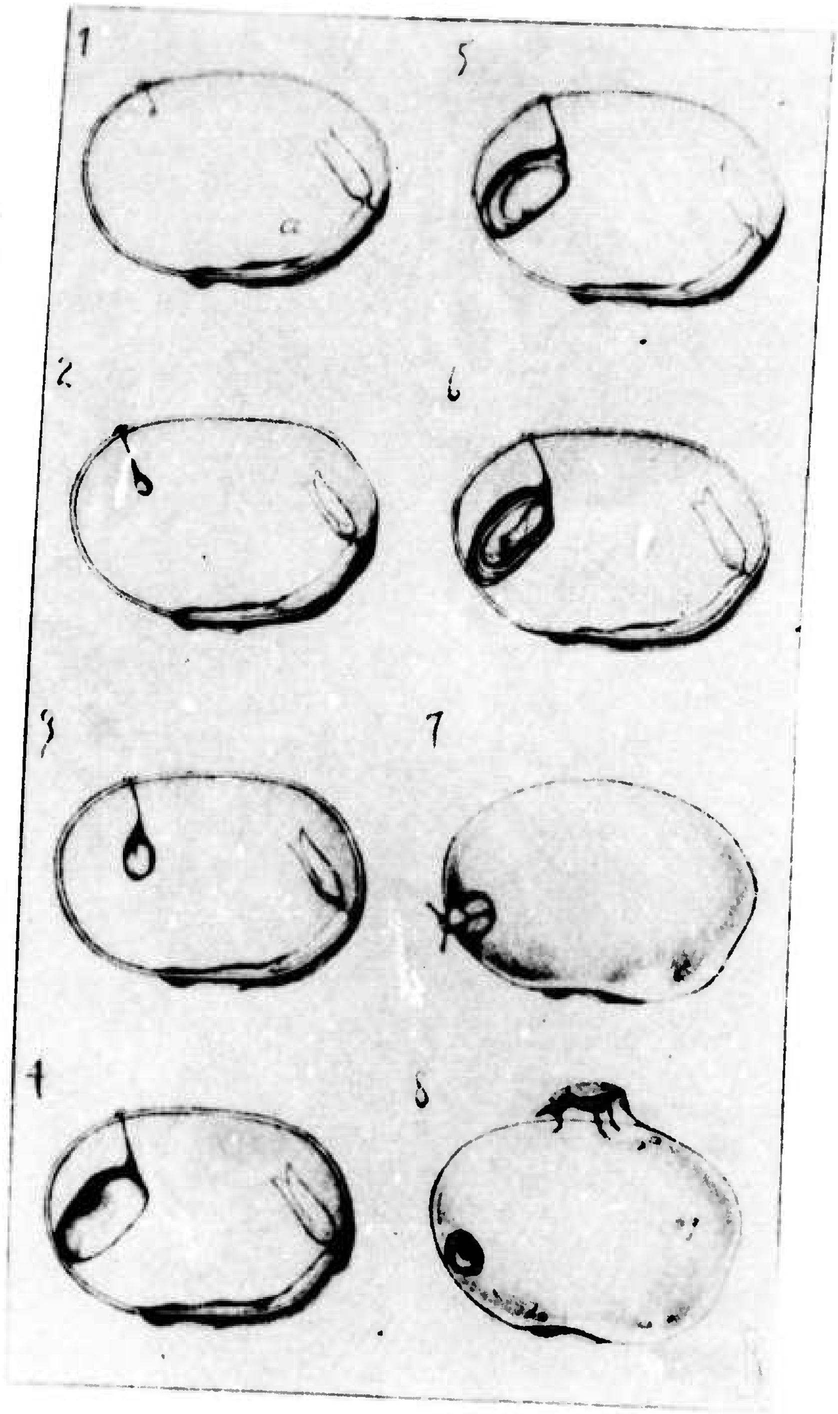

Figure 57: Life history of a bean weevil. Notice the egg shell in upper left of #1 and additional eggs being laid in #8. Growth of the grub in nos. 1 to 4; pupation nos. 5 & 6; emerging adult in #7.

Figure 58: The corn sap beetle. The adult beetle is about one-eighth of an inch long.

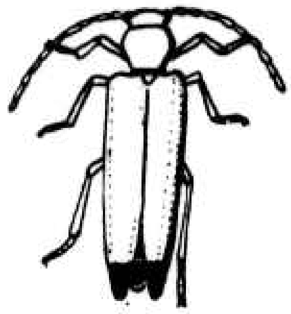

Figure 59: Dutch Wharf Beetle. Yellow with black tips to the wing covers which are rather softer and flexible. The grub is long and worm-like. Length of the beetle about 1/2 inch.

Figure 60: The cadelle. This beetle is about one-third of an inch long.

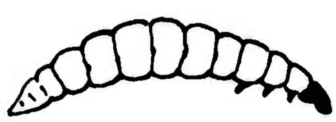

Figure 61: Grub of the cadelle. Length about one-half inch.

are 4 to 6 generations a year. A relative humidity between 26% and 93% is needed for reproduction. The optimum temperature is about 86°F and reproduction occurs between 62½° and 93°F. The insects are mostly killed in one hour at 5°F.

This species is almost exclusively a pest of stored beans and will breed in them continuously destroying a large part of the stock and building up huge populations. The adults at emergence will perforate paper but not closely woven cloth.

Family Nitidulidae

This considerable family of rather small, flattened and frequently shining beetles comprises some 2200 species distributed throughout the world. Rather few of these have been associated with economic products, and most of our knowledge of their habits is European. It is rather commonly assumed that the nitidulid beetles are scavengers. They attack, as will be seen in the appendix, on the whole quite a variety of material with a marked tendency to favor dried fruits. There is no region in which we would especially look for damage by members of this family.

Carpophilus dimidiatus - U. S.: corn sap beetle; German: Saftkäfer

This species and the one following are both cosmopolitan. This species is attracted to many foodstuffs infected with molds. It seems also to be attracted to the sap of certain plants and owes its American name to its depredations upon green corn. It is both a field and a store-house insect. Neither it nor the following seem to have any great power of attacking hard materials. They are found in the flesh of dried fruits, not in the seeds, and in shelled nuts.

Carpophilus hemipterus - U. S.: dried fruit beetle; German: gemeine Saftkäfer

The dried-fruit beetle is primarily attracted by fermenting fruit of almost any sort. It, therefore, is reasonably common about orchards and drying yards. It is highly probable that the beetles themselves are responsible, in part, for the spread of organisms causing fermentation. Unless great pains are taken in handling the fruit both at processing and after the completion of ordinary drying it is fairly certain to be infected with microorganisms and to remain attractive to the beetles. Under some conditions, at least, this beetle also attacks various grains, bread, beans, nuts, and copra. The period of development is extremely variable, ranging from 20 days to several months.

Family Oedemeridae

Only a very few species of this family of some 600 species have been recorded as doing any damage. The 5 species which I have on record all attack wet and more or less rotted timber. They are consequently to be expected in the wood of docks, piers, and bridges. It seems to be matter of indifference to them whether the wood is wet with fresh water or with salt. The known damage from beetles of this family is largely restricted to Europe and North America, and the genera in which

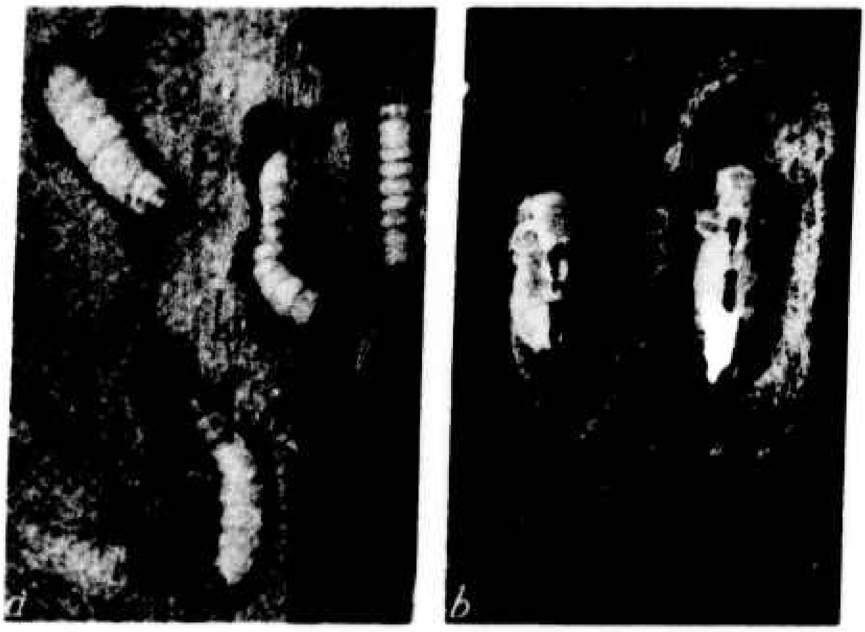

Figure 62: Grubs and pupae of the cadelle: The larvae (a) are shown in the galleries they have made in a piece of timber, and the pupae (b) in cells hollowed out where two boards were in contact.

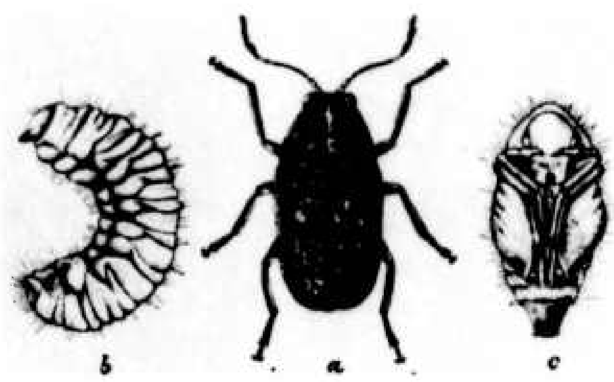

Figure 63: The coffee-bean weevil: a, Adult; b, well-grown grub; c, pupa. The adult is about three-sixteenths of an inch long.

the economic species are placed are largely restricted to the temperate regions of the northern hemisphere, but it is by no means out of the question that some damage might appear almost anywhere in the world.

<u>Nacerda</u> <u>melanura</u> - U. S.: Dutch wharf beetle

This is the best known of the economic oedemerids.. It is sometimes very abundant in wood that has become softened from long soaking in seawater. The slender wormlike larvae go down almost to the actual water line. It is much less commonly found away from the ocean, although it has been recorded as far inland as Indiana and in some other places where the wood is certainly not wet with seawater. It is the general opinion, with which I agree, that it is not found in wood which has not been considerably softened.

Family Ostomatidae

Although this family contains nearly 600 species, only two of these species have achieved any noticeable importance as pests, and both of these chiefly in association with stored grain, although they are known to damage a variety of other materials, chiefly foods of vegetable origin. It seems also fairly certain that the grubs of these beetles are to some extent predacious on other insects. Incidental damage is done by the cadelle at the time of pupation since like the Dermestidae it may burrow into wood for shelter. One would anticipate the most damage from beetles of this family in the New World tropics.

<u>Tenebroides</u> <u>mauritanicus</u> - U. S.: cadelle; German Getreidenager

This species is one of the best known grain beetles, probably in good part because it is fairly large and, therefore, even a few will attract attention. It has been found associated with a considerable number of seeds and their products, but it is also of importance because the larvae are able to penetrate various materials such as paper and cardboard and in mills do damage to the bolting silk. At the time of pupation the larvae burrow into woodwork and often do great damage.

The development requires 70 days or more. The optimum temperature is about 82°F, but the larvae and adults will withstand freezing temperatures for some days.

Family Platypodidae

The 300 odd species of this family are closely related to the engraver beetles of the family Scolytidae. These beetles burrow into fresh or partially seasoned wood of broad-leaved trees and in some regions are known as shothole borers. They are not usually of very great importance. Most of the damage recorded is from the tropics and in fact very few of the species occur outside of the continental tropics.

Family Platystomidae

Although this family contains about 2200 species only 3 have been recorded in connection with stored materials, and only one of these at

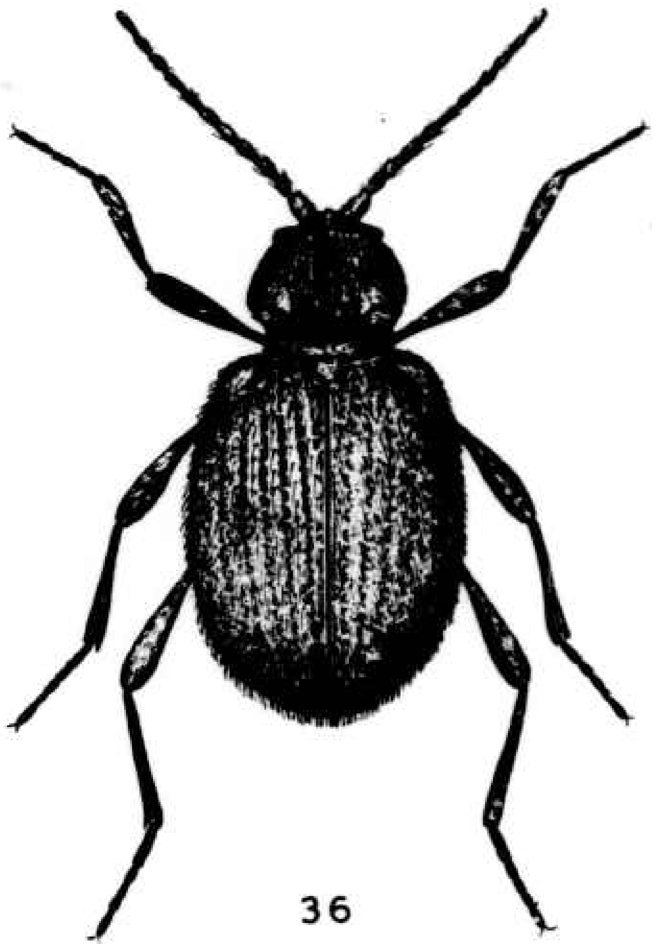

Figure 64: Adult of <u>Ptinus tectus</u>. It is about one-fourth of an inch long.

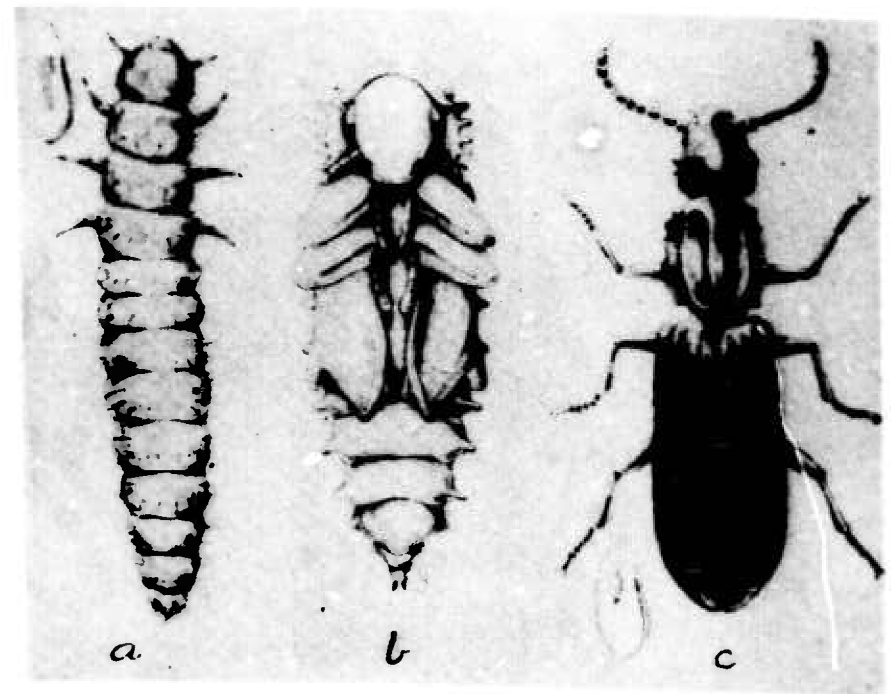

Figure 65: The saw-toothed grain beetle: a, Well-grown grub; b, pupa; c, adult beetle. The adult beetle is about one-tenth of an inch in length. Beside the larva and adult are shown grains of wheat with the relative size of the insect indicated on them.

all frequently. The coffee bean weevil is now cosmopolitan and attacks a great variety of foods. The two species of Brachyterasus are rare infestants of stored seeds in eastern North America. The family is fairly abundant in the Old World tropics and has some species on islands of the Indian and Pacific Oceans. The 43 species related to the coffee bean beetle occur mostly in Madagascar and from Ceylon to Australia with very few of them native anywhere else.

Araecerus fasciculatus - U. S. official: coffee bean beetle; German: Kaffeebohnenkäfer; English: mace weevil.

This beetle, although found all over the world, appears to be especially associated with seeds and roots of tropical origin and it probably came originally from tropical Asia. I would be inclined to assume that any materials at all similar to those listed in the appendix would be attacked. Its development requires about 8 weeks at 60 to 80% relative humidity. I do not find a record of the optimum temperature but it is probably relatively high. The insect can be killed in 3 days (a surprisingly long time) at 122°F.

Family Ptinidae - U. S.: spider beetles

About 10 per cent of the 420-odd known species have been recorded as doing damage, and there is almost no material of plant origin that they will not attack, although wood is very rarely damaged, in addition to which they will do damage to various materials of animal origin. Once a material is infested they tend to breed in it continuously, sometimes building up very large populations, and leaving behind a large amount of cast skins and other debris. Although the family is cosmopolitan, damage is best known in the north temperate zone, and most of the genera containing economic species are particularly well represented in the said zone.

Ptinus tectus

This species may serve as an example of the spider beetles and like the other important members of the group is cosmopolitan, although it appears to be of rather recent introduction into North America. It feeds on a very large variety of plant products, especially seeds and roots and including a number of poisonous or highly irritant materials, like cayenne pepper, Hyoscyamus, and Datura. In addition, it attacks a certain number of animal products, such as fish meal, casein, and dried soup. These beetles are able to utilize fairly finely powdered materials.

Much of the damage caused by spider beetles depends on their ability not alone to attack food materials but to injure containers such as wood, cellophane, and cloth. Apparently the spider beetles do not normally attack wool, but they do attack woolen cloth and I suspect that in all such cases the cloth has been soiled with some attractive material.

The development requires some 9 weeks to 6 months, depending very markedly on temperature. The optimum temperature is about 75°F and the maximum at which development is possible is recorded as 86°F. this seems rather low. A relative humidity of 50% appears to be necessary and this indicates that in cereals the minimum moisture would be about 10%.

Family Scolytidae - Engraver beetles

The characteristic habit of this family is for a mated pair to drill through the bark of a tree and then in the inner bark or in the cambium make a long burrow, from this at intervals lateral burrows go out. This system of burrows is infected with a particular fungus, depending on the kind of beetle, and eggs are laid in the lateral burrows. The young as well as the adults feed on the fungus which grows as a dark layer on the walls of the burrows. The young are dependent upon the continued presence of the adults. This damage may occur in living trees, freshly dead trees, or in some cases partially seasoned timber. It necessitates the presence of bark. Relatively few species utilize partially seasoned wood. This typical form of damage is obviously of no very great significance, although it does result ultimately in loosening the bark so that it falls away; and it can evidently be prevented by the prompt barking of timber. A few species in the family make much deeper burrows which may go clear into the heart wood, and they, therefore, cause much more real damage. A still smaller number of species attack seeds mostly of palms; but two attack seeds of corn; and about two other species attack dried roots, in one instance dried sweet potatoes.

Family Silphidae - The carrion beetles

The members of this family are frequently large and rather conspicuously colored. They are especially around the carcasses of animals on the ground. Two species in northern Europe are known to attack dried fish in houses. The damage actually recorded, therefore, is rather inconsequential. I mention the family because it is known that they are particularly attracted by fly maggots in meat and the young of many of the species found in the north temperate zone seem to feed nearly exclusively on such maggots. They might, therefore, be attracted to fly-blown meat and be considered as more important than they really are.

Family Silvanidae

This rather small family contains a few species of grain beetles of very considerable importance. The best known of these is the saw-toothed grain beetle. It seems probable that the family as a whole consists of feeders upon seeds. Most of the species related to those known to cause damage are found in the tropics of the Old World and a fair number are native to Australasia.

<u>Oryzaephilus surinamensis</u> - U. S.: saw-toothed grain beetle: German: Getreideschmahlkafer, Getreideplattkäfer

This familiar cosmopolitan beetle is immediately distinguished by the serrate edges of the thorax. As shown in the appendix it attacks

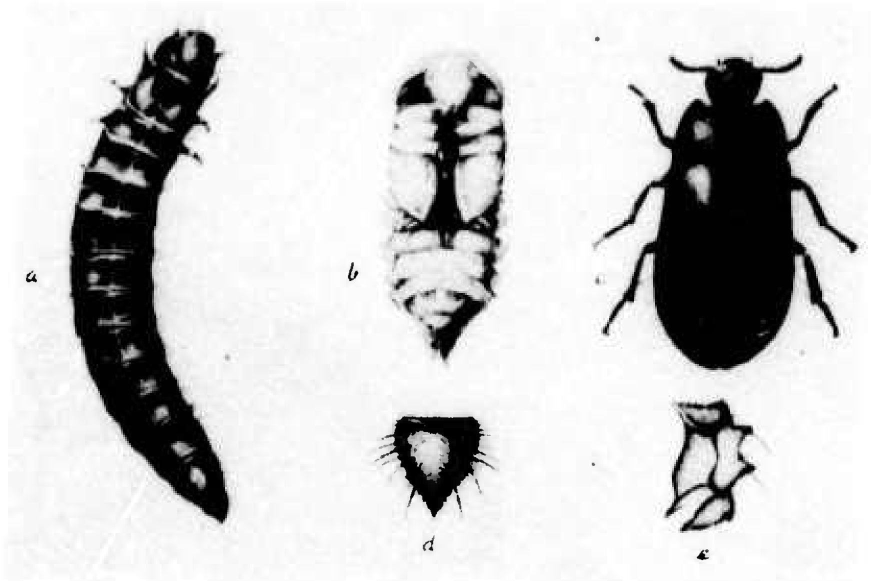

Figure 66: The black fungus beetle: a, grub; b, pupa; c, adult; d, tail end of grub. The grub is about one inch long.

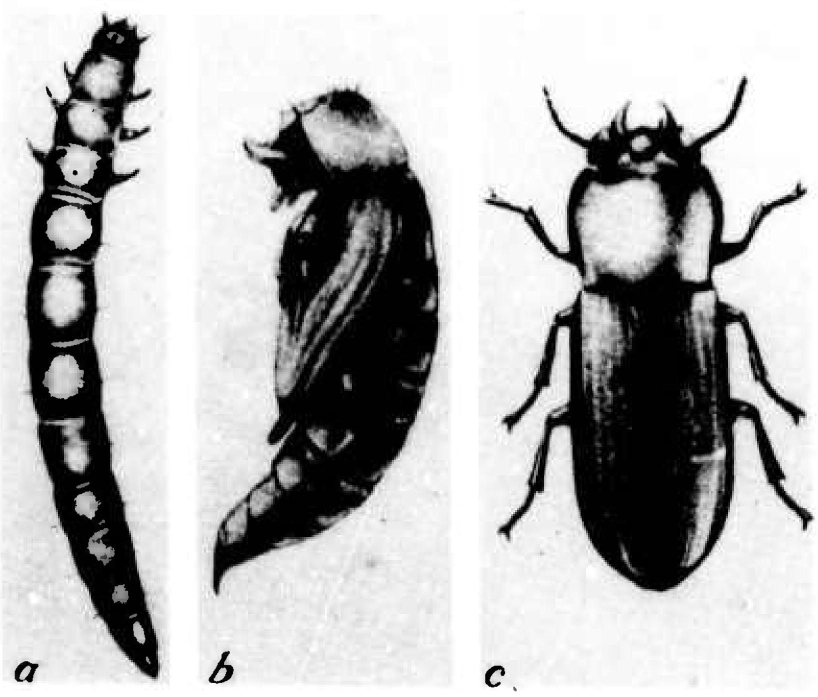

Figure 67: The broad-horned flour beetle: a, grub; b, pupa; c, adult. The beetle is about one-sixth of an inch long.

a very great variety of plant products, but seems not to be known from animal products. It is not particularly liable to attack entirely uninjured seeds in natural condition and is usually found in processed materials. It is extremely likely to spread from one material to another since the beetles are both slender and flat and can go through small openings. I have never seen it fly, but it runs very rapidly.

The development requires 50 days or more and in unfavorable materials may be greatly prolonged. The best moisture content is about 18% and the best relative humidity 70% or more. In Malaya macaroni was protected by storage at 60% relative humidity. This beetle is rather readily killed by elevated temperatures, for example, in two hours at 122°. It is one of the few pests that can be killed with some certainty by refrigeration, although even here fairly low temperatures are needed, 20° to 25°F for 7 days or 0° to 5°F for one day.

Family Staphylinidae - the rove beetles or devil's coach horses

This is a vast family of nearly 20,000 species found all over the world and usually in considerable numbers. It is not very probable that the few species reported in connection with stored products actually do any damage. They are probably predators upon other insects or mites in the material, but the family is so large and of such varied habits that it seems worthwhile to say a few words about it. The members of this family are usually rather elongated and remarkable in having the wing covers very short so that most of the upper surface of the abdomen is exposed. The wings, however, are of full length and many of the species fly well. At rest the wings are carefully folded away under the wing covers and one of the most characteristic reactions of the family is the raising of the abdomen which is done when the wings are folded but is also done if the insect is disturbed, and sometimes for no apparent reason. Aside from the lack of forceps the rove beetles greatly resemble the earwigs in general appearance. Some species in this family might be expected anywhere in the world in connection with infested food materials, and the number of species related to those listed in the appendix is considerable. The genus Atheta contains more than 1250 species and the genus Philonthus contains about 850.

Family Tenebrionidae - the darkling beetles

For the most part the members of this large family (about 11,000 species) are dull blackish or brownish insects usually nocturnal and very often flightless. A considerable number of species have been taken in association with stored food, particularly fruit and grain. The most important of these species are now cosmopolitan and on the whole they are of Old World and to a considerable extent tropical origin. Hence, if any additional species were to be encountered in the field I would expect that they would be found primarily in the continental tropics of the Old World and perhaps more frequently in west and north Africa than in any other one region

Figure 68: The yellow mealworm. Four well-grown grubs, two pupae, and the black adult beetle, with five kernels of wheat to indicate relative size. The grubs when full-grown are about one inch long and yellowish. The adult beetles are slightly more than half an inch long.

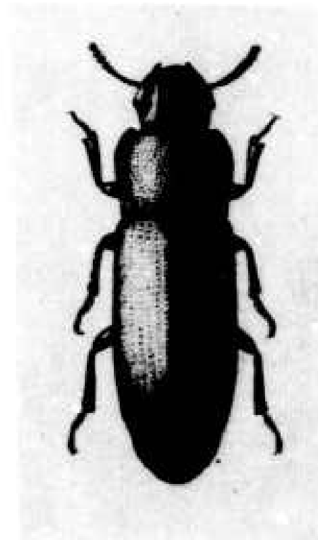

Figure 69: The confused flour beetle. The adult beetle is about three-sixteenths of an inch long.

Alphitobius diaperinus - U. S.: lesser meal worm: German: Stumpfschwarze Getreideschimmelkäfer

This cosmopolitan insect may be considered a secondary infestant since it does not damage sound, dry grain. In addition to grain products and similar materials, it is also recorded as attacking dead insects and hides. Development requires about one year.

Tenebrio molitor - U. S.: yellow meal worm; German gemeine Mehlkäfer

Although this species is cosmopolitan and one of the largest of the grain beetles, it seems to be better known in North America by reputation than by personal acquaintance. It is, in fact, very commonly raised as food for small insectivorous animals. It can, however, be an extremely serious pest since it attacks not only grain and their products but a few animal substances such as meat and feathers. The optimum temperature is about 80°F and there is usually one generation a year. It may be killed in a reasonable time at 10°F and at 125°F. The larvae shows considerable powers of penetration, going through paper and boring readily into wood.

Tribolium confusum - U. S.: confused flour beetle; German: amerikanische Reismehlkäfer

The common English name of this cosmopolitan beetle merits a word of explanation. The confusion was in the minds of entomologists not on the part of the beetle. That is, it was originally confused with the extremely similar rust-red flour beetle and what I have to say about the present species applies almost equally well to the other.

This species has been found attacking a great variety of seeds and their products and since it is small and active it passes easily from one package to another. It does not appear, however, to show any great power of penetrating materials like paper and cloth. It has been pointed out that an infestation by this beetle of any part of a ship's cargo is likely to lead to an infestation of anything else in the cargo which the beetle can eat. It does not, however, as a rule, attack completely uninjured seeds. I have recently seen an infested shipment of Brasil nuts where all of the attack by these beetles appeared to be localized at points where the nuts had already been bruised in handling.

The development requires a minimum of 4 weeks. Reproduction occurs between a temperature which is lower than 80°F and 102°F. The required relative humidity is from 65 to 90%. This beetle is supposed to be killed at a temperature of 102°F and fairly readily at temperatures of 21°F or lower.

3a11. The order Hymenoptera - Ants, bees and wasps

The wings, when present, are in two pairs and membranous. The hind wings are much smaller than the fore wings. The mouth parts are built for biting, but there is often, in addition, a lapping or sucking tongue. The abdomen is usually very much narrowed at the base. An egg-laying device (ovipositor) is almost always

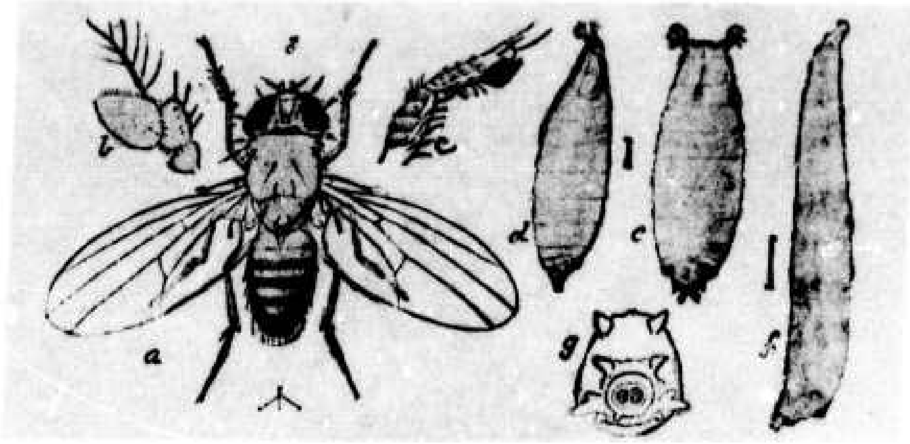

Figure 70: Fruit fly: a, adult fly: d, side pupal case view; e, same, dorsal view; f, maggot. The adult fly is about three-sixteenths of an inch long.

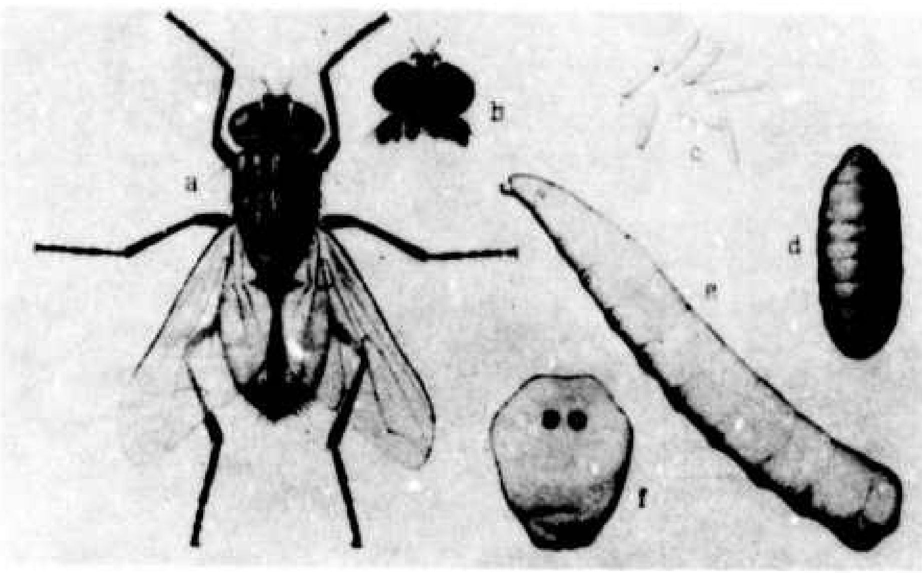

Figure 71: The house fly: a, adult female, about five times natural size; b, head of male; c, eggs, about six times natural size; d, puparium, about four times natural size; e, larva or maggot, about seven times natural size; f, last segment of larva to show spiracles. The adult fly is about five-sixteenths of an inch long.

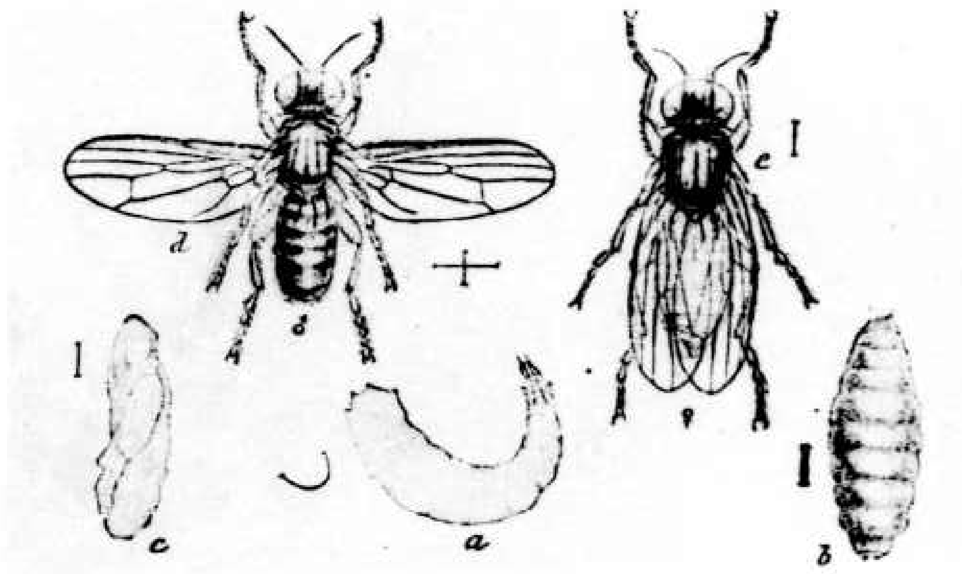

Figure 72: Cheese skipper: a, maggot; b, pupal case; c, pupa; d, adult male fly; e, adult female fly. The adults are about three-sixteenths of an inch long.

Figure 74: Leaf cutting ants showing method of carrying piece of leaf and the various sizes of workers and in the upper right an ant cutting out a piece of leaf.

present in the female. It may be modified as a sting. The metamorphosis is complete. The larva is generally a legless grub and the pupa is usually enclosed in a silken cocoon. This large order contains some 60,000 species, but a very large proportion of these species are parasites upon other insects and do not concern us here. The forms in which we are interested fall into 3 groups. (1) The wood wasps; rather large primitive forms in which the grub is provided with strong biting mouth parts and excavates rather sizable tunnels in wood. (2) The carpenter bees and wasps; a considerable group, some of which attack sound wood. In these forms the tunnels in wood are excavated by the adults as nest sites in which the young are reared. The tunnels are not permanently inhabited. As a consequence, they may be very frequently found to be quite empty or inhabited by subsequent interlopers. (3) The ants. This group will be discussed in much more detail later. We need merely here to point out that the ants form perennial colonies, often of immense size and that there is a clear distinction of castes--the workers being completely wingless.

The life history of a typical member of this order differs in no very essential respect from that in either of the two preceding orders. However, except for the ants very few Hymenoptera have become domesticated, and the consequence of this is that for many of the species with which we are concerned the life history is still tied to the seasons. This means that for wood wasps and carpenter bees and wasps, the adults will be on the wing for some definite and short time during the year in temperate regions, and each of the other stages will be similarly restricted to some definite part of the year. In the case of the wood wasps the larval life may last more than one year.

I have already referred to nest building among bees and their relatives in other places. We may here summarize the types of nests that are constructed. For our purposes we may start with those nests that consist of the mere occupation of chance cavities, a habit of a number of economic ants. The insect does little or nothing to improve the dwelling site. Many other ants either improve an existing cavity or produce their own either in the earth or in wood or other materials. Such nests may be enlarged gradually over a considerable period, and they may ultimately become very extensive. In these cases it is evident that the nest serves as a dwelling place for the entire population as well as a nursery. In the case of the nests of carpenter bees and similar forms, the nest is merely a nursery; although during its construction it may be occupied by the producing female as a place to sleep. Of a similar nature are at least some of the nests built of wax or of "paper", but many of these nests are occupied by colonial wasps or bees, either temporarily in the breeding season or permanently. Although the paper-making species utilize wood as a source of their paper, they ordinarily do no appreciable damage to wooden structures since the wood must be quite well weathered before it is useful to them, and only the very surface is removed.

Ants. - Ants are recognized at once by their colonial habit which leads to foraging in files and by the absence of wings in the workers. On closer examination all ants may be recognized by the interposition between the apparent thorax and the apparent abdomen of one or two minute and often bead-like body segments which form the petiole. There are a few non-colonial Hymenoptera which are wingless and generally resemble ants, but all of these lack the petioler segments.

An ant colony consists of a varying number of functional reproductive individuals, most of which are queens, and as seen in the colony, if functional, they are wingless, the wings which they usually originally possessed having been ripped off. The number of functional queens in the colony may vary from one to a considerable number, certainly more than forty. Most of the individuals in an ant colony are workers which may be of one form or of several forms, but all agree in being permanently wingless with a correspondingly modified thorax and in being for the most part sterile. All worker ants are female. In addition, at some seasons at least, the colony may contain winged individuals both male and female. These are reproductives which are as yet unmated and non-functional, and they will leave the colony before mating, and the females will found additional colonies, other things being equal. The size of an ant colony varies not only with the kind of ant, but with the age of the colony, so that in some cases there may be no more than a dozen workers; in other cases there may be many thousands or possibly hundreds of thousands of workers. We cannot here go into the extraordinarily interesting problems of social parasitism among ants and other operations which result in mixed ant colonies.

The food of ants is obtained from a great variety of materials. It seems fairly certain that originally ants were predacious upon minute animals and many ants retain this habit to at least some extent. Many more content themselves with gathering fragments of dead animals either fresh or more or less dried. As a consequence ants will attack meat, particularly when somewhat dry. In addition to this, numerous species have taken to the use of the nectar of plants and other similar sweet substances such as honey dew, which is the liquid excreta of certain sucking insects on plants such as plant lice and tree hoppers. This latter habit leads ants to visit any sort of sweet substance, and they are not very particular whether the sugar is in solution or is in the solid form. They will consequently visit jams, syrups, honey, the sugar bowl, and, in addition, bread and cake. (It is quite customary to feed ants in captivity on cake crumbs.) A few ants utilize seeds, but generally speaking, such seeds are smaller than those of the usual grains, but such species might well carry off coarsely-ground grain products.

The dependence of ants upon an appropriate nesting site to a slight extent restricts their activities, but from our point of view it renders them particularly liable to be found in dwellings because the cracks of foundations or the disturbed earth under or around a building may make excavation somewhat easier for the ants. In addition to which, certain wood-dwelling forms take advantage of any streak of rot in wood to start their excavation. In the tropics a considerable variety of ants either construct papery or earthy nests in trees or utilize more or less natural cavities in the thorns or the stems of certain living trees, the so-called ant trees, or spin together leaves with silk obtained from the grubs. These above-ground nests are practically wanting in temperate regions. Having established a nest, a colony of ants may forage to very considerable distances from the nest, Here, fortunately the habit of traveling en file enables us to trace the ants back to their nests, which can then be attacked directly.

Although ants are world-wide in their distribution, they are vastly more numerous in the tropics than in temperate zones. This is more true of the number of species than of the number of individuals. But to about 45 N. Lat. the number of species of ants is considerable. In addition certain sorts of ants, mostly possessing rather numerous queens and minute workers, are able to nest in such small cavities that sufficient fractions of colonies can be carried by commerce to allow of the establishment of such species at any place where they can survive. Hence, even fairly far to the north we find colonies of several species of tropical ants which in temperate regions have become restricted to buildings.

The actual damage done by ants in visiting food is usually rather small. Their habits are such that they do not tend to soil food, and even a large colony takes away comparatively little from any one source of food. However, people rather naturally dislike the presence of files of ants on the table; and in the case of jams and syrups ants are prone to fall in and drown. From the point of view of destruction, vastly more damage is done by the various sorts of carpenter ants which excavate their dwellings in wood and may therefore seriously weaken buildings. The ants of this type are apparently most numerous in the north temperate zone, although a few forms extend into and through the tropics. In addition to these comprehensible sorts of damage, ants attack materials which seem to be of no significance to them at all. Especial attention has been given to this in the Dutch East Indies where it has been shown that certain species, notably the huismier, attack rubber goods of almost all kinds, electric insulation, will perforate metals, and may even bore into cement. A few ants, the one just mentioned and some of its relatives and one or more species of leaf cutting ants of the New World tropics, will attack various fabrics.

Bees and Wasps. - The food of bees and wasps, except the wood wasps, is of no great concern to us since both as adults and young they feed on pollen and nectar or their products or on insects. The wood wasps, however, do actually as grubs damage wood for the food substances which it contains.

The only bees and wasps with which we are really concerned are those which inhabit reasonably sound wood, and I have already spoken of the character of their use of wood.

The wood wasps are most prominent in the north temperate zone. The various forms which I have referred to as carpenter wasps, not implying any close relationship thereby among the various species, are widely scattered over the world, and the great majority of those which might be here included make their excavations not in wood, but in pith or in seriously rotted wood. I have included in the appendix notes on the few species which seem to do damage to sound wood. The

Figure 75: The carpenter ant. Showing 3 workers of assorted sizes and winged male. The workers are about 1/2 inch long.

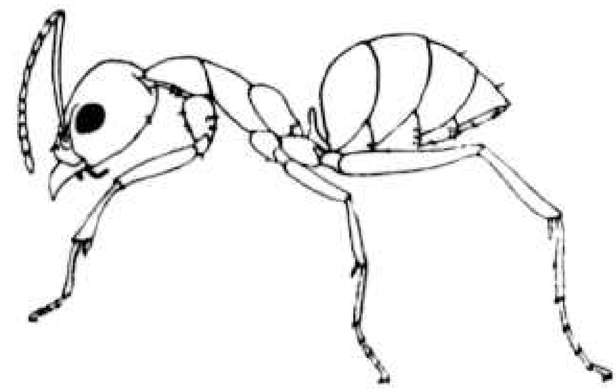

Figure 76: Side view of a worker of the Argentine Ant. Length about one-tenth inch.

Figure 77: Upper figure the Pharach ant workers gathering sugar and carrying young and toward the right a winged female. Below the fire ant showing various sizes of workers. These ants sting viciously.

third group, the carpenter bees, quite customarily utilize sound wood. They fall, for our purposes, into one rather extensive family which is predominantly tropical, although a few members run into the temperate regions of both hemispheres. The family is especially abundant in tropical Africa. I do not, however, find any records for the Pacific Islands, east of New Guinea, with the sole exception of Hawaii where a species does occur. They are scarcely pests in cool, temperate areas.

Family Formicidae - Ants

Tribe Attini - Leaf cutting ants

This tribe includes the leaf-cutting ants of the new world. They go under numerous local names some of which are recorded in the appendix. Although they are predominantly tropical, a few species of no special importance range north into the United States as far as California and New Jersey. The leaf-cutting ants make extensive subterranean nests, usually with mounded entrances and the colonies are as a rule populous. The sole food of these ants consists of specialized bodies produced by the mycelium of certain mushrooms. The fungi are grown in chambers in the nest and pieces of vegetation are used as the food for the fungi. The ants leave the nests in processions, repairing to nearby trees or bushes from which they cut pieces of leaf to take back to the nest. The workers are extremely variable in size. Some of the leaf-cutting ants are known, at least occasionally, to cut up cloth and, perhaps more rarely, to attack certain vegetable products, even grain. It is by no means unlikely that, if abundant, they might do considerable damage.

Camponotus herculeanus - U. S.: carpenter ant; German: Rossameise.

This species is reported throughout the cooler parts of the North Temperate Zone, having a great variety of slightly differing forms. It is normally either all black with whitish or yellowish hair, or deep red and black; in which case, the red is usually on the thorax, the two ends of the ant being black. The present species is one of the largest ants in the northern hemisphere. The workers vary in size from one-fourth to five-eighths of an inch long; the queens are still larger.

It customarily utilizes for its dwelling places wood which has been somewhat affected either by rot or by water, although having started in such wood it may invade very sound wood close by. The excavations are often extensive. The ants may utilize the inner six or eight inches of a telephone pole for a distance of eight or ten feet, or more. There is always a permanent opening to the nest, which may be in the ground or at some distance above the ground. In the latter instance I have seen a spike hole used. The sawdust produced is ejected from the nest, and none of the wood is eaten. The colonies contain, at a maximum, about three thousand individuals and have a length of life up to about fourteen years; no individual ant probably lives as long as this. The ants, themselves, forage for sweets quite widely, invading kitchens or attending various insects. Of several forms found in North America, only two, the black carpenter ant and the Modoc carpenter ant, are usually found in dwellings. Apparently they are able to utilize drier nesting sites than the other races. This is especially striking when one considers that the New York, or red and black carpenter ant, has practically the same geographical distribution as the black carpenter ant but is very rarely found in artificial structures unless they are extremely damp. I have heard of a few cases in spring houses and well covers.

Iridomyrmex humilis - U. S.: Argentine ant; French; Fourmi d'Argentine; German: argentinische Ameise; Portuguese: Formiga argentina; Itanian: Formica argentina

This well-known pest is probably a native of South America, but has spread over the tropics and warm temperate regions of the world. It seems to be still spreading since it was first found in Victoria, Australia in 1939 and in Hawaii the next year.

The Argentine ant damages all kinds of food, particularly sweets and cooked meats.

The colonies are very large and contain numerous queens. The nests are usually in earth, rather near the surface and sheltered by leaf debris. During the winter the ants in a colony accumulate into a large mass in some sheltered cavity.

A limited area can be made unfavorable to the ants by cleaning off leaves and other plant remains. The usual control is by means of sweet baits. These baits should not be too strongly poisoned and should be distributed in many small containers. A formula is given elsewhere in this report.

Monomorium destructor

The present species, although not the most widely distributed is perhaps the most destructive of all the species of Monomorium. It is found throughout the tropics and in the southern United States. Although it will take sugar readily, it prefers animal to vegetable food. The nests are built in crevices in walls or in similar situations away from buildings.

This ant is probably the most destructive known species in connection with inedible materials. It is not, of course, surprising that they would attack clothes and fabrics, since this could be due to the presence of grease or other attractive substances. It is, however, surprising that they will voluntarily bore into cement and are capable of perforating lead almost a millimeter thick. It has been rather frequently found that the ants have damaged electrical material, both insulation on wires and the lead sheathing of electric cables. Lately it has been reported to have a predilection for rubber. Very few other insects attack rubber at all.

Monomorium pharaonis - U. S.: Pharaoh's ant; Australian: little yellow ant; German: Pharaoameise.

This tiny yellow or reddish ant (1/16 inch long) is a characteristic house pest all over the world and is so easily transported that it is even established on such islands as Johnston and Wake. Although it is usually regarded as a meat eater it does not disdain sweets and will also attack butter, soap, and cold cream. No particles of food are carried back to the nest.

The nest is made in crevices in walls or, in the tropics, under bark. The colonies are immensely populous. One investigator trapped 350,000 in his house in six weeks and that was by no means the whole colony. The failure to carry any uneaten particles back to the nest gives emphasis to the general rule not to make out poisons too strong. The ants must live long enough to carry some back to the nest in their crops and regurgitate it to the other members of the colony.

Pheidole megacephala - U. S.: Madeira ant; South African: brown house ant

Pheidole is a vast genus occurring all over the tropics and warm, temperate parts of the world. Only a relatively few species have ever been associated with economic damage of a sort interesting to us. The most important of these few species is the Madeira ant, originally described from the island of Madeira. It is distributed pretty much throughout the tropics. The Madeira ant is an agressive species which holds its own against, or even overcomes, such relatively strong species as the fire ant. However, in its turn it falls victim to the Argentine ant. The colonies of the Madeira ant are very sizeable and workers, as is typical of the whole genus, come in two sizes, the small harvesting individuals and the large seed crushers, which in the books are usually called the soldiers. This species prefers to nest under slabs of stone, but may use crevices in walls.

It invades a considerable variety of stored foods, but it is orinarily a harvesting ant, that is it gathers seeds of grasses and similar plants. As a pest it appears to be most serious in Australia where the Argentine ant is as yet comparatively scarce, and its native relatives not agressive. In most other tropical regions the Madeira ant is not regarded as a very serious pest, except quite locally.

Solenopsis geminata - U. S.: fire ant; Dutch East Indies: roode tabaksmier; Indian: small red ant.

The genus Solenopsis falls, for practical purposes, into 2 groups:

(a) the thief ants, in which the workers are very numerous, very small and all of one size. These species, by preference, steal the defenseless young of other ants and of termites, but will to some extent invade houses.

(b) fire ants, in which the workers are also extremely numerous but of several sizes, ranging from very small to moderate. The fire ants are characterized by their great willingness to sting and the relative severity of the sting, compared to that of most other ants. There are at least four specie

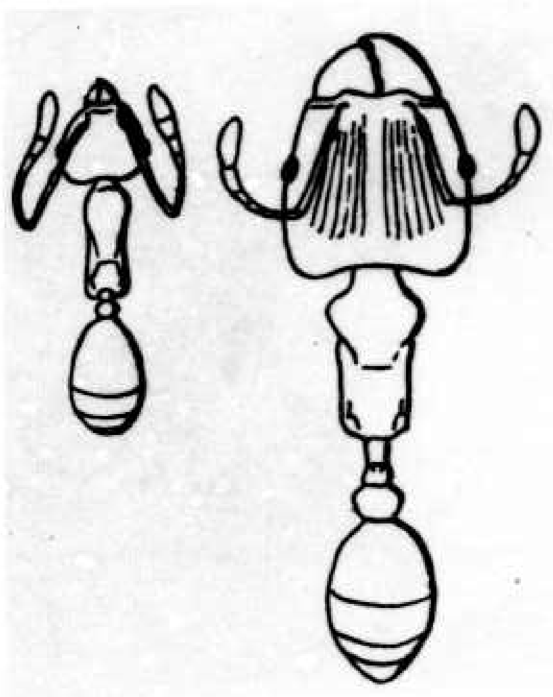

Figure 78: Madeira ant. Worker at the left and seed crusher at the right. The worker is about 1/12 of an inch long. The legs are omitted from both drawings.

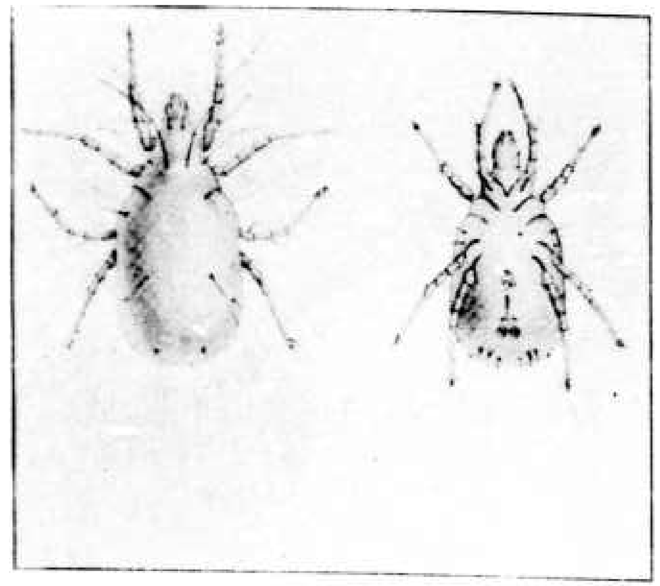

Figure 79: Grain mites. The adults are about one-fifteenth of an inch in length.

of this genus which may be considered fire ants: that is to say, all the forms mentioned in the appendix except Solenopsis molesta. With regard to most of these we have no very specific information.

As to the fire ant proper, it is a ground nester which prefers the loamy soil along stream banks. Its original food was probably seeds and insects, but as a domestic ant it is a rather general feeder that prefers meat to sugar. There is a not very satisfactory indication that they will perforate rubber covered with cotton, either impregnated with paraffin or not.

3a12. The Order Diptera - two-winged flies.

This order consists of insects possessing at the most a single pair of membranous wings, the hind wings having been converted into tiny knobbed processes. The mouth parts are fitted for sucking and sometimes also for piercing. Examples of this latter modification are mosquitoes, black flies, and horse flies. The metamorphosis is complete. The larvae are legless maggots, usually with a reduced head. The pupa is commonly enclosed in the hardened last larval skin. This is one of the great orders of insects with some 50,000 species now known, and a very large number still awaiting description. Numerous species are parasitic on other insects, and a very considerable number are blood sucking insects with which we are not here concerned. Only a relatively few types of Diptera have taken to feeding upon materials of interest to us.

The eggs of Diptera are either laid before hatching, in which case they are commonly deposited on a material appropriate for food for the larvae, or the eggs are hatched in small batches or even singly within the body of the female and larvae at some stage of development are deposited. In either case, the larva undergoes a few molts, and upon becoming full grown usually leaves the food material, wriggling out of it and in many cases, simply dropping to the earth into which it proceeds to burrow, or wriggling out of the food and proceeding along the ground and burrowing in. After the larva has reached an appropriate point, it molts at least once without feeding, and the larval skin hardens forming a somewhat pill-like structure within which is the pupa. After a time, usually not very long, the adult emerges from the pupal case.

Since very few Diptera are provided with real biting mouth parts at any stage in their existence, they are dependent for their food either upon materials which are already fluid or materials which can be rendered fluid by the exudation of some digestive juice and then taken up. There is a very strong tendency on the part of the Diptera to favor as food materials those which are high in protein. There is relatively little attack on starchy substances.

The damage done by Diptera is for the most part an invasion of meat or fish or similar materials by the maggots. We leave out of account here the bacterial contamination of food by the rather inconsequential feeding or visiting of food by adult flies. As a rule, larval Diptera do not burrow very deeply into meat or fish. A few materials, jellies, jams, fruit juices, may be visited by the tiny vinegar flies and may even serve as breeding places for them.

Calliphora - blue bottle flies

This genus comprises many species found throughout the world, even well up into the Arctic region. The females deposit their eggs or larvae on a variety of substances, generally meat or decaying grain. When the larvae are full grown they leave the food and transform elsewhere nearby. Obviously, the damage done by the blue bottle flies and their close relatives, the green bottle flies, is in two parts: (a) the actual damage, at least to the surface of the meat, and (b) the esthetic damage. Meat which is not seriously infested can be trimmed to remove the larvae and the damaged meat, but it is naturally much better to protect it by proper covering and screening.

Drosophila - vinegar flies, pomace flies, fruit flies

A number of species in this cosmopolitan genus have become more or less domesticated. They are attracted to all sorts of materials infested with yeasts. The term fruit fly is rather a misnomer, for which the geneticists are to blame. The term fruit fly is used by the economic entomologists for insects of an entirely different family which attack living fruit and living plants, and are of no immediate interest to us. Vinegar flies lay their eggs on moist surfaces where yeasts are growing. The young feed near the surface of the material and eventually crawl up out of the material for transformation. The adults are likely to be pretty numerous around garbage, but are attracted as well to wine, beer, vinegar, pickles, catsup, and similar prepared materials. They have also been found in some cases in connection with partially dried milk and still more rarely in association with meat. It does not seem to be clear to what extent they can use bacteria in place of yeast.

Musca domestica - U. S.: house fly; German: Hausfliege

I mention the house fly mostly out of deference to its tremendous reputation. It does not, in fact, breed ordinarily in edible foodstuffs. The adults, it is true, visit food, but aside from the carriage of disease the damage they do is inappreciable. In the oriental tropics, at least, other closely related species are common.

Piophila casei - U. S.: ham or cheese skipper; German: Käsefliege; Australian: bacon fly

This species represents a comparatively small family of flies and has long been well known as an infestant of all sorts of animal proteins, with an express preference for those which have been processed.

Although it avoids fat, it has been taken from oleomargarine. The common name is derived from a habit of the larva of bending the body around and seizing the tail by the mouth hooks. When the hold is suddenly released the body straightens, and the maggot flies into the air. The maggots are remarkably resistant, both to extremes of temperature and to insecticides. They are said to withstand from -8° to $131^{\circ}F$, and reproduction takes place between 56° and 102°. The latter temperature is above that of most insects. The adults can be kept out by a 30-mesh screen.

Sarcophaga - gray flesh flies

This genus is as yet rather poorly known, except in a few regions: North America, Malaya, and Australia. It is one of the most difficult of all groups of flies to study because the adults are singularly hard to discriminate. It is certainly known that a large number of the species do not attack meat, but on the contrary are parasitic on insects. A few species have still other habits. In the appendix will be found a list of thirty-one species which have been associated more or less definitely with meat in some form. The life history is very similar to that of the blue bottle flies.

3b The Order Acarina. - The Mites

The great group of spider-like animals includes extremely diverse forms. Spiders and ticks are familiar to most people who have been in the tropics, as are also scorpions whose relation to spiders is not quite so obvious at first glance. In addition to these large forms there are a host of minute animals collectively called mites which make up the order Acarina. In addition this order includes the ticks.

The mites with which we are concerned are, almost all of them, very minute, mostly much less than 1/25 of an inch long and without evident coloration. They seem originally to have been pests of growing plants and perhaps particularly grasses, and from that habitat some forty species have moved indoors either partly or wholly. In addition, there are a few other mites of different groups which have become associated with stored products. Except at one point the life history of the mites resembles that of insects; that is, they hatch from eggs and grow without striking change into the adults. However, some individuals in each species, but not all, when about half grown go into a peculiar resting stage which is almost invariably attached to some other animal, usually an insect; and it is supposed that the primary function of this stage is to disseminate the mites. The protection of the part-grown mites against adverse conditions, while real, seems to be secondary.

Our knowledge of this great group of grain mites and cheese mites is still extremely fragmentary. In the tropics we might almost say we have no knowledge. This is due in large part to the extreme difficulty of naming the species. There are probably fewer than ten men in the world competent to identify particular species of grain mites. There is only one in the United States, Dr. Harry E. Ewing, of the Department of Agriculture.

Mites have been found in association with the following sorts of materials: grain and all kinds of grain products except pure starches, other seeds, especially oil seeds, dried fruits, cheese, jams, preserved meats, wine, tobacco, hair, fur, feathers, yeast, drugs, spices, copra, stored potatoes.

It is usually assumed, although the evidence is not clear for a good many species, that these mites are associated with the presence of molds on the substances attacked. One evidence for this is the relatively high moisture content required - in all recorded cases at least 13 percent. This is noticeably higher than the requirement for many of the grain insects which we know attack the grain itself, but it is within range of the requirement for molds. However, mites will attack materials which show no visible evidence, to the unaided eye, of being moldy.

The true grain mites are accompanied by a few species of predators, also mites, and these predators, together with at least some of the grain mites are able to cause a dermatitis in persons handling the infested material. This has long been known as "grocer's itch".

There are two general methods of attack on mite infestations: (1) heating the material to a temperature sufficient to kill the mites and (2) storage of materials at sufficiently low moisture content to prevent infestation. A specific recommendation in the case of the flour mite has been made as follows: in the temperate zone store grain at 11 percent moisture, and in the tropics at a much lower percentage. However, we must point out that 11 percent moisture is not sufficiently low to prevent attack by grain insects.

I have referred to the resting stage carried by insects. The transport of mites into buildings can be to a great extent prevented by adequate screening to keep out flies.

3c - Phylum Mollusca - the mollusks

<u>Teredos</u>

Having been asked to include some comments on possible protection of landing stages and other structures in sea water from teredos, I can make the following comments:

A. Teredos are marine organisms related to clams. They attack all known woods to a greater or lesser extent. They are naturally vastly more abundant in the tropics than in temperate waters, although occasionally, at least, damage is done by teredos quite far to the north. Such damage, for example, is well known in the New England states.

B. The diagnosis of teredo damage is relatively simple since each animal bores its own hole in the wood and does not cut into those of other teredos, and the hole is lined with a white limy deposit. The attack starts at the surface of the material and works inward.

C. In many areas teredo attack may be accompanied by, or followed up by the attack of various shrimp-like animals.

In order to get an authoritative statement of the possibilities, I applied to Mr. William F. Clapp of Duxbury, Mass., who has had a long experience with this general problem. Under date of April 7, 1943, he writes me as follows:

"The landing stage problem is a tough one. I saw one which was practically destroyed in eight weeks. It is almost, if not quite, as difficult to obtain resistant timbers as it is properly creosoted timbers. Timbers injected with oils and resins extracted from resistant woods such as Southern Cypress, Tulip, etc., have shown no increased immunity to borer attack. The protection provided by preservative treatments such as creosote, is not entirely due to toxicity, but rather the preservative provides a more or less mechanical barrier. This is also true of the resistant timbers, many of which are silica-bearing. As you know the bamboos and palms are almost entirely immune to borer attack. In locations where untreated hard pine piles are destroyed in one year, palmettos will be serviceable for twenty years or more. But, of course, such woods have only slight value for structural purposes. The most resistant timbers I have seen in service, in what I believe to be the order of their efficiency, are Manbarklac, Greenheart, Angelique, and Vera, all from the Guianas or the vicinity. All should be purchased directly from the various agencies which are controlled by the British and Dutch governments with the official government stamp. Otherwise, the buyer is certain to get stuck with "Brown Heart" and other very inferior grades. All of these timbers are more costly than the best grade of creosoted Southern Yellow Pine, even when, because of their greater strength, smaller sizes can be used. I have examined scores of large docks and piers in the West Indies, Trinidad, and Venezuela and still prefer properly creosoted Southern Yellow Pine. In New York and Boston there are several thousand Greenheart Piles in some of the more important structures and they are giving excellent service, but as great care must be exercised in the selection of these timbers as we use in purchasing creosoted timbers. One Greenheart wharf in Bermuda failed in seven years. I examined the piles and found that while they were Greenheart, the grade was <u>very</u> poor. It is the same with our native oaks. White Oak is very resistant, ranking not far below such woods as Azobe, but Red Oak has but little more resistance than hard pine."

3d The Mammals

There are two groups of mammals of considerable importance to us: the rodents and the carnivores. In addition, one shrew has been reported in Europe as occasional in houses and rarely attacking cheese, meat, bacon, and milk.

The rodents are mostly of rather small size and provided with chisel-like gnawing teeth in the front of the mouth. These teeth form their chief means of entry to buildings and packages. Although the rodents are originally for the most part feeders on seeds and bark, some domestic rodents have become very nearly omnivorous.

The only carnivores that seem to be of importance are the bears, particularly the polar bear, and the wolverine. These animals are, of course, primarily feeders on flesh, but the bears, even in nature, by no means disdain fruit and berries. The carnivores use their strong claws to tear open caches or packages.

3d1. The Rodents

It is, of course, perfectly well known to everyone that various rodents customarily attack not only foodstuffs but many other materials. The attack of rodents in fact is based on two needs; first, food, and second, shelter. The ordinary domestic rats and mice are nocturnal animals, utilizing relatively narrow passageways and capable of gnawing through considerable thicknesses not only of hard wood but even of concrete. They are not actually social in their habits, although where you find one you generally find more, and it has been pointed out recently that the number of rats seen is a small proportion, usually less than half, of those actually in the vicinity.

There are three widely distributed house rodents. First, the brown or Norway rat, which is a relatively large animal, addicted to burrowing and a very poor climber. It exists in the wild state in various parts of the Old World, including the Celebes, although not apparently elsewhere in the Pacific. The second species is the black or roof rat, which occurs in two forms - a very dark form which is properly the black rat and the white-bellied roof rat; but there is very little difference in habits between these two forms. This species is also found in the wild state all through the tropics and sub-tropics of the Old World, including many of the Dutch East Indies. The third species is the house mouse, also a native of the Old World both in warm and in cool regions. It is hardly possible to say how far it extends as an actual native animal although a form of it is known from the Marquesas.

All of these species have become extremely widely distributed by commerce, to the extent that they may be expected anywhere in the world that conditions are at all suitable. As is well known, the brown rat is able to exist in association with man far to the north, and it also occurs widely in the tropics. The black rat on the other hand, does not generally occur in cool temperate regions, although instances of its occurrence are known as far north as Vermont in the eastern United States.

The house mouse is probably at least as widely distributed as the brown rat. It is a matter of common experience that where the brown rat and black rat come into direct competition the brown supersedes the black. But they are able to coexist in those regions in which the black rat can, by taking to trees, be out of the way of the brown. Probably neither species competes appreciably with the house mouse.

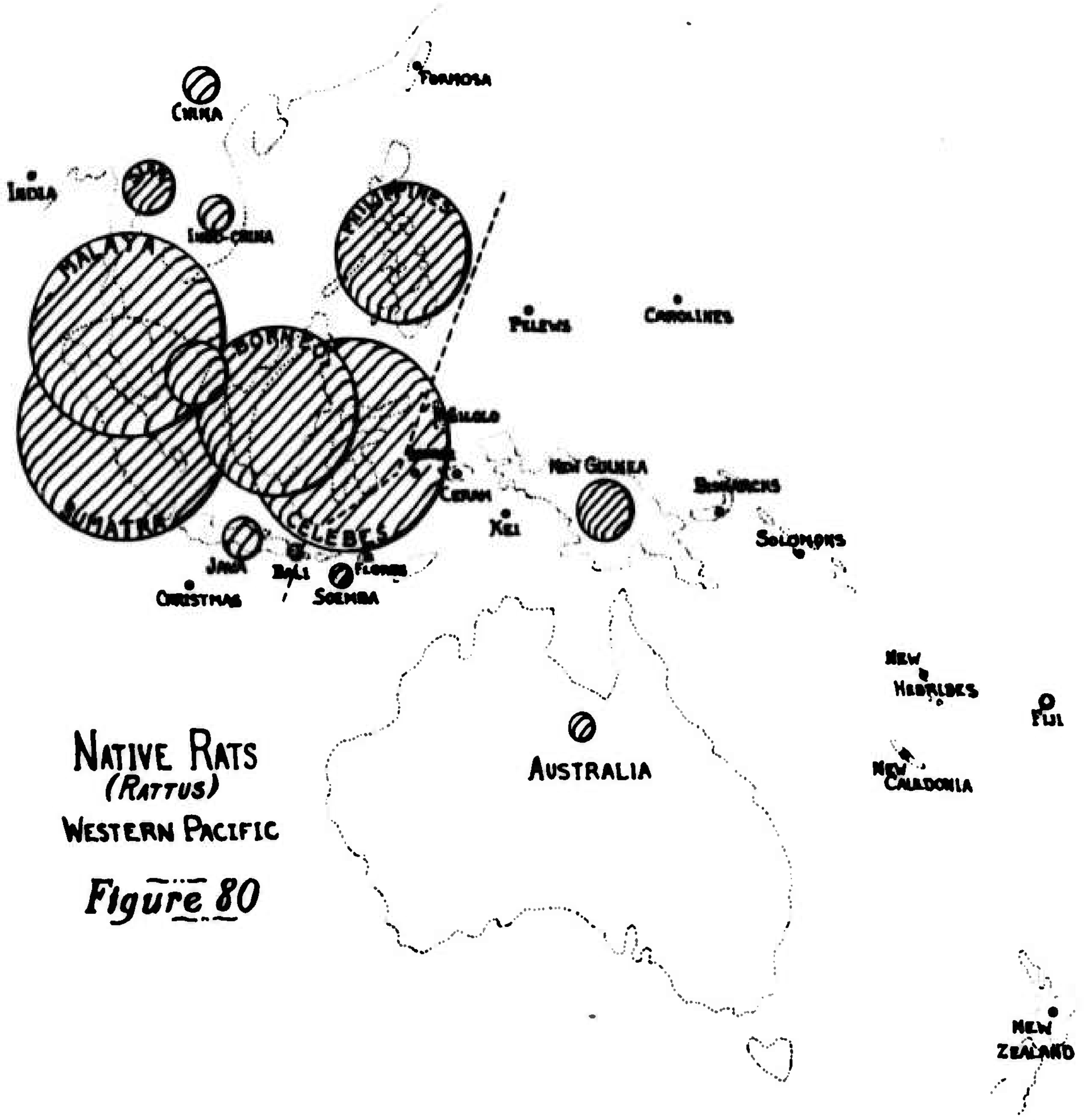

Figure 80: Distribution of native rats in the western Pacific. The diameters of the circles are proportional to the number of species known. The dashed line is Wallace's line.

In addition to these rather thoroughly domesticated rodents there are a large number of species of rats closely allied to them which are found from the warmer parts of the Asiatic continent, southward and eastward to Hawaii. There is no point in listing the very numerous specie

The numbers of these native species show a very definite geographical arrangement. The number of native species is greatest in extreme southeastern Asia and Sumatra, declining as one goes away from the continent or as one goes northward. Furthermore, the number of species declines as the islands get smaller. This relationship is shown graphically on the accompanying map, where it will be noted that the Celebes forms an exception since it has more native species than Malaya. It will be noted also that a dashed line has been drawn on the map passing between the islands of Bali and Lombok and the Celebes and Gilolo and the Philippines and the Pelews. Eastward of this line there is a very remarkable decline in the number of species so that even New Guinea has only a few more native species than the much smaller island of Java. This is Wallace's Line with some modification.

The importance of mentioning these native species is that we have little information about their habits, and we can only say that the presence of a large number of native species renders it more probable that one or more of them will succeed in invading storehouses and dwellings. Where only a few species occur, the risk of this invasion is correspondingly diminished. It is perhaps germane to point out here that the occurrence of these native rats is closely associated with the history of bubonic plague in the Pacific area. Fortunately, it is possible to make certain recommendations, which will be done later, that will tend to minimize the difficulties to be met with on account of rodents. Primarily, of course, these consist in (1) keeping food out of their reach and (2) depriving them of shelters in immediate vicinity of dwelling places.

It should also be pointed out that some rodents, such as porcupines, which are not ordinarily destructive of stored materials, will attack wood which has become soiled with grease, particularly from salt or smoked meat, or has been soaked with salt water. They may do very considerable damage.

3d2. Carnivores

The only bears which are at all destructive occur in the colder parts of the northern hemisphere. This, of course, includes practically all the known bears, since outside the region mentioned there are only the Malayan sun bear and the spectacled bear of the high Andes. The northern bears fall into two groups, the gray, brown, and black bears, which include the grizzlys and the ordinary brown and black bears of America and Europe, and the polar bear, which is the only white bear. The first group normally hibernates and is, for the most part, terrestrial; the polar bear does not hibernate, is strongly aquatic and subsists mostly upon seal.

The wolverine is a comparatively small animal, attaining the weight of perhaps fifty pounds, and found from at least southern Canada to the Arctic Ocean. In is very powerful, in proportion to its weight.

The essential point in the protection of stores from carnivores is that the animals should not be able to smell anything which they can recognize as food. So far as the wolverine and the grizzly and brown bears are concerned, almost any sort of meat would be so recognized. In the case of the polar bear, on the other hand, Dr. Stefansson points out to me that although the polar bear will come up wind a long distance to seal meat, it will ignore caribou meat which is close by; I think he is correct in saying that this is because for the polar bear caribou is not food. In the section on control I will discuss a possible construction of animal-proof caches.

4. SUMMARY OF CONTROL METHODS AND SUBSTANCES

Speaking in the most general terms we can obviously control insects either by prevention of infestation or by curing the infestation after it occurs and it will be useful here to summarize the types of methods which follow under these two headings. On the other hand, for practical purposes, a classification based on the methods themselves rather than their time relation to the infestation seems more useful and the latter course will be adopted in the major discussion.

1. Prevention. For our purposes we may consider four methods of preventing insect infestation.

a. Separation of the insects from the material to be protected by an impassable barrier. Two examples of this are the use of a copper shield between concrete foundation and the wood of a building to prevent passage of subterranean termites and the storage of foods in insect-tight glass or metal containers.

b. Poisoning of the material. A simple illustration of this is the impregnation of wood with creosote.

c. Substitution of immune materials as, for example, the use of concrete instead of wooden posts under buildings.

d. Environmental control. One of the most familiar examples is the cold storage of furs. In effect, the material is removed to an environment in which the infesting insects are inactive.

2. Cure. Here we are committed, on the whole, to killing the insects after they have reached and generally begun to multiply in the material and we may do this by 3 general sorts of methods.

a. Physical methods. Of these the most useful is heat. This will be discussed in more detail later but it suffices to say that no insect is able to withstand, for any length of time, temperatures in the general vicinity of 140°F or higher. This holds, by the way, even of insects found in deserts. Such insects possess special adaptations for avoiding extreme heat. Cold and light are not adequate methods for killing insects under ordinary conditions, although they may prove to be very useful adjuvants.

b. Poison. There are now known, at least, some hundreds of substances which are poisonous to insects and we may say, in general, that any substance which is poisonous to the higher animals will be in some degree poisonous to insects and vice versa. There are 4 main methods of poisoning insects.

1. Baits. That is food materials which have been mixed with a poison and which, therefore, attract the insects to the poison.

2. Sprays. Liquid poisons distributed in the form of fine droplets. These may act either by contact with the insect or by giving out a vapor which is poisonous, the former is the usual mechanism.

3. Solid contact poisons. The usual roach powders are of this nature. That is we use a finely divided solid which adheres to the insect and the poisonous effect may be obtained either by passage of the material through the integument of the insect or by the insect grooming itself and swallowing some of the poisonous substance.

4. Fumigation. This is the introduction of a poisonous gas into the space in which the insects are situated. It is of no consequence whether the fumigant is originally introduced as a gas or as a liquid which volatilizes.

c. Biological methods. These correspond, generally speaking, to the methods of environmental control noticed under prevention. They utilize the habits of certain predacious or parasitic organisms which depend for their food upon attacking that species of insect of which we wish to be rid.

I will consider actual methods of which we can make use under five heads:

a, Poisons.
b, Ground treatments.
c, Wood treatments.
d, Structural methods.
e. General procedures.
f. Special procedures.

4a. Poisons

It will be convenient to discuss poisons and closely related control substances under six heads as follows:

1, Baits
2, Sprays
3. Fumigants
4, Contact solids
5. Moth proofing, etc.
6. Repellents

4a1. Baits

There is no one bait which will work for all insects under all conditions. It is, therefore, necessary to determine in some general terms, at least, the type of insect present, and its habits. This determination can be made with sufficient accuracy by means of the keys already given, particularly in section 1f6. Where there is any question as to the habits of the organism, which is most likely to arise in the case of ants, there should be no difficulty in testing with the use of sugar, syrup, and meat scrap, since one or the other of these is pretty certain to attract any house ants.

It is rather important in making up baits that the compounding be done with considerable accuracy. This is especially true of ants, which may be repelled by a bait too strongly poisoned, or, what is often more important, the poison if taken will act so quickly that the ants have no opportunity to return to the nest and distribute doses of poison to other members of the colony by regurgitation. I, therefore, take up a selected series of baits, according to the groups of organisms to which they are best adapted.

Silverfish

a. 4 oz. plain wheat flour, 4 oz. sugar, 1/8 oz. salt, 1 oz. finely powd. Na_2SiF_6, 1/2 oz. gelatin 3 pt. water; make flour into cold paste with part of water; add rest of water; heat to form paste; stir in other ingredients; spread hot on cards and let dry.

b. 1 pt. Na_2SiF_6 + 9 pt. powd. sugar. (Use as a dry powder.

Crickets

a. 20# rice or wheat flour, 1# Na_2SiF_6, 1# molasses with water to moisten.

b. 4 oz. As_2O_3 or Paris green, 1 pt. molasses, 1 qt. H_2O, 5# bran, 1/2 tsp. amyl Ac, 12 oz. NaCl.

It is probable that baits of this nature will also be effective against other related organisms such as grasshoppers, and could probably be used against earwigs.

Roaches - baits

a.	Powdered borax	3 parts
	ground pyrethrum	1 part
	sugar or chocolate	small amount
b.	Plaster of Paris	1 part
	sugar.	2 parts
	(use dry)	

It is generally considered that roaches are more effectively controlled by trapping or by the use of solid contact poisons. These methods will be noticed later.

There are other poisons which have been used against roaches. One of them is a bait consisting of one part sodium fluoride to ten parts of yellow corn meal. It is a rather slow acting bait, but reasonably effective against the German roach.

It has been shown in recent years that the various roaches are by no means equally affected by a given poison. For example, some tests made using yellow phosphorus as the poison demonstrated numerically what had long been known as a practical observation by professional operators, that it is very much easier to kill the American roach with phosphorus than it is to kill the German roach. The latter species requires approximately five times the amount of phosphorus per unit of body weight as the former. We, therefore, cannot recommend yellow phosphorus as a good general roach poison.

Earwigs

Na_2SiF_6 1 part, wheat bran 12 parts, fish oil 1 part.

Beetles

Apparently no one has used poison baits for the control of stored-product beetles, and it is highly unlikely that such baits would work against grain beetles. It might, on the other hand, be possible to control larder beetles by poison baits based on some of the more attractive substances, such as bacon.

Ants

a. Na arsenite 1 part, water 18 parts, honey 288 parts.
b. 1# sugar, 1/4 oz. borax, 1 pt. water, to which is added 1/16 oz. Na arsenite in 2 oz. water and finally 1 oz. honey.
c. 100 oz. sugar, 2½ pt. H_2O, 0.1 oz. tartaric acid 0.1 oz. Na benzoate, 0.3 oz. Na arsenite.
d. 1 pt. tartar emetic, 100 pt. lard.
e. bacon rind, into which tartar emetic has been rubbed.
f. tartar emetic 1 part, sugar 10 parts, water 100 parts
g. molasses 4#, water 1 qt., Na arsenite 1/2 oz., ground up orange 1.

Of these only d and e are suitable for meat ants; the others are for use against sugar ants.

If an ant bait fails to work, one or more of the following reasons may be involved:

a. It may contain the wrong attractant, that is to say, we may be trying to attract sugar ants with meat, or vice versa.
b. It may be too toxic. In such a case the ants which are actually taking bait may be killed, but the destruction of the colony will depend upon visits by practically all of its members, or the bait may actually repel the ants because of the high concentration of the poison.
c. There may be an insufficient number of dispensers. It isn't easy to see the biological reason for this last point, but it is well known, as a matter of practical experience.

The following points based on observations on several species of sugar ants in Germany may be helpful in connection with the modification of existing ant baits: Each species reacts differently, but all those tried are "attracted" by such sugars as glucose, fructose, and saccarose in solution at concentrations ranging from 1/800 molal to 1 molal, but take no interest in lactose, arabinose or xylose.

Dispensers

Obviously, the way in which any poison is to be made available to the insects depends on, first, the character of the bait or poison: second, the habits of the insects themselves; and third, adequate protection of man and animals from the poison. A proper design of dispensers will take into account all of these items. I have above given a description in certain cases of the physical state of the material as used. Evidently the first bait under Silverfish is ultimately dry and the cards may be put out of the way in places in the building where silverfish have actually been seen to go.

Powders are ordinarily either placed along the edges of rooms or shelves in the form of a small windrow, or with the use of a dust gun are blown against the bottoms of walls or into drawers and also into cracks. It is, of course, perfectly plain that the first method allows a better separation between the poisoned material and containers of food; the second method can only be used with safety where no human food is involved or where only the walls are powdered. I suppose that from the standpoint of the army the application of dusts in the ordinary commercial ways would be frowned upon since the dust should be left in place for at least a week or ten days, and consequently, thorough cleaning can not be undertaken during that period.

Syrup baits, which are particularly ant baits a-c and g, have usually to be put in a waterproof container, such as a small metal can or box, or a waxed paper cup. These syrups are likely to pick up water and increase considerably in both volume and fluidity upon standing. The dispensers can be put in reasonably out-of-the-way places. In a few cases the syrups are stiff enough so that they may be placed in dispensers like an ordinary pill box with two or more openings, 1/8 to 1/4 inches square, cut in the upper half of the wall. The ants enter and leave, of course, through these openings. It does not seem to be feasible to use similar covered dispensers against crickets and roaches; the openings required are too large. There are a few commercial ant poisons which are very nearly dry, and which are sold in the form of a sugary material pressed into a crown cap. This sort of device is known commercially as an "ant button". The poison involved in commercial ant buttons and ant jellies in normal times is thallium sulphate.

4a2. Sprays

Most insect sprays consist of a poisonous material dissolved in an appropriate solvent, which is usually a light paraffin oil of the general type of Stoddard solvent, but any good grade of kerosene will do. Not infrequently, some stablilizing or activating substanc is included. A few poisons, notably nicotine are best handled in aqueous solutions, and consequently have had relatively little employment in the treatment of household pests. The attempt on the part of the manufacturers of household sprays has been to achieve a nearly odorless spray in which the solvent is relatively quickly volatile and which does not stain wallpaper or hangings.

The following four groups of substances seem to be especially adapted for use as sprays: (a) aliphatic thiocyanates and isothiocyanates; (b) pyrethrum, or more or less purified extracts of it containing pyrethrins, (c) rotenone, and (d) nicotine.

While the amount of poison used per unit volume in any of these sprays is not large, and it might appear that the material could be readily shipped, it will be noticed that the diluent required in most cases is not locally obtainable and would also have to be shipped to the point where the spray was to be used. Therefore, I am not giving formulae for the compounding of the sprays. It seems better on the whole that sprays, particularly lethane or pyrethrum, be obtained ready for use in this country and shipped abroad. This, of course, does not hold for nicotine and some rotenone sprays which are diluted with water; however, for the most part, these sprays are less useful than the oil base sprays.

Taking the first two materials, the choice of spray depends only in slight measure upon the sort of insect which it is desired to kill. There are two general methods of using sprays. One is to apply the spray to surfaces over which insects may run, or force it into cracks where the insects hide. In this case, it is expected that the insects will pick up the material from the surface and that the spray will be effective after the solvent has evaporated. The other procedure is to use the spray to form a mist in the air, depending upon the insects' flying into it or being affected by the volatilization of the poison, as well as the solvent. This latter method seems to be somewhat feasible in the case of pyrethrum, but it is well known that the best knock-down of flies and mosquitoes is obtained by actually striking the insects with droplets of spray.

Although the materials used as poisons are not especially toxic to man, they are somewhat toxic. Of the four listed here, nicotine is the most dangerous. There have been reports of the occurrence of symptoms upon handling the thiocyanates, although it is claimed that the use of isothiocyanates is not accompanied by evidences of poisoning. I have not personally had sufficient experience with the lethane sprays to know how the symptoms appear. In the case of pyrethrum, relatively high concentrations of the vapor in a room lead quickly to headache. This is, of course, more easily obtained by the use of pyrethrum powders in a closed room.

Rotenone has a considerable local anesthetic effect, even in moderate doses. A small amount of rotenone dust in the mouth causes a tingling sensation on the tongue followed by transitory numbness. This effect is noticeable, although apparently not dangerous.

In the cases of pyrethrum and rotenone it is considered necessary to use a stabilizer in the spray. Oil of sesame is the usual one in the former case.

We must also point out that at the present time supplies of both pyrethrum and rotenone are scanty and since the latter is of special importance to agriculture, it would seem desirable to avoid its use in household sprays where the lethane group are at least as good and more readily obtainable.

4a3. Fumigants

We may divide fumigants into two groups; those which are applied primarily as gas and those which are applied as solids which volatilize. The familiar members of the first group are hydrocyanic acid, methyl bromide, ethylene oxide, carbon monoxide, sulphur dioxide, and formaldehyde. In the second group we may place particularly paradichlorobenzene, calcium cyanide, and calcium cyanamide. One liquid, orthodichlorobenzene, may also be considered with the solids. These various substances differ somewhat in their applicability and in their effectiveness.

(a) Hydrocyanic acid

This is in some respects the most poisonous, the most effective and, at the same time, the most dangerous of all insecticides. Because it is so highly effective, it has been employed in recent years almost to the exclusion of other fumigants. Its enormous toxicity imposes very special problems in connection with its use. As is well known, it is at ordinary temperatures a very volatile liquid. The gas has about the same specific gravity as air. It therefore penetrates cracks fairly readily and is fairly easily distributed through a building. It is colorless, apparently tasteless, and according to the text books, has a characteristic odor of bitter almonds. The difficulty with this last characteristic is that no one nowadays is familiar with the odor of decomposing bitter almonds. In addition, it would appear that not everyone detects the odor readily. I can say from personal experienc having used cyanides for a number of years, that I have been able to detect the odor only on two or three occasions, and so it cannot be assumed that a lethal concentration in the air will be detectable by its odor. Attempts have been made to get around this difficulty in the employment by mixing other substances with the cyanide. The two that have been chiefly used are cyanogen chloride and chloropicrin. The difficulty in the employment of either of these substances is that their specific gravity is much greater than that of the hydrocyanic acid, and it does not yet seem possible to guarantee that they will distribute themselves in a building in exactly the same way as the cyanide gas does. Chloropicrin, however, has been used very effectively as a warning gas introduced into holds of vessels a little while in advance of the introduction of the cyanide.

The dosages of cyanide required vary with temperature, probably to some extent with humidity, but are of the general order of a few ounces to a thousand cubic feet. The poison will not only kill all the active stages of insects, but is also quite effective against the eggs. Very few other insecticides, as ordinarily employed, are effective against eggs of insects. It must be noted also that hydrocyanic acid is soluble in water and in alcohol and slightly so in fats. It stains copper, silver, gold, and brass, at least in the presence of moisture. It affects a few dyes and also photographic materials. The gas is inflammable and it is explosive between the limits of 5.6 per cent and 40 per cent by volume in air.

The National Pest Control Association has set up standards for the safe employment of fumigants, and especially cyanide, which are based on the actual experience of the members and those standards are included herewith, as revised to October 28, 1942. In Section 6 I propose a tentative restatement of these standards for military use.

GOOD DOMESTIC FUMIGATION PRACTICES

1. No crew be allowed to fumigate unless they are properly equipped with gas masks approved by the U. S. Bureau of Mines and which have been properly tested before entering into the gas.

2. All fumigating crews be required to carry to all jobs sufficient warning signs and such safety devices as necessary.

3. No fumigation of any building and re-occupancy take place within the same 24 hour period, and in no event shall a fumigated space be re-occupied before an 8 hour ventilation period. This does not include a treatment for mice or rats in burrows and harborages.

4. No partial fumigation of any building be allowed unless the entire structure be vacated.

5. On every job one or more watchmen be on guard outside the fumigated structure during the entire period from time of the fumigation until it is safe for experienced fumigators to enter without masks.

6. All greasy or damp foodstuffs be removed. This also will include milk, butter, green vegetables, eggs, opened and not corked bottles of liquids, unexposed films, fine clocks, and all plants and pets.

7. All toilets are to be flushed at the completion of the fumigation. If toilets are used for the disposal of any fumigant residue, several flushings should be made.

8. Any premise to be fumigated will be sealed in such manner as to confine the fumigant to the space intended to be fumigated and careful examination will be made of all parts of the enclosed space to determine that no persons or domestic animals remain before fumigation material is distributed and the final exit made.

9. Lock all doors and accessible windows; place warning signs on all entrances before the fumigant is released.

10. Two or more experienced men be on every fumigation job, both at the time of releasing the fumigant and at the time of initial ventilation. Under no circumstances should anyone but an experienced fumigator be permitted to conduct or supervise a fumigation.

11. Fumigation regulations in effect in the city, municipality, or state in which fumigation operations are to be performed will be strictly complied with. In the event of no local ordinance or law pertaining to fumigation operations, notification should be made at least to the fire department and recommend notifying the police department or any sub-division of the local municipal government that would have jurisdiction over fumigation operations.

12. All bedding and overstuffed material as well as absorbing articles such as woolens and furs should be placed for easy penetration and ventilation of the fumigant. It is recommended that the structure be heated when necessary to assist to drive the fumigant out of the materials. The use of fans or any other mechanical means of ventilation is recommended.

13. Extreme caution should be taken to make sure that all tenants are notified of the fumigation as to the time to vacate and when to re-enter the premises. It is recommended that such notification should be made in writing to each individual or a notice posted in a conspicuous place in the building.

14. Each crew be outfitted with a safety kit containing the following:

(a) a diagram showing the Schafer Prone Method of resuscitation.
(b) smelling salts (Ammonium carbonate).
(c) Amyl Nitrite, 5 minims.
(d) gauze bandage, Band-Aid adhesive tape and an antiseptic.
(e) Turkish towels.
(f) new canister.
(g) permit, if such is required
(h) aromatic spirits of ammonia (well stoppered and in a dark bottle)

15. No fumigation project be carried out unless the operators be familiar with the Schafer Prone Method, especially on Cyanide fumigations.

16. No person will be permitted to enter the fumigated premises before the fumigator has satisfied himself by personal inspection without gas mask that it is safe for occupancy.

(b) When test papers are used for the detection of cyanide, it is recommended that a color chart be used.

(c) Warning signs should include the name of the fumigant, the fumigator, with the address and telephone number; the word "Danger" and Skull and Cross Bones; and printed black on red, or red on white; the letters to be two inches in height.

(d) An additional gas mask and canister shall be available on all fumigating jobs.

(b) Methyl bromide

This substance has commanded a great deal of respect in recent years as a somewhat safer fumigant than cyanide, especially for foodstuffs. It is, of course, an anesthetic and, therefore, dangerous to man. It has a rather heavy vapor and therefore should be applied toward the top of a building, but is apparently satisfactory for chamber fumigation and similar procedures. Methyl bromide is stated to cause some slight injury to rubber, leather, and furs. It would also be absorbed by any fatty materials. Other foodstuffs will also absorb this gas to some extent. Flour, for example, may hold 250 parts per million.

Dr. B. E. Proctor brought to my attention some data chiefly on the use of methyl bromide, and from those I quote the method of treatment for grain, which is also applicable to dried fruits. The same data sheets recommend, however, giving nut meats only half the exposure time. A quite similar procedure could be used for almost any dry food in sacks.

Pre-treatment requirements - if grain is stored in bulk, a gas-tight bin is essential for high kills.

If grain is stored in bags, and treatment under rubberized tarpaulins is to be made, placement on a gas-tight floor is essential. Concrete or earth floors are preferable. If floor is of open wooden construction, grain should be moved to a new location and restacked on lappe rows of roofing paper. For optimum results, dumps of five bags high are advisable.

Extra bags of grain placed top of the stack proper at each corner as well as here and there in the middle, will hold the tarpaulin above the grain mass, thus effecting an air dome, greatly facilitating gas diffusion and efficiency.

After injection tubes are set at the upper part of stack, tarpaulin edges should be dropped and weighted down entirely around stack to prevent leakage. Either sandsnakes or extra bags of grain are advisable for this purpose. Dimension lumber, while sufficiently heavy, is too rigid to account for the usual undulations of the floor, thus permitting gas leakage.

Test base of tarpaulin with halide test lamp for leakage five minutes following injection.

Under no circumstances should canvas tarpaulins be used, as they will not retain the vapors of methyl bromide.

Treatment Requirements

Dosage - 1 lb. per M. cu. ft.
Exposure - 24 hours

Higher efficiency will be realized if treatment is made when grain temperatures are above 60°F.

(c) Ethylene oxide

This fumigant appears mostly in the form of commercial mixtures of it with carbon dioxide (usually 1 part ethylene oxide to 9 parts carbon dioxide). It has been used somewhat extensively in the disinfestation of flour and grain. It is inflammable in the pure form between the limits of three and eighty volumes per cent. The recommended dose is 2 lb. per 1000 cubic feet.

(d) Carbon monoxide

As a pure gas, carbon monoxide now is rarely, if ever, used as a fumigant, but there are some circumstances under which the impure form produced by automobile exhaust can be employed. For example, burrows of rats can be fumigated by attaching a hose to an automobile exhaust pipe and allowing the engine to pump the exhaust fumes down into the burrow. With very slight modification, this same method can well be used against very large ant nests. In the latter case, it would probably be necessary to enlarge one of the openings into the nest with a rod, in order to insert the hose. In any event, wet earth should be placed around the hose to make a tight seal. It is probably unnecessary to point out that carbon monoxide is a very dangerous poison, and in its pure form, odorless, tasteless, and inflammable.

(e) Sulphur dioxide

Sulphur dioxide, produced by the burning of sulphur, is an old and well known fumigant. It is not, however, a very effective one. It is not very highly toxic, although it is very irritating. As a consequence, insects subjected to it tend to close the spiracles and remain alive; furthermore, the gas itself, on contact with water forms sulphurous acid. Not only will this acid corrode metals, but as well it will bleach a great variety of pigments and dyestuffs. On the whole, the employment of sulphur dioxide for most purposes cannot be recommended however, in figure 82 I show a device which is used in Brasil for the fumigation of the nests of leaf-cutting ants, and under these special circumstances, sulphur dioxide appears to be a very satisfactory poison. The same procedure might be used, of course, against large nests of other sorts of ants.

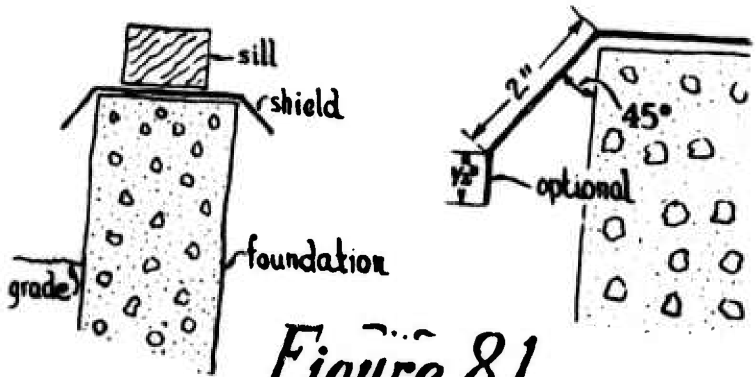

Figure 81

Figure 81: Bread-pan termite shield.

Figure 82: In Pará leaf cutting ants are killed by pumping sulphur fumes into the nest. The can at the left contains a charcoal fire upon which sulphur has been placed. This can is placed over the entrances and the fumes are blown into the nest by the pump at the right.

(f) Formaldehyde

This also is a well known, but quite unsatisfactory fumigant. It is somewhat poisonous, but as in the case of sulphur dioxid its irritating properties render it not very useful against insects. Perhaps its best property is the specific gravity of the gas, which is about the same as that of air.

(g) Other fumigants

(1) Chlorpicrin

I have already remarked on the use of this substance as a warning gas. It can be used by itself as a fumigant, but only of course, in buildings which can be completely cleared of occupants In even rather small dosages the gas causes vomiting. Chlorpicrin is not particularly volatile and is usually applied as a spray or mixed with carbon tetrachloride. It is a difficult material to dissipate, clinging not only to food, but to almost all other articles. The usual dosage is 2 pounds to 1000 cubic feet.

(2) Carbon disulphide

This fumigant is of course very well known. It can be used only in buildings that can be evacuated. It is not expeciall toxic, requiring 10 pounds per 1000 cubic feet. Its worst disadvantage is its extreme inflammability. The limits are one and fifty per cent by volume and its flash point is extraordinarily low, a few instances being recorded of explosions being touched off at around 100°F. From this point of view it is the most dangerous of all fumigants.

(3) Methyl formate

This substance is used as a mixture of 1½ parts with 8½ parts of carbon dioxide. It has been found reasonably satisfactory. The inflammability limits are six and twenty volumes per cent.

(4) Ethylene dichloride

Although this material has been used to some extent in fumigation, it is not extremely satisfactory since it requires the high dosage of 14 pounds per 1000 cubic feet. It is absorbed by oily materials. It is usually used as a mixture of 3 parts with 1 part carbon tetrachloride. The inflammability limits of the pure substance are six and sixteen volumes per cent.

(5) Carbon tetrachloride

This material has been somewhat used as a fumigant; its volatility is not very high as compared with the ordinary gaseous fumigants and it requires rather a high dosage. Like some of the substances just mentioned, it is absorbed by oily materials. It is much more useful as a diluent for ethylene dichloride and propylene dichloride. It can, however, be used by itself in tight containers, which are left closed most of the time. Carbon tetrachloride is not inflammable but must not be used in the presence of an open flame since the vapors, passed through a flame, produce an appreciable quantity of hydrochloric acid and phosgene, from which serious poisoning can result.

The following three substances are not applied as gases but may be considered fumigants:

(h) Naphthalene

This material is familiar to everyone as mothballs. It is very slow acting, but can be used quite effectively in tight spaces which will remain closed for a long time. The amount required for saturation is .04 pounds per 1000 cubic feet. Naphthalene cannot be used for disinfestation of food, since it is absorbed by such materials and causes a tainted taste.

(i) Paradichlorobenzene

In the fumigation of storage spaces used for textile especially wood, this material has proved to be quite satisfactory. It cannot, however, be used very effectively for closets that are to be opened very frequently since it is a slow-acting poison, which must be present at very near saturation. Saturation requires 1/2 pound per 1000 cubic feet. It cannot be used with foods since it imparts a serious taste, and in the case of grain treated with it, this same taste affects the flesh of animals who feed on it, and even the eggs of chickens.

(j) Orthodichlorobenzene

Aside from the fact that this is a liquid, at ordinary temperatures its properties are very similar to those of paradichlorobenzene. It has also been used for spraying wood infested with wood-boring beetles or carpenter ants when it was desired to eliminate the infestation without replacing the wood. The vapor of this substance should not be inhaled. It may cause collapse with symptoms which are somewhat like those of shock.

4a4. Contact solids

On a technical basis this category should be restricted to those solid substances which are in some way able to penetrate the cuticle of insects. In practice, a sharp line between contact poisons and stomach poisons cannot be drawn. The reason for this is that most insects, having come in contact with some foreign substance, proceed to groom themselves and thereby to swallow more or less of the substance. There is no very large number of poisons which have been ascertained to be contact poisons.

a. Borax

This substance has been used in the control of ants for a great many years. The usual procedure is to place a small windrow of the powder along the edge of a door sill or some other point where the ants will have to cross it to enter the room. It has not been proven that borax will penetrate the insect's cuticle; nonetheless, it is usually used as though it were a contact poison. It does not appear to have been used much against roaches. In the first place, it lacks adhesive qualities, and in the second place, it is not certain that it is very toxic to roaches. It is used mixed with sodium fluoride (1NaF: 10 borax).

b. Sodium fluoride

This is the most useful of the contact insecticides and one whose adherence to this category has been definitely proven. It is usually applied much as borax is, but it is fairly adhesive to vertical surfaces and consequently can be blown against them. It is especially useful against roaches.

Quite recently, Mr. Harold E. Jennings, 216 West Jackson Boulevard, Chicago, has devided a sodium fluoride crayon, consisting of powder compressed to the general dimensions of a piece of blackboard chalk, which has been shown to be a satisfactory method of producing on vertical surfaces a sodium fluoride barrier. Patents on this device are pending. The reports that I have seen in literature look very promising, and it is certainly much quicker and easier to apply than powder blown from a dust gun. It should be noted, however, that sodium fluoride is, at the present time, a critical material.

c. Rotenone

I have already mentioned rotenone in connection with sprays. It remains only to point out that it is a contact insecticide and that it can be used as a powder, strongly diluted with some inert material, probably preferably pyrophyllite.

d. Pyrethrum

Although pyrethrum is most usually applied as a spray, it has had, at least in the past, a considerable employment as an essential ingredient of insect powders, where it probably plays a multipl role. The familiar powder of this type is "Black Flag" roach powder. Pyrethrum also is fairly scarce.

e. Paris green

This substance is not, properly speaking, a contact insecticide, but it has been considerably used as though it were. Actually this employment depends on the grooming habits of the insects.

As an example, we may cite the recommendation in the case of <u>Camponotus irritans</u>, to dust some of the ants every day with Paris green. Also, in the Philippines, Uichanco has shown that termites of certain sorts, especially the milk termite, may be controlled by breaking open a small part of the workings and blowing in a small amount of Paris green with a dust gun. The termites pick up bits of the material and take it into the stomach by grooming.

4a5. Mothproofing, etc.

The term mothproofing signifies the application to clothing or fur of some substance, which prevents at least most of the attack from moths. It is evident that two sorts of effect may be present.

a. contact repulsion
b. actual poisoning upon ingestion of a small amount of the protected material.

It does not seem to be certain that the commercial mothproofing agents have been very completely tested to determine which of these two properties is involved in each case.

In this same section, we can also take up the problem of beetle proofing against carpet beetles. It must be emphasized at the outset that all the experimental work indicates very strongly that substances good against moths are likely not to be good against beetles, and vice versa. Mothproofing agents fall into several categories.

a. substances which form a poisonous, adherent coating on the fabric.
b. substances which penetrate into the fabric after the fashion of wool dyes.
c. finishes which are inedible, such as at least one synthetic resin.

The first class of substances has the disadvantage that it is fairly easily removed by washing, and apparently also by wear and dry cleaning. The second and third groups are fairly fast in washing and at least moderately fast to dry cleaning.

There seems to be no good purpose to be served by even listing the rather vast number of patented mothproofing agents. For the majority of them there are few, if any, actual service records and the patent literature itself does not tell us sufficiently accurately the composition of the materials, as actually employed. Instead I shall confine myself to saying something about a few mothproofing agents which are actually recommended on the basis of tests and to making a few suggestions with reference to one or two possibilities.

a. Sodium aluminum silicofluoride. This is known commercially as "Larvex". It is not fast to washing with water, although one washing does not remove all of the addendum. For those articles which are not to stand washing or dry cleaning, this treatment is highly recommended.

b. There are several dye-type mothproofing agents. The most familiar trade name in this group is "Eulan". This, of course, does not represent a chemical family. The manufacturers of this group in this country are the General Dyestuff Corporation in New York. Their technical director, Mr. J. R. Bonnar, tells me that the following have been manufactured by them:

(1) Eulan CN; it has the following composition: Sodium 2.2' - dihydroxy - 3.3', 5.5', 6- pentachlorotriphenylmethane - 2" - sulphonate. This is an acid dyestuff and is recommended by the Department of Agriculture.

(2) Eulan BL, which is a dichlorobenzenesulphonamide. With this diethylbutylglycolphosphate is used as a solvent.

(3) Eulan NK, which is a quaternary phosphonium salt.

Of these the first two appear to be most promising, especially if an attempt were to be made to insect proof materials other than wool. Unfortunately, Eulan BL is not being manufactured for the duration. Eulan CN could only be utilized with cellulose fabrics by animalizing the fibres, which is done by treating the cellulose with an isocyanate.

Another Eulan (LW) applied at 3 per cent by weight is sai to resist washing well. None of these materials are completely fast to washing or dry cleaning.

I also find reliably recommended a material called "Demotex", which is produced by Demotex, Inc., 683 Fifth Avenue, New York. The composition of this material is not known to me.

We have been speaking so far of mothproofing agents in the proper sense. There is relatively less known about beetle proofing, except that the silicofluorides apparently work well. Dr. Back considers pentachlordioxytriphenylmethanesulphonic acid, applied in the dye bath at 2 per cent by weight, to be good against carpet beetles.

In the past some little use has been made of cinchona alkaloids. One material of this sort goes under the trade name of "Konate".

c. There are a variety of substances which have been used primarily as moldproofing agents applied to cellulose fabrics. I know of no tests of these materials directly against carpet beetles or clothes moths, and applied to cellulose, it might be difficult to persuade either insect to touch them at all. I have, however, myself made some tests of a number of these materials against the eastern subterranean termite. A full report of my tests has been already submitted to Colonel Doriot. It suffices at this point to notice only the best of the treatments that were submitted.

(1) 1 3/4% orthophenylphenol
(2) copper naphthenate
(3) "Puratize" process (a phenylmercuric lactate)
(4) 1% copper fluoride

These four processes are ranked approximately in order of diminishing protection. It should be noted that in the case of the first one, a lesser dosage does not protect.

The following four copper compounds related to Paris green might have some significance in insect proofing:

(1) copper stearoarsenite
(2) copper crotonoarsenite
(3) copper lauroarsenite
(4) peanut oil green

4a6. Repellents

In theory, at least, repellents fall into two classes:

a. those substances which give off an odor appreciable to insects and repellent to them. Such substances, as a consequence, may act at a distance. This is the ordinary meaning of the term repellent.

b. those substances which repel the insect only after actual contact is made. These may hence be called contact repellents. Relatively little is known about them.

In addition a considerable number of substances regarded as repellents in the literature seem not to come under either of these heads, but rather to be substances which repel only after an attempt has been made to feed on them, and presumably, at least a minute amount of the material ingested. The literature on repellents is in a rather bad condition from our point of view. In the first place, most of the work has been done on attrahents and repellents, with the emphasis primarily on the former class of substances, largely because they are very much more numerous and in some ways the reactions of the insects much more readily measured.

Further, the interest in repellents has centered largely around the biting flies: mosquitoes, black flies, horse flies, and the like.

Mr. W. M. Hoskins has recently presented a good summary of the best repellents for this general group of insects. Against mosquitoes he finds that the active ingredients in "Sta-way" lotion are very satisfactory. These are carbitol and butylcarbitol acetate. He quotes from Mackay another good repellent for biting insects as follows:

Conc. extract of pyrethrum in light oil. .	2 parts
Oil of thyme	1 part
Castor oil	4 parts

Two other repellent substances are phenoxychloroethyl ether and butylmesityl-oxide oxalate.

In India the powdered bark of Mundulea suberosa is used as a repellent with foodstuffs. It is spread on as a rather thick layer (1 to 2 inches) across the top of the material which is stored in an impervious container, such as a jar. I find also some references to the use of tetramethylthiuramdisulphide.

4b. Ground treatments.

The primary purpose of a ground treatment is to keep pests from taking up their residence beneath or immediately adjacent to a building or to eliminate them if they are already present. The first procedure is necessarily, then, to remove possible sheltering objects, especially vegetation. This does not mean that a denuded space of any great extent must be left around the periphery of the building. In the case of a building set on wooden posts, even a foot or two is not unlikely to be adequate in most cases. If a building, on the other hand, has an impervious concrete foundation, it is usually not necessary to clear any space around the building. Further, this applies on the whole only to small vegetation, grass and herbage. Obviously, stumps and buried wood should be removed from the ground as far as possible, but trees not in contact with the building may be left. In the tropics it is important to make sure that the branches of such trees do not at any point actually touch the building.

There are a number of chemicals which have been utilized for ground treatments. Their function is, of course, to render the soil uninhabitable. Some of them in any event protect against rodents as well as against insects.

1. Crankcase drainings.

Any sort of lubricating oil, such as would come out of the crankcase of the motor is remarkably effective. It is of no consequence how dirty it may be, nor whether it is somewhat diluted with fuel. It may be sprayed or distributed generally over the ground beneath a building and immediately around foundation piers, or if the clearance between the ground and the building is sufficiently great, it may be restricted to the area immediately around the piers. The question of clearance will be taken up later. This treatment is at least somewhat effective against rodents and is one of the best cheap treatments against ants and termites. It is not, of course, extremely permanent, but is easily renewed.

2. Lime

Lime, either slack or quick, may be spread on the soil; the amount required is a layer about one inch in thickness. The purity is of no great consequence. It would seem as though any native lime would be good enough. Obviously, in any event it will air-slake. Like the preceding treatment, this will require renewal from time to time. It is somewhat effective against rodents.

3. Other treatments

There has been over a number of years a good deal of interest in soil treatments against termites. The principle of these treatments is to form around and under a building a poisoned layer of soil, through which termites cannot penetrate. For obvious reasons the amount of material added has been kept at a minimum, and this has, of course, necessitated the use of fairly toxic substances. In addition these treatments have been applied after the building has been erected, for the most part, and it has been, therefore, necessary to use a certain amount of water-soluble substances which could be carried quickly down into the soil and to some extent at least, reprecipitated. The majority of these treatments are proprietary; one at least, has been quite satisfactory from the standpoint of service records. It is known under the trade name of "Antimite". In all fairness it should be pointed out that the good record of this material is in considerable part due to the care in its application by the licensees and to repeated inspections and, if necessary, retreatments of the buildings. This, of course, brings up a fundamental point in all such treatments, namely that the treatment is in fact only as good as its application and maintenance. It must, therefore, be a complete treatment, leaving no possible passageways through which organisms might invade the building.

According to the information that I have, the treatment which is mentioned utilizes primarily fluorides and silicofluorides. A somewhat similar treatment, for which I know no trade name, utilizes essentially sodium arsenite and calcium arsenite with or without the corresponding arsenates, arsenious oxide, and soda-lime. These materials are applied with considerable water to carry them down into the soil to some extent, but do not move horizontally to any appreciable distance.

In applying the foregoing treatments to existing buildings it is necessary to drill small holes at intervals of 2½ to 3 feet through the concrete slab of the cellar and to force the treating material, as a suspension or solution in a considerable volume of water, through these holes and into the ground beneath.

Another substance which has been used a little against insects is borax. The only recommendation as to dosage is that between 4 and 8 pounds per 100 square feet should be used. This may be applied in the form of a 5 to 10 per cent solution. Borax is especially effective against fungi and in the tropics this may be a matter of some consequence.

Recently dilute solutions (1 to 8000 or 1 to 10,000) of dipheylamine have been used experimentally. It was found that they were effective against subterranean termites, a treatment lasting five to seven months. The substance is not easily leached from the soil.

No ground treatment is actually permanent and it must be expected that if used, replacement, wholly or partly, will be necessary within a period of time that depends on the nature of the soil and upon the climate. Pervious soil and high rainfall both lead to early removal of the substances applied.

4c. Wood treatments.

So far as I am personally concerned, there are no wood treatments of any real value against termites, that can be applied to the wood after it is in place. Under some conditions wood treatments against beetle attack can be applied to wood in place. The wood treatment problem is a double one. Since we have on the one hand insects like termites carpenter ants and some beetles, in which adult insects make more or less extensive excavations in wood, and on the other hand, attack as by powder-post beetles in which appropriate conditions for egg laying must be present at the surface of the wood and attack is initiated almost exclusively by newly hatched larvae, it is evident that preventative measures against the second kind of attack will not avail against the first kind.

As a practical matter the investigation of wood treatments has concerned itself for the most part with the prevention rather than the elimination of the first type of attack. Wood treatments have been in use for more than a hundred years, and it is a remarkable fact that almost the earliest commercial wood treatment, impregnation with creosote remains to this day the most durable and satisfactory of all the numerous proposed treatments. It must be strongly emphasized that good creosoting of lumber is a specialized undertaking; that the protection does not reside in the mere presence of a sticky black, ill-smelling coat on the surface of the wood, but requires the penetration into the wood for an appreciable distance of a good grade of creosote. This can be obtained by more than one method, but all of them involve the use of heat and pressure, with or without prior vacuum treatment.

Even under the best conditions penetration of heart wood is difficult, although sufficient penetration can be obtained to be protective. The American Wood Preservers Association has specifications for the various types of creosote treatments. If a piece of wood is properly treated with creosote, and this means among other things that no alteration of the dimensions of the piece shall be made after the treatment, then we may say that on the average such a piece of wood will not fail due to insect attack within the expected service life of the wood as a structure. If it is necessary to dimension pieces after they have been creosoted the operation should be restricted, as far as possible to the ends of the timber, since there is some penetration without pressure along the grain, although there is practically no penetration across the grain. After the piece has been dimensioned it should be given two or more brush coats of a good quality of hot creosote.

Of the other materials which have been used, tetrachlorophenol and pentachlorphenol seem to be the most promising. Their chief advantage is that they may be used on trim which must be varnished or painted. They were devised primarily as procedures for rot proofing rather than insect proofing.

With regard to the second sort of attack, it usually suffices to cover the wood completely by varnish or oil such as linseed oil, the object here being merely to prevent egg laying.

More temporary sorts of protection, using borax solution and a variety of other solutions, have been utilized successfully in the protection of stored logs and lumber against both certain fungi and insects.

The procedures which have been utilized for the injection of toxic materials into wood in place cannot be recommended, the primary difficulty being the very small amount of transverse penetration of any of the materials. By the same token, the mere painting of wood with creosote in a solvent is by no means a protection against termites.

With regard to the storage of logs and sawn timber prior to use, one finds a variety of recommendations. The reason for this variety is primarily that there is no method of storage of untreated timber which will fully protect it against insects. This is especially true of newly felled trees; however, taking everything together it appears that the least damage is done if the branches are trimmed and the logs barked as soon as possible. It should then be stored off the ground, preferably in the sun. It is perfectly true that there are some insects which prefer barked logs for egg laying and also some which prefer logs in the sun, but as just remarked, the recommended method seems to be the one which will result in the least damage.

4d. Structural methods.

Although we have become accustomed to thinking of protection against termites as the main reason for particular methods of constructio in a building, it is important to realize that the protection of building and their contents against rats and against numerous other insects can be improved by proper attention to construction and design. This holds also of other structures, such as supply dumps. I will try to discuss the structural points somewhat in the order in which a building is erected, that is starting with the foundation and ending with the interio trim.

4d1. Foundations.

Where a cellar is necessary in a building or where it is necessary to utilize continuous foundation as opposed to piers, there seems to be no better material than poured, reinforced concrete. It is important that there should be complete bonding between successive pours. Attention must also be given to the design of openings in the foundation.

In the first place, any space which is to be left under a building must be provided not only with ventilation at at least the rate specified in the ordinary building codes, but must be provided with accessway for inspection. If the space is not to be used it should be cleanly excavated to a distance of three feet below the floor stringers and all stumps and wood scrap removed. In the case of cellars intended for use, the following points should be particularly noticed:

The slab should be poured in such a way that it shall be continuous from wall to wall, that is to say, no nailing blocks or wooden partition footings. Posts either for support of the floor above or for stairways must be emplaced on the slab, not in it. Partition bases of all kinds must also be placed on and not in the slab. Baulks for bulkheads must be cut off above the grade of the top of the slab before the slab is poured. The bottoms of window openings should be at least six inches above grade unless an embrasure is provided, in which case a clearance of six inches above the bottom of the embrasure is satisfactory Outside, the foundation should show a clearance of six inches or more between the grade and the wood nearest the ground. This may be the sill or the outermost sheathing (shingles or clapboards).

Fill porches should be avoided as far as possible. If they cannot be avoided a special effort should be made to prevent contact between the porch and the wood of the building. This can be done by leaving a chase at the back of the porch which goes down below the bottom of the adjacent wood. It is much better to use porches on piers, in which case the piers and the lowermost step should be concrete at least six inches above grade.

The same sort of precautions must be taken in the case of garages and loading platforms, but here it is sometimes possible to avoid a six-inch elevation by extending the slab beyond the footings of the wooden posts of the structure, leaving a clear horizontal expanse of six inches or more.

For more than forty years metal shields have been used between the foundation and the wood structure. Properly built and maintained they are excellent, Figure 81 shows a satisfactory design of the bread-pan type. There also exist similar shields which are let into chasers in the foundation. In current American practices these shields are made of fairly heavy rolled copper, but it is not necessary to use copper; the original shields used in Australia were of galvanized iron. The design and installation of adequate shielding calls for care and a visualization of the end to be accomplished.

a. The foremost object of the shield, in my opinion, is to force the termites out to the surface of the foundation at a known level, which is subject to inspection.

b. The shield must be continuous, even around or under bulkheads and cellar windows. It must nowhere be buried in the ground, and it must be nowhere cut away to allow pipe risers to be more easily installed. If it is to be placed between the top of the foundation and the sill then the sill cannot be spiked to the foundation. Successive lengths of shielding should be lock-jointed and not soldered.

The foregoing recommendations as to design and installation of foundations for the protection of buildings against termites are not based so much on a conviction that termites cannot by any possibility overpass such obstacles, as on the provision of definite levels at which the termites must come to the surface where inspection can be made, and the passageways destroyed, or specific ground treatments undertaken. We must on no account regard the presence of copper as a talisman that will prevent the appearance of termites. Any sort of termite protection is only as good as its installation, maintenance, and inspection.

It appears to be practically impossible to so construct a stone, brick or cinder-block foundation as to render it impervious to termites. As a consequence, all such foundations should be shielded. This, of course, does not apply to the use of single large stones as footings for piers, granting adequate clearance above grade. In the case of brick it is sometimes more convenient to insert the shield one or two courses below the top of the foundation. This will, of course, allow for the spiking of the sills to the upper course of the foundation.

When buildings are set simply on piers the recommended clearance of three feet need not be maintained, but in any event a clearance of eighteen inches should be maintained as a protection against rats For building with more or less temporary life, it is possible to avoid the use of shielding and in some cases the use of stone or concrete for piers by soaking the soil around each of the piers thoroughly with old crankcase oil.

The possibility of using rammed earth foundations (terre pisée) should not be overlooked. Apparently in many parts of the tropics suitable soil for this process occurs. One tribe in central Africa protects its houses against termites by setting them on a pedestal of rammed earth about three feet high. This pedestal is in turn surrounded by a moat bridged by a single, narrow earth passage. As far as I can learn, this is the only native conscious protection against termites, used in the world.

4d2. Walls.

If the foundation of a building is properly constructed it is not usually necessary in the north temperate zone to take any special precautions in the design of walls against wood-boring insects, the essential point being that the construction provides as far as possible against the trapping of moisture in the walls. Primarily this seems to entail the provision of proper vents at the base of the wall; these vents should be small metal pipes, sufficiently small to prevent the access of mice, and secondarily to avoid certain types of insulating material. One of these is aluminum coated paper; the second is any sort of insulating pad of animal fibre. It would be well also to avoid the use of most plant fibres. The third, there has been a certain amount of difficulty found in the employment of glass wool.

In other parts of the world there are wood-attacking insects, particularly dry-wood termites, which can commence their operations in any crack or nail hole. It is, therefore, advisable to close, as far as possible, such small entry ways with paint or other finishing material. It is, of course, perfectly satisfactory from a control point of view to utilize creosote in clapboards and shingles provided the insects cannot get past to untreated wood further in. It is also perfectly possible to construct a building, as has been done, entirely of treated timber. In a few parts of the world there appears to be a reasonably adequate supply of termite-resistant timber, and I have already in Section 2 given a list of such timbers. I repeat here the caution already given, that some of these timbers are decidedly not resistant to rot and in some cases not to beetle attack. There is perhaps no perfect timber available. If buildings are to be used for a considerable period of years in the tropics, it would doubtless be best to have all the dimension pieces properly creosoted. This is a protection not alone against insects but against rot.

It is evident that in any event the access of rodents to the spaces within the walls must be prevented. Fortunately, the general tendency of rodents is to utilize or enlarge pre-existing entry ways rather than to construct their own where no passage exists. In the tropics, it is important that such access be denied both at the top and at the bottom of a wall. The problem, of course, is somewhat simpler in those buildings which are not ceiled inside.

4d3. The Roof

What has been said of the character of the outside walls applies with equal force to the roof. It is probable that tightly laid asbestos or other mineral shingles are better for most tropical buildings than any wood covering. For permanent buildings thatch is perhaps the worst covering. It must also be remembered that one of the most convenient means of access to a building for climbing animals is at the junction of wall and roof, and I would recommend that specifications for tropical buildings should take particular account of this point. If a space is necessary for ventilation purposes, it should be closely screened with 20- or 30-mesh screen.

4d4. Interior Trim

Initiation of attack on wood is unlikely to occur from the inside of a building unless the wood is already infested, when additional attack may begin in the trim. The importance of proper design of trim is especially great in the case of buildings used for the storage or handling of food since the most useful preventative measures against food infestation are, in part, the provision of storage places which can be kept scrupulously clean, in which there are a minimum of cracks in which food materials may lodge and be overlooked, and a minimum of cracks and corners in which insects like silverfish, moths and certain beetles may take refuge. In the tropics generally it is recommended that the inside of the building be frequently whitewashed. In more permanent structures the floor covering should be brought up against the baseboard with a rounded cove.

It will be, of course, observed by the reader that this list of recommendations contains a certain minimum which should be applie to every structure and various additional points, whose application depends upon the permanency of the structure in question. It is perfectly conceivable that a tent would be under some conditions perfectly feasible as a storage place or a kitchen; it is ultimately a matter of housekeeping and of an understanding of the limits of the structure and, as far as food insects are concerned, my recommendations are based on the idea that greater care in construction will in the long run render the housekeeping easier.

It is, of course, assumed in this discussion that all windows and doors will be equipped with screens of sufficiently fine mesh and properly installed.

2d5. Supply Dumps.

Whenever it is at all possible the placing of cases or boxes of supplies directly on the ground should be avoided. They should be placed on platforms which have a clearance above ground of twelve to eighteen inches. These platforms can be built of any available wood by driving sharpened stakes of appropriate length and spacing into the ground, and then laying logs across them to form a grid of the proper dimensions. The posts should be protected by the use of crankcase oil as described above. Very limited protection can be obtained by charring the surfaces of dry posts before they are set. More permanent dumps should be built with concrete piers and, if possible, creosoted wood or iron rails. I shall return later to the arrangement of the stored material,

4e. General Procedures

In this section I am including for the most part those procedures which involve neither the application of poisons nor special methods of construction. They will be taken up under two headings, Preventative and Curative.

4e1. Preventative measures.

a. Elimination of Harborages

This point is particularly directed against rats, but may sometimes be significant in connection with moths and beetles. In fact, if we define harborage as any space suitable for the concealment of a pest, then we might take it down to almost the smallest cracks between boards, and harborages of such dimensions are frequently important in connection with roaches and silverfish, to say nothing of bedbugs. It is evident in the first place, that enclosed spaces offer opportunities for rat harborage, whether these spaces arise from faulty construction or the faulty stowage of materials. I have already pointed out the necessity of preventing access to walls. Such access may be had not only through spaces left at the tops and bottoms of walls during construction, but alongside pipes of various kinds where the opening for the pipe is to big and not shielded. Care should be taken that such openings are adequately shielded or plugged. The elimination of small cracks can in most cases be achieved by some sort of surface covering like paint or varnish, and in many cases, whitewash.

b. Cleanliness

It is hardly necessary to mention cleanliness in the ordinary sense to the armed forces, but I am convinced from my own observations in this country, and I believe it will prove to be even more strongly true in the tropics, that the elimination of materials which are attractive to pest insects or on which they may succeed in breeding, transcends any ordinary standard of cleanliness. In fact, it may well be impossible to achieve. Here again the effect of certain washing procedures, such as those using kerosene emulsions or the application of whitewash, tends to render such small particles of food, unavoidably left behind, unattractive to insect pests.

I, therefore, mention only one or two particular points, the first of which is garbage disposal. So far as I have seen the army manuals dealing with camp sanitation, the procedures laid down should be perfectly adequate to prevent the breeding of pests in garbage after its disposal. The point which should be brought up here is that, especially in warm climates, garbage may become extremely attractive to insects within a very few hours and would not necessarily be sufficiently putrid so that its presence would be obnoxious to personnel. For example, it appears that flies of the genus <u>Drosophila</u> may be attracted to garbage due to the growth of yeasts, and that the specific attractive odor may be either an organic acid or an aldehyde. On the whole, substances of these classes are not likely to possess a disagreeable odor. It is, of course, extremely unlikely that any garbage will be allowed to remain undisposed of long enough to provide for the actual breeding of insects, but it is the part of wisdom not to attract insects to any place where food is stored. The solution for this problem seems to be the frequent disposal of garbage and probably with some insects at least, its treatment with more or less repellent materials such as waste oil or chlorinated lime.

I find washing with kerosene emulsions especially recommended for the control of mites and cheese skippers but it would be useful against any insects tending to hide in cracks. One per cent soft soap has been used in washing to kill eggs of the Indian meal moth.

c. Arrangement of Contents

The arrangement and handling of contents of storerooms and supply dumps can be of great importance. In the first place, it is strongly recommended that fixed articles of furniture, such as stoves, refrigerators and other such items which cannot be readily moved, be placed away from walls, leaving clear passage around and behind them between one and two feet wide. This serves two purposes: first, it prevents rodents from invading such containers from the rear and makes possible also the more effective trapping of rodents; second, it permits the complete cleaning or whitewashing of walls. It is also important in arranging packing cases that no closed space be left in which animals may hide. This is significant in connection with supply dumps. Packing case should be arranged either completely solid so that there are no passageways for animals, or if spaces must be left for classification purposes then those spaces should go completely through the pile so that the space can be inspected. If dumps are to be covered by tarpaulin provision should be made for inspection of the dumps at regular intervals.

It is probably not always possible in kitchens to keep all food in insect-proof, or even rat-proof containers, but as far as feasible this should, of course, be done. Small amounts of foodstuffs can be kept in glass jars with either glass or metal tops. They certainly should not, especially if cereals or dried fruits, be left in opened cardboard containers.

Dried or smoked meat can be kept relatively free of insect attack by careful wrapping in cotton cloth.

d. Light and Ventilation

In discussions of the prevention of insect attack on store fruits and similar products, I find that the provision of adequate light and ventilation is especially stressed. The advantage of light and ventilation is, first, that many of the food insects are light-shy and tend less readily to invade illuminated storerooms, and second that the ventilation prevents the accumulation of moisture either in the room itself or in the containers.

e. Screening

Particularly in the tropics where we may expect pest insects to survive outdoors as well as indoors, screening is an important factor in preventing their access to buildings.

f. Whitewashing

Since I have already spoken of whitewashing in connection with the finishing of walls, I include it here merely to make the list complete.

4c2. Curative measures.

There are a few general procedures which may be undertaken to salvage materials which are not too seriously damaged by infestation and which do not involve the use of poisons.

a. Heat

Practically all insects can be killed in a reasonably short time by exposure to a temperature of 140°F; at lower temperatures the time required is very greatly lengthened. At the temperature just mentioned five minutes is ordinarily sufficient, while at 120°F five hours is required. It must be noted that I am here speaking of the temperature applied to the insect itself. This means that where we are disinfesting a fairly bulky object, adequate time must be allowed for the temperature to rise at the center of the object to the level required. This time depends in part on the nature of the material and in part on the differential of temperature which can be permitted. The usual recommendation is to expose the material for some hours to a temperature of 160 or 170°. If the differential is less than 30° or so, the rate of penetration of the temperature becomes extremely slow.

b. Cooling.

This not as a rule a satisfactory method for the elimination of infestations; however, most insects are inactive below 50°F and at such temperatures the increase of an infestation is prevented. Some pest insects will survive at temperatures well below freezing for an appreciable number of days, and relatively few are killed even in twenty-four hours at the freezing point.

c. Drying

Since the majority of pest insects require a moisture content of their food, which is above 6 or 8 per cent, it is sometimes possible to eliminate infestation by drastic drying. I should judge that on the whole, however, the method would not find wide application in the field.

d. Trimming

In the case of cheese and meat, infestations which are not too severe can be eliminated and the material reconditioned by trimming away the infested portions. The analogous procedure of screening insects out of grain or grain products can be applied to a limited extent. In the case of whole grains it is likely to be unsatisfactory because some of the most important grain pests tend to live within the grains, and all that is removed by screening is broken grain and frass.

4f. Special Procedures

1. Traps

A considerable number of insects can be caught in traps if they are properly constructed and baited. The Sanitary Corps field manuals give instructions for the construction of fly traps.

Roaches also may be trapped by using wide-mouthed fruit jar taped on the outside so that the roaches can crawl up. The jar is fitted with a cardboard lid, the center having two crossed slits and the points bent down to form a funnel entrance. Such traps can be baited with banana peel, fermented yeast cakes in sugar or molasses mixture, stale beer, meat, vegetables, etc. It should be noted that bananas or plantain can be obtained practically anywhere throughout the tropics.

Some moths, especially the fig moth, can be trapped by hanging strings covered with a sticky material, either tanglefoot or native birdlime. This species may also be trapped with pans of soap and water at a concentration of 6 parts of soap to 1000 parts of water. A similar method, using dilute formalin, is set out in pans as a fly trap.

Tanglefoot may be made by heating 12 ounces of crude castor oil and mixing into it 27 ounces of powdered rosin until it is all melted. Do not overheat.

2. Special Repellents

A few simple repellents have been noted in the literature for particular insects. These have not been sufficiently used so that I can make any guess as to how generally applicable they may be to related insects.

One group of foraging termites (Hodotermes) can be kept away from paper and similar materials by applying to the material a wash of 1/2 oz. of copper sulphate in 4 gal. of water.

A lime-naphthalene mixture in the ratio of 20:1 has been used against Tapinoma simrothi, one of the house ants of northwest Africa.

3. Books and Papers

In the tropics there has been naturally some interest in methods of protecting books and papers against the attack of termites, silverfish and roaches. For books, two repellent paints have been devised in the Pacific islands.

a, Rosin 1 oz., shellac 2 oz., creosote 1/8 fl. oz. alcohol 1 pt., and methyl salicylate to flavor.
b. Alcohol 1 pt., shellac 1 pt. (or better, Chinese varnish) white phenol crystals 1 oz.

These are brushed on to the back, covers, and edges, and in the Solomon Islands the second formula is said to be effective for two years. For paper protection one may use against silverfish, 1 per cent solution of tricresyl phosphate in a petroleum base as a spray.

4. Pharaoh's ant is especially hard to control by the ordinary methods used against ants, and for a very long time people have used sponges containing sugar syrup. These are put about in convenient places and when well covered with ants the sponges are picked up and dropped in boiling water. They can then be again baited and put out. Some of the poison baits which I have already mentioned are somewhat useful against this ant.

5. Ants may be prevented from crawling up the legs of furniture either by ringing the legs with vaseline or by setting the legs in shallow dishes containing kerosene. Either material must be renewed from time to time.

6. Carpenter Bees

The carpenter bees spend the night in the unfinished burrows and can be killed by injection of any volatile poison. A few drops of gasoline would do. The hole should be promptly plugged, both to keep in the fumes and to prevent its use by other insects. Plastic wood or putty is usually recommended, but in default of those an appropriate-sized pebble driven in would do very nicely.

7. Methods against mammals.

There is a very large amount of information available on methods of combatting certain of the rodents, especially rats and mice. In my opinion the most important measures are those which exclude such animals from buildings and food containers. Obviously if they are to be effective, such methods must be applied to all connecting buildings. I have already mentioned that the brown rat can penetrate up to four inches of concrete slab. If rats are present they may either be trapped or poisoned, and here we should point out a very distinct difference between the domestic rat and the house mouse. Rats are decidedly trap shy. Mice, on the other hand, are readily trapped. Both can be taken by the use of poisoned baits. In the case of mice, baits which incline a little to the sweet side are preferred, peanut butter and grain being the best materials. Several different poisons are in use, depending on the character of the bait. The chief of these are strychnine, white phosphorus, zinc phosphide, and thallium sulphate. These are, of course, dangerous materials to handle, particularly phosphorus and thallium, and should never be entrusted to inexperienced personnel. In the case of rats the same poisons must be used, but a meat base bait is preferable and it is necessary to avoid handling the bait at any time with the bare hands, since rats are extremely averse to materials bearing the odor of man. No one bait base or poison will work continuously against the same local group of rodents. It is necessary to change both at intervals.

I have not mentioned the use of red squill specifically because the supply is small and in large part of uncertain quality. A small amount, which is of definite bioassay, is available.

At the present time it seems unwise to recommend the use of any of the so-called rat viruses. If they contain living organisms they are too dangerous in any place where either the material itself or rats affected by it can come in contact with human food. These viruses depend on the presence of bacteria of the genus Salmonella. So far as I can learn all of the types which have been used against rats are known to be causative organisms of human food poisoning (so-called ptomaine poisoning).

If traps are to be employed they should be baited with materials like those noticed above as bases for poison baits. They should be placed along pathways ordinarily used by the rodents and plenty of them should be set out. To avoid the possibility of traps going without inspection and consequent possible decay of dead rodents in them, I advise that the traps used by any one unit be serially numbered, then when they are picked up for inspection and rebaiting the personnel will have some means of knowing when they have picked up all of the traps which were set out.

Against carnivores in the Arctic the only satisfactory method outside of occupied buildings seems to be the use of elevated food caches. The problem is not especially difficult against bears because they climb rather poorly and are attracted to rather specific odors, especially the polar bear. The wolverine is a very different problem. It apparently will break into caches, regardless of attraction by odors, and is both a fairly good climber and extremely ingenious. The following discussion of a possible cache is adapted from one in Stefansson's "My Life With The Eskimo".

The most nearly wolverine-proof cache that he had seen was constructed by an Indian near Great Bear Lake. It was constructed by finding four trees in suitable position to form upright posts of the corner of the cache and cutting them off ten or twelve feet from the ground. The posts were notched on the inner sides to support horizontal beams, and logs laid across to form a floor, projecting two or three feet beyond each end. The logs forming the sides of the bed were notched to receive end pieces of short logs. When filled up the cache was roofed with heavy, green logs, three or four feet deep, too heavy for a wolverine to move, and too deep to gnaw through if he succeeded in getting on top. The uprights are stripped of bark and made as smooth as possible. If a wolverine succeeds in climbing the upright posts, the projecting ends of the floor timbers prevent him from getting around to the top of the cache. Having no foothold he cannot work at the bottom or sides of the cache, and consequently, one thickness of timber suffices for these. The Indians and Eskimo and most white men residing in the North generally come to look upon a certain amount of the depredations by wolverines as unpreventable, fated and like the annoyance of mosquitoes are taken as a matter of course. The ordinary method of capture is by heavy steel traps but log or stone dead-falls are commonly used.

Summary

It may be convenient here to give a very brief review of some of the methods noticed above by groups of animals.

1. Insects
   a. Silverfish
      Poisoned bait
      Fumigation
   b. Crickets
      Poisoned bait
   c. Roaches
      Cleanliness
      Poisoned bait
      Insect powder
      Spray
      Fumigation
      Trapping

d. Earwigs
   Poisoned bait

e. Termites
   Structural methods
   Ground treatments
   Wood treatment or poisoning of edible materials
   Resistant wood
   Repellent wash in one special case

f. Embiids
   Dryness

g. Booklice
   Dryness
   Spray
   Fumigation

h. Mayflies
   Hard or treated wood

i. Caddis-worms
   Hard or treated wood

j. Moths
   Cleanliness
   Selection of food stock
   Light
   Ventilation
   Fumigation
   Mothproofing
   Trapping

k. Beetles (One or more of the following, depending on the type of material attacked)
   Cleanliness
   Dryness
   Spray
   Fumigation
   Structural methods
   Treated wood
   Beetle proofing

l. Ants and Bees
   Cleanliness
   Poisoned baits
   Insect powders
   Sponge trapping
   Ground treatments
   Structural methods

m. Flies
   Cleanliness
   Sprays
   Screening
   Garbage disposal
   Trapping

2. Mites
   Dryness
   Screening against flies

3. Teredos
   Treated wood
   Resistant wood

4. Mammals
   a. Rodents
      Cleanliness
      Structural methods
      Poisoning
      Trapping
      Ground treatments
      Fumigation
   b. Carnivores
      Caches

5. GEOGRAPHICAL SUMMARY

At this point the reader is referred to sections 1c and 1f5 for additional information.

It is necessary in the beginning to draw a sharp distinction between the number of species or insects in an area and the number of individual insects in the same area. For the most part we have some information about the former and none at all about the latter number. It seems generally fair to assume, however, that the largest numbers of individual insects occur in moderately forested tropical areas. The dry tropics and the very densest forests have lesser numbers. The same sort of distinction holds in temperate regions where fairly open and mixed forests can be expected to have the greatest population; and deserts and very dense and especially coniferous forests lower populations.

North and south of the respective temperate zones the number of species decreases with very great rapidity and the number of individuals with less rapidity.

Our knowledge, even of numbers of species, is very greatly influenced by the relative intensity of zoological exploration. This results in many apparently anomalous situations. For example, we know large numbers of insects from British Guiana; fewer from Surinam and still fewer from French Guiana which has been scarcely visited by zoologists for more than half a century. Consequently, it has been necessary for me to make what seem to be reasonable assumptions based on the nearest well explored areas.

It is evident also that the insect fauna of a region will be influenced by the abundance and diversity of natural foods. Agricultural Antomology is filled with examples of this. The restriction of an area to one or a few crops with the consequent destruction of natural vegetation leads on the whole to a fauna composed of many individuals belonging to few species. Hence, it may be reasonably expected that intensely cultivated tropical areas will have abnormal insect faunas and it is important to realize here that the insects which may be favored by such an agricultural practice may be the very insects which are important in their attack on imported materials particularly foodstuffs. See in this connection the remarks on copra in section 2a11.

Biologists divide the world into a number of natural geographic regions. For our purposes the interest of such regions is that each possesses a reasonably unified fauna which shows fairly definite relationship to the faunas of certain adjacent regions. I will speak briefly of each of these regions.

Nearctic region. This region comprises all of North America except extreme sourthern Florida and extends through the northern highlands of Mexico. It is evident that the number of species per unit area cannot be in any way uniform in an area which extends from south of 22° north to about 82° north and we take account of this variation by dividing the region into subregions.

We may take out first a Canadian or Arctic region whose southern limit is a little south of the tree line. This includes all of Alaska. The animals of this region are few in species and, generally speaking, arctic in character and show very close relationship on the whole to northern Europe and Asia.

South of this Arctic subregion there are three subregions. An Eastern one characterized by moderately high rainfall, extending from the Atlantic coast west approximately to the 100th meridian.

The next region to the West comprises the high plains and the Rocky Mountains. It is, on the whole, a region of low rainfall.

Finally, there is a Pacific Coast region whose eastern boundary is approximately the crest of the Sierra Nevada. It is of no great consequence whether a subregion is entirely forested or consists of both plains and forests. The insects will be restricted to their appropriate natural habitat within the subregion but on the whole a given species will not occur in other subregions.

South of the Nearctic region is the Neotropical region. This includes the West Indies, the warmer and lower parts of Central America, and all of South America. Although the question is entirely academic it is probable that the Hawaiian Islands belong in this region. It also may be divided into subregions.

The first of these is the West Indian subregion which includes extreme southern Florida, but does not include the islands of Trinidad and Tobago. It has developed to some extent a peculiar fauna of its own and for various reasons the total number of species is reduced.

West of this is a Central American subregion extending to southern Panama which shows quite evident relationship to the Nearctic and to the next subregion south, the Brasilian.

This third subregion extends south to southern Ecuador on the Pacific Coast and nearly to the southern boundary of Brasil on the Atlantic Coast. It is typically a hot, forested area and the most obviously tropical portion of the New World.

South of it is the Patagonian subregion which is largely grass land and has a reduced fauna. The climate is temperate but the animals are chiefly of Neotropical origin.

Crossing the North Atlantic we come to the largest of all the zoogeographical regions, the Palaearctic. This extends from Iceland, the Azores and the Cape Verde Islands, east to the Bering Strait.

It, therefore, extends more than half way around the world. Its southern boundary is the southern boundary of the African desert, the entrance to the Persian Gulf, the Himalayas and the valley of the Yangtze. It may be divided into four subregions, the first being the European, bounded on the south by the Pyrenees, the Alps and the Caucasus and on the east by the Caspian Sea and the Urals. Climatically this area is much like the California subregion of the Nearctic.

South of the European is the Mediterranean subregion which extends east to the valley of the Indus. It is a hot and largely dry region similar in some respects to the West Indies subregion, but it is not at all tropical.

The third subregion corresponds to the Canadian Arctic and is cut off from the fourth by a boundary line which begins high up in the Yangtze valley and extends northeastward and then eastward following approximately the north boundary of Manchuria, but including the whole of the island of Saghalin and the Kuriles.

The fourth subregion, the Eastern Asiatic, comprises what is left, being Chinese Mongolia, Korea, northeastern China, the main islands of Japan south to, but not including, the RiuKiu. The whole Palaearctic region is, as I have said, clearly related to the Nearctic and clearly distinct from the tropical regions to the south of it. Hence, the Nearctic and Palaearctic together are referred to as the Holarctic. South of the Palaearctic we find first the Ethiopian region divided into four parts. First, a Sudanese savannah area of largely unforested hot country. Second, a West African subregion of rain forest extending from about Dakar east to the French and Belgian Congos, but not including Angola which belongs to the first region. South of the Sudanese subregion is the Cape subregion bounded on the north by the Kalahari Desert and Tanganyika. The fourth subregion comprises Madagascar and the islands of the western Indian Ocean. This last subregion is in many respects very peculiar.

Turning now to Asia we find south of the Palaearctic the Oriental region which is very difficult to divide into usable subregions. However, the unforested portions of India are somewhat distinct as also south China. The fauna of the remaining grades from the Malayan area toward the Philippines and toward the Dutch East Indies, but since all this south portion consists of islands it tends to show the peculiarities to which all island regions are more or less subject. The southeastern boundary of the Oriental region, in any event, goes between the Islands of Bali and Lombok, but whether it passes just west or just east of the Celebes is to some extent a matter of argument.

The last great region is the Australian. It takes in not only Australian and New Guinea but all the islands of the Pacific from the Pelews, east at least to the Tuamotus. It can be divided reasonably satisfactorily into a definitely tropical area, a New Guinea subregion, which takes in the eastern Dutch East Indies, New Guinea, Bismarck

Archipelago and north Queensland. This is on the whole a region of large or moderately large islands. South of this is the Australian subregion proper which resembles particularly the Patagonian subregion and the New Zealand subregion and to a lesser extent the Cape subregion.

Still further southeast is the New Zealand subregion which is fully temperate. It extends as far north as Lord Howe and Norfolk Islands and includes the sub-Antarctic islands lying south of 40° south. North of this and east of the Australian and New Guinea subregions it is convenient to set apart a Fijian subregion, including the Solomons, New Hebrides, Fiji, New Caledonia, and Samoa. It is characterized by moderately large islands with a much richer fauna, therefore, than the last subregion, the Central Pacific, which is almost entirely a region of small and low islands, Tahiti is a notable exception, and in which we may include the Japanese Mandated Islands and everything east to the eastern boundary of the region.

It will be noted that certain areas have been left out of consideration mostly because they are not of any real importance. These include, for example, the islands of the southeast Pacific, the islands of the south Indian Ocean, Antarctica and Arabia. Necessarily all these regions for one reason or another have limited faunas and are for the most part rather poorly explored.

It is evident that the boundaries of all these regions represent mostly not great natural barriers such as the oceans or continuous, snow-capped mountains or uninterrupted deserts. They represent rather the line along which the dominating character of the animals changes from that of one region to that of an adjacent region. In addition, any one of these regions could be divided again and again into smaller and smaller units which has, in fact, been done for North America and Europe, but at no point do we come to absolute boundaries applicable to a large number of species. The usefulness of these regions is that an organism found in one part of one region may be reasonably expected in similar habitats throughout the region or subregion and we are, therefore, able to undertake some small amount of prophecy.

The size as well as the degree of isolation of land masses has its effect on the number of species or insects to be expected naturally. In the case of oceanic islands this is probably because the smaller islands have less diversity of natural conditions and, hence, fewer niches into which insects may fit. Such comments, of course, do not apply at all to thoroughly domesticated insects, such as many of the ants. In such instances the mere habitation of a house may provide the requisite environment.

The type of civilization occurring in a particular region has a certain amount of effect on the occurrence of pest insects. Evidently the storage under more or less unsanitary conditions of quantities of a single material predisposes to its infestation by the insects peculiar to that material. Whereas a less developed region in which food substances in particular are stored, either in small quantities or not at all may be expected to be freer of massive infestations of insects.

Before passing to specific details it may be well to point out the basis on which I have ventured to make some predictions of the extent to which special infestations may be expected in certain areas. In those groups in which it was possible I have considered the distribution of all of the species at all closely related to the known pests, and it is very striking that pest species do tend to be related to one another and the less closely related families and genera in an order show fewer pest species. This tendency of pest species to be more or less closely related is illustrated by the beetle family, Tenebrionidae. Gebien divides this family into eighty-five groups (subfamilies), of which the file contains representatives of twelve, comprising twenty-five genera. Nine genera or more than one third of the total fall in the one subfamily, Ulominae. No other subfamily is represented by more than three genera.

It remains also to make clear what I mean by certain statements of range used in the text, and also in the appendix:

(a) Cosmopolitan species - These species are not literally found everywhere in the world, but they have become so widely distributed that they may be reasonably expected wherever adequate food, shelter, and temperature do occur. Naturally, therefore, very few of them occur in the arctic, largely from lack of adequate heat. They may be considered as, for the most part, domesticated insects.

(b) Widespread species - This designation is difficult to define consistently, but I have used it in reference to those species which are found in an assortment of geographical regions such that they could not have naturally spread to the whole of the recorded range. It is probably fair to conclude that most of these species are on their way to becoming cosmopolitan.

(c) Tropicopolitan- These species are found generally throughout the tropics but not in temperate regions. They may, therefore, be thought of as cosmopolitan species whose extension of range is terminated by their requirement of relatively high temperatures throughout the year.

Natural Regions or Military Areas Considered Separately

In this section I shall take up twenty-nine areas in which it is reasonable to suppose that considerable numbers of army personnel will eventually be operating. The division of the separate regions is based on large part on zoological convenience, but I have omitted, on the whole, those parts of the world in which it was fairly apparent that large scale military operations would not be undertaken.

North America

1. The Northeast

This comprises the region from Chesapeake Bay northward and extending west to the Great Plains. It is on the whole a region in which the numbers of native insects are not extensive. In fact its fauna consists for the most part of immigrants since the last glaciation. Those that came without the aid of man were chiefly from southeastern America, but most of the important pests arrived from diverse regions through commerce. As a result, the larger part of the pest insects are cosmopolitan or widespread. The chief native species are a few wood-destroying forms like the black carpenter ant and the eastern subterranean termite. As a whole, the region offers rather few problems. Having been long settled and the scene of great commercial activity, it is well provided with professional pest control operators.

2. The Southeast

This area lies south of the preceding and like it, extends west to the Great Plains. It has a larger fauna, derived for the most part from Central America and the West Indies and as in the northeast most of the pests of stored materials are cosmopolitan species, with a very few tropicopolitan ones occurring in the extreme southern part of the area. This invasion of tropicopolitan species is most noticeable in the case of the ants and a few anobiid beetles. The striking native pests are a few termites and, in the Alleghenies, several wood-boring long-horned beetles. The area as a whole is not well provided with relatives of the well known pests.

3. The West Coast

This area extends from the Rockies west, including, therefore, the Great Basin deserts. Technically it should include Lower California, which is rather poorly known, and extends north to about the Queen Charlotte Islands. The insects, of this region are derived in part from central America and in part from eastern Asia. The former component is the more important. There are the usual cosmopolitan and widespread forms, but as would be expected from the emphasis on fruit growing and drying in much of the western part of the region, it is particularly rich in those insects which infest dried fruits. It is also a region in which there are many native species of tenebrionids, and we may suppose that ultimately many of these will prove to have some small significance. Further, it is the one part of temperate North America in which both dry-wood and damp-wood termites are of marked importance and widespread.

4. Alaska

Very few pest insects have been reported from Alaska, but I do find reference to the rather general occurrence of the widespread blue bottle flies in arctic America. Quite recently Ptinus tectus has been noticed damaging furs, near the coast in latitude 59°. Probably neither of these two species is native. At least one anobiid beetle has been recorded from Alaska and is a native species. It is known to do some damage to wood. Insect damage on the whole, however, must be very small since neither Sir Hubert Wilkins or Dr. Stefansson has considered it at all noticeable. Obviously, storage in unheated buildings would eliminate most infestations. Bears and certain rodents, so far as I can learn, chiefly field mice, do a reasonable amount of damage.

5. Central America

We now jump to a clearly tropical region, from which many insects are known, not only the familiar and widespread species, but a certain number of native and restricted forms. As is true in all tropical regions, our interest turns first to the termites and we find that the various dry-wood termites are especially well represented, but there are only rather moderate numbers of species of subterranean termites, and only a few wood attacking forms in the family Termitidae. The total number of species of termites reported from various Central American countries varies from about thirty-five to fifty - by no means a large number of species. The twenty-eight species actually known to cause damage is the greatest number recorded from any single region except Australia. Most of the food substances are attacked in Central America by rather small numbers of native species. The largest number recorded, for grain, is nine species. There are no special references to meat attacking insects native to the area. This is probably due to lack of observation. There are probably also a considerable number of wood boring beetles yet to be found. Fourteen native species are on record.

6. West Indies

As I have already pointed out, the West Indies have a rather peculiar and reduced fauna, much of which appears to be of Central American rather than South American origin. We must remember here that the islands of Trinidad and Tobago are considered a part of South America not of the West Indies. As in Central America, the most prominent termites are dry-wood forms, and of these the powder-post termite is especially destructive. The subterranean forms are very poorly represented and the genus, Coptotermes, seems to be nearly wanting. The few recorded species are all importations. The total number of species of termites on various islands runs from eight to seventeen. There are almost no insects native to the West Indies which I find recorded as pests, except for a few crickets about which the information is not too definite.

South America

7. Northern Coastal Region

This part of South America is on the whole rather poorly known except for British Guiana and Trinidad. Even the northeastern part of Brasil seems not to have been well explored. Commencing again with the termites, we find that Trinidad has a total of fifty-six or more species and British Guiana of seventy-seven. About one-fifth of these are dry-wood termites and fewer than ten are subterranean termites, but the genus Coptotermes is here included. Native wood-boring beetles are notably numerous in species (twenty-one recorded). Taking South America generally, there are a rather few, about six, native insects recorded from peas, beans, and edible nuts; there are about twenty-two grain insects, mostly beetles, peculiar to South America. It is very probable that there are additional pests of peas and beans and perhaps some meat infesting dermestids still to be found. The region is matched only by Central America in the probable intensity of attack by dry-wood termites.

8. Europe and North Africa

This area, extending northward from the southern boundary of the Sahara, should probably be divided into several smaller parts. I have already pointed out that the whole region of the Mediterranean basin forms a unit. Western Europe north of the Pyrenees and the Alps, and extending along the coast as far as Denmark, forms another area which to a considerable extent resembles the Pacific northwest in climate. The whole of Europe north of the Alps and the Transylvanian mountains forms a third, fairly satisfactory area with more severe winters than the preceding. However, all of these areas are temperate and appear to have derived their fauna for the most part from the eastward, rather than from tropical Africa. The whole region is characterized by the very small number of species of termites, with one dry-wood species being practically confined to the Mediterranean Basin and the other, a subterranean termite, extending a moderate distance northward into France.* There are, in addition a very few other termites recorded from North Africa; in all, twelve in northwest Africa and twenty in northeast Africa, not including Eritrea. On the other hand, I find recorded for Europe generally, not less than twenty-eight species of wood boring beetles, the most of which are restricted to the continent, and some fourteen insects associated with peas, beans and lentils, and about the same number associated with dried fruits. Turning to the grain insects, I find twenty of them with restricted ranges, occurring in North Africa, and about seventy-eight in Europe. This last figure is, in part at least, a tribute to the very extensive work on the pests of stored grains which has been carried out in England and in Russia. It does not, undoubtedly, reflect an extraordinary prevalence of such

*The eastern subterranean termite (Reticulitermes flavipes) has been introduced (!) in a few places, including Hamburg.

insects in Europe as opposed to other regions. On the whole, I should expect the situation to be generally no worse than on our Pacific coast, although it appears worse due to relatively better exploration.

Africa

9. Eritrea

As seems to be true generally of the former Italian colonies, Eritrea is but little known from the entomological point of view, and, incidentally, the same may be said of Ethiopia, French, and British Somaliland; however, the area with which we are concerned is largely coastal desert and would not be expected to have a large insect fauna. It possesses, for example, twenty termites, of which seventeen belong to the Termitidae, the same number as are found in northeastern Africa, with almost the same distribution among the families. Of these species, but two are actually known to damage wood. There is also one wood boring beetle of rather wide distribution recorded from Eritrea. Beyond this there are practically no special reports; however, there is certainly nothing to prevent the establishment of any of the cosmopolitan or widespread insects of stored products, or most of the tropicopolitan species.

10. West Africa

In some respects the region from Dakar to the mouth of the Congo, extending inland across the Belgian Congo, is one of the richest in the world, from the point of view of insect life. For example, there are recorded from the Belgian Congo at least one hundred and eighty-four species of termites, which is nearly twice as many as from any other region of comparable size.* The remarkable fact about West Africa is that there are comparatively few dry-wood termites and very few subterranean termites of the family Rhinotermitodae. The twenty species of termites recorded as causing actual damage in tropical Africa are, for the most part, members of the Termitidae. In addition to these the region possesses about fifteen other insects, mostly beetles, that are known to damage timber. Partly due to special interest in the substances, West Africa possesses a small number of insects which attack cacao and a still smaller number infesting peanuts, which are reported from no other area. Special grain insects are relatively few, about thirteen species; however, a large proportion of the widely distributed food insects are already known from West Africa. It would not be in the least surprising if the region yielded a considerable number of tenebrionid beetles as pests.

Asia

11. Western Asia

Western Asia, like northeastern Africa, is for the most part a decidedly dry region, and in some portions, such as Iran, high enough

*The whole Australian continent possesses 140.

to be cold in the winter time. As a consequence it appears to have a relatively small insect fauna with comparatively few wood boring insects although a good many food infesting species have been reported from the region, especially from Tashkent. These are mostly widespread forms, which have been introduced. I do not anticipate any very serious special problems in the area.

12. India

Like Europe, India is so large that it can hardly be considered a unified region. It seems to show almost all conditions from hot desert, through tropical forest, to cool temperate forest. For our purpose we may include Ceylon with India. We find a fair number of dry-wood termites, naturally most abundant in the warm forest regions, a much smaller number of subterranean termites, and a considerable proportion of Termitidae. The total number of species reported from India proper is eighty-one and from Ceylon, fifty-nine. In addition, the more tropical portions of India are particularly rich in wood-boring beetles, and there are a fair number from the somewhat cooler forest area of Assam. It is rather interesting that almost all of the information on damage by wood-boring beetles to actual military equipment comes from records, published by Mr. Beeson, on the basis of specimens submitted by the Rawalpindi Arsenal. Largely through the efforts of the same investigator we know relatively more about wood-boring beetles in India than in any other tropical region, although it seems fairly certain that the number of such beetles occurring perhaps in North and South America and in the Dutch East Indies is likely to be actually still larger. There are also about fifteen grain insects of fairly restricted distribution reported from India. I would expect the region to yield a fair number of silvanid beetles, attacking stored products, and a few dermestid beetles and clothes moths infesting wool and other animal products.

13. Burma and Malaya

With the two named political areas we may also include southern Siam and Indo-China. The whole area is, of course, definitely tropical but much of it is imperfectly known. From Malaya, itself, there are reported some seventy-eight termites, of which one-sixth are Rhinotermitidae and it is to be expected that most of the termite damage of the area will be due to such termites. In addition there are nearly thirty other wood-boring insects, mostly beetles, included. Aside from the wood-boring insects most of the pests reported seem to be a fairly general distribution, and on the whole similar to those occurring in India and the Dutch Indies. We do happen to know that there are a large number of meat infesting flies of the genus, *Sarcophaga*. The region is certainly not peculiar in this respect, but has been particularly studied by Senior-White. The area is very rich in beetles and in roaches, but very few have been reported as pests. I suspect that too much of the actual handling of stored material has been in the hands of non-Europeans to provide us with real information.

14. Southeastern Asia

We may include northern Siam and Indo-China and extreme southern China in this area; probably Formosa also should be included. The region verges upon the temperate zone, and as one would expect, has a much smaller fauna than Malaya. On the whole it is a similar fauna with relatively little in the way of temperate elements.

15. Eastern Asia

This includes the general coastal region from about Hong Kong, northward to Korea and Japan. It is a temperate area with a relatively small infiltration of tropical species, and in many respects is closely similar to the northeastern United States. What has been said of the northeastern United States seems to apply relatively well, even to the fact that the chief genus of subterranean termites is the same in the two regions, although in south China there is probably more termite damage than in the middle states. A considerable proportion of our references to silk destroying insects, for obvious reasons, comes from this region.

Dutch East Indies, etc.

16. Dutch islands, west of Wallace's line

This area for the most part consists of the continental islands of Sumatra, Java, and Borneo, but includes the outlying islands and those between the named islands and Malaya. Its eastern boundary passes between Bali and Lombok, through the middle of the Flores Sea and through the Molucca Sea, to the westward of all the islands except those immediately adjacent to the Celebes. From there it runs northwestward, the area including the large southern islands of the Sulu Archipelago, thereafter following the international boundary between North Borneo and the Philippines.

The main islands here included are either but slightly separated from the Asiatic mainland and each other, or, in the case of Borneo, of continental dimensions. The Celebes, which has a very peculiar fauna, is included largely as a matter of convenience. The fauna on these larger islands is relatively rich and in many ways closely related to that of the Asiatic mainland. So far as wood destroying insects go, there are about the same number of termites as in Malaya, but rather fewer beetles, perhaps because of less exploration. The pests of stored products have not been extensively investigated; however, one list of such insects from Java shows for the most part widespread species rather than native species. The ants of the region are fairly well known, but here also, regardless of the question of ultimate origin, the destructive species prove to be widely distributed.

17. The Philippines

This area includes the Philippines as a political entity, except for the division of the Sulu Archipelago mentioned in the preceding paragraph, and the inclusion of certain Dutch islands north of the Moluccas as far south as Pulu Sangihe.

From a zoological point of view the Philippines may be considered large oceanic islands. They have, therefore, a moderately extensive fauna and have been fairly well explored. Aside from the termites, of which the islands afford nine destructive species, most of the pests are widespread, non-native forms.

18. Islands from Wallace's line to western New Guinea

This area is bounded on the west by the main portion of the Dutch East Indies and on the north by the Philippines. Its eastern boundary begins in the Timor Sea, passing northeastward between the Zuid Ooster Eilanden and the Tanimbar Islands, thence northward, immediately east of Ceram and west of Misool island, then northeastward and northward just east of Tobi

These islands are very poorly known for the most part, in spite of the fact that they have contributed to European commerce for some four centuries. They are also small and as a consequence should have a rather restricted fauna. The insects would be expected to be for the most part related to those of Australia, rather than the western Dutch Indies. We, therefore, can anticipate no special problems, especially as it seems certain that the number of wood destroying insects is decidedly limited.

Australasia

19. New Guinea

This area lies east of the preceding, with its southern boundary passing through the Arafura Sea and north of the islands in Torres Strait, thence around the extreme easterly end of New Guinea, including the coastal islands, but not the Trobriand and Louisiade groups, thence close to the coast of New Guinea, northwestward and westward just north of the Schouten Islands.

It is still true that New Guinea is the largest unexplored area in the world. We can be sure, for example, that the nineteen species of termites so far recorded from New Guinea represent a rather small fraction of the total number of species occurring there, and we can be equally sure that termite damage will prove to be very severe. In all probability the same sort of thing can be said for wood-boring beetles and at least some pests of stored products, but there is scarcely information enough to hazard any guesses. One might, to be sure, anticipate damage to protein materials, caused by the genus Trogoderma. It is a fact of considerable interest under present conditions that all we know of the termites of the Tanimbar and Aroe islands is due to the collections made by a Japanese investigator nearly forty years ago. That same investigator visited virtually all the points in the eastern Dutch East Indies and the New Guinea region, which have since become Japanese operational bases.

20. Tropical Australia

This area takes in northern Australia and the coastal islands, and its southern boundary may be drawn for convenience through the following settlements: Broome, Tennant's Creek, Hughenden, and Rockhampton.

This part of Australia has a rather rich fauna, distantly related to that of southeastern Asia; it is, for one thing, very rich in species of termites, there being known from the continent as a whole, 140 species. Of these, thirty-nine are known to cause actual damage; however, the region is not so rich proportionately in wood-boring beetles, and aside from clothes moths, far from rich in native pest insects. Quite surprisingly, none of the native roaches, of which there are many species, are recorded as pests. The ants referred to in the next paragraph are probably as serious in tropical Australia.

21. Temperate Australia

Temperate Australia is all of the continent south of the preceding, and including Tasmania and Lord Howe Island.

This area contains many fewer species of insects than the preceding, but they are of the same general origin. Termite damage, for example, diminishes considerably as one leaves tropical Australia, although it is not unnoticeable, even in New South Wales. Most of the pest insects on record are importations from elsewhere. However, there is a considerable list of ants, chiefly the genus Iridomyrmex, which are native to the continent and regarded as very troublesome.

Pacific Islands

22. Micronesia

This area includes the Japanese mandated islands, that is to say, the Caroline and Marshall groups and the islands north of them as far as the Bonins and Rasa Jima. Its southern boundary is on the Equator as far east as 160°E, thence southeastward to include the Gilbert and Ellice islands, as far south as Nurakita island, thence north on the 180 meridian to the Equator, west to 177°E, thence north to 30°N. It therefore includes Wake Island.

As I have already pointed out, small and low islands have in genera a very impoverished fauna unless they happen to lie very close to large land masses. This appears to be especially true of the rather isolated islands of Micronesia. For example, but four termites are recorded, of which two are subterranean members of the Rhinotermitidae. Even these do not seem sufficiently numerous to cause much damage. Much the same thing can be said of the insects of other groups. As far as I can learn all of the pest insects recorded on Guam, the largest island in the area, are imported although presumably there is at least one native termite there. It is highly doubtful whether more exploration would yield an appreciable number of indigenous pests.

23. The islands east of New Guinea

This area lies east of New Guinea and south of the preceding; it includes the Bismarcks, the Solomons, the New Hebrides, and a few other islands. Its southeasterly boundary is the jurisdictional line between New Caledonia and the New Hebrides, and thence north in Longitude 175°E to the southeastern boundary of Micronesia.

These islands are, many of them, of respectable size and high enough to bear dense forest. As a consequence, they have a rather rich though not well known fauna. To take the termites as an example, I find recorded from the Bismarcks eleven species, from the Solomons ten, and from the New Hebrides five. All of these figures and especially the last, are considerably under the mark. The government entomologist at Suva, Mr. Lever, writes me, under date of April 9, 1943, to the effect that termite damage in the Solomons can be expected to be very severe, and we may assume about equal severity in New Britain, New Ireland, and the larger islands of the New Hebrides. Rather interestingly, six termites are recorded from the Santa Cruz islands. Aside, however, from the termites, virtually no native insects are recorded as pests. This is not entirely surprising since a number of families, like the tenebrionids and the dermestids, which supply fair numbers of pests in continental areas, show few species in the Pacific islands.

24. New Caledonia

The boundaries of this area follow exactly the jurisdictional boundaries of the French colony.

This island and the adjacent Loyalty islands are a rather isolated group that appears in some ways to be quite different from the surrounding areas. In regard to the insects of interest to us, it is by no means well explored. For instance, but six termites are recorded, of which five are Kalotermitidae, and the significant families of beetles appear to be almost unknown. One could, however, assume that in forested parts of the island considerable damage might be expected, but relatively little in the drier areas. A few genera of beetles which are usually continental are known from New Caledonia.

25. New Zealand, etc.

This area includes not only New Zealand proper but all the islands dependent on it, as far as 170°W, and including also Norfolk Island, which is a dependency of Australia.

The fauna of New Zealand is in many respects an extremely peculiar one. The islands now possess ten species of termites, mostly imported from Australia, and as the genus Coptotermes is here represented it lends weight to my earlier comment on the relative ease with which members of that genus are transported. So far as I can say the native insects of New Zealand are relatively unimportant, but it is worth repeating here that weevils of wood-boring types are remarkably numerous in species, although there seems to be no clear report of damage by them. At least one long-horned beetle is fairly serious.

26. The Fijis

This area includes the Fiji group proper. The following nearby islands are excluded: Rotuma, Wallis, Horne, Niuafoo, and the Tonga group.

Although fairly large islands, the Fijis are so far removed from the Australian continent that they have a rather small fauna. It is probable that the six termites recorded (at least one of them introduced) represent about all of the species of this group to be expected. Termites do, however, cause a certain amount of damage, but in any event, much less than in the Solomons. There are rather few native insects of any importance to us.

27. Central Pacific Islands

This includes all islands east of the Fijis and Micronesia to latitude 10°N. For our purposes it may be considered as having its eastern boundary in longitude 133°W, that is to say, just east of the Gambier Islands.

What has just been said of the Fijis applies with even more force to the Central Pacific islands, of which the main islands of Samoa are the largest. Termites are almost unreported from most of these islands. There are six reported from Samoa and two from the Ellice group, but almost the only reports from any of the other islands deal with one widely distributed dry-wood species, which is probably native and one or two instances of imported species. Commerce, however, has distributed a number of the well known pests, especially ants, almost universally throughout the Central Pacific islands.

28. Hawaii

This includes not only the Hawaiian chain proper, but, as well, Johnston Island for convenience.

These islands have received almost more than their share of importations, including the very injurious Coptotermes formosanus, but they possess a very small native fauna of any interest to us. Like New Zealand there are a fair number of potential wood-boring weevils althoug

I find no report of damage from this cause. In addition the very curious beetle, Micromalthus debilis, has been imported from the United States.

29. The Galapagos

This includes only the Galapagos Archipelago.

The aridity of these islands and the paucity of their human population seems to have combined to render them nearly wanting in known pests. They do, to be sure, have a small native fauna of South American origin, which includes a very few termites, and naturally, some beetles. We would not, however, expect any great amount of damage.

The features brought out in the preceding discussion ignore almost completely the widespread insects which can be expected over considerable areas, even in regions where none of their near relatives are native. Based on the definitions given above for cosmopolitan, widespread, and tropicopolitan, the following tabulation shows the total number of species so far recorded and the number of species having a wide distribution.

	Total Species on list	Cosmopolitan	Widespread	Tropicopolitan	Total of 3 preceding columns
Thysanura	11	2		1	3
Orthoptera	23	5		7	12
Dermaptera	4		2	1	3
Isoptera	137			1	1
Embioptera	1				
Ephemeroptera	2				
Psocoptera	19	2			2
Trichoptera	12				
Lepidoptera	102	20	6	6	32
Coleoptera	547	66	44	16	126
Diptera	71	3	5		8
Hymenoptera	88	2	5	10	17
Arachnida	41	3	2		5
	1058	103	64	42	209

It will be seen, therefore, that generally speaking, in the tropics one may expect to be faced with the very good possibility of contending with some two hundred species of pest insects without taking any native pests into account.

6. Conclusions and Recommendations

In this section I shall attempt to draw such broad and general conclusions as the present state of our knowledge seems to warrant and to make a number of recommendations. The reader should be warned that I have, to some extent, made recommendations which are somewhat idealistic. I have done this because it is my conviction that the progress will be chiefly made because there is an adequately high goal at which to aim. The recommendations fall under five heads: -

a. The obtaining and dissemination of information on which control measures may be based.
b. Regulations and manuals covering at least the basic items in the supervision and performance of pest control operations.
c. Means of obtaining the most effective actual operations against insects and rodents.
d. Specifications aimed toward obtaining certain sorts of raw and processed foods, as nearly as possible free of infestation when delivered to the Quartermaster Corps.
e. Means of testing, both in the laboratory and in the field, the efficiency of such substances and methods as may be proposed for pest control, as well as the determination of the possibilities of insect attack on newly proposed or invented materials, such as synthetics. As a corollary, there is included the testing of substances applied as preventatives against other conditions, such as mildew and rot.

6a. Conclusions

Although every separate fact already mentioned is in the nature of a conclusion, I here bring together a certain number of general statements, most of which have not been previously made in this report.

6a1. The Appendix to the report lists about 1050 species of insects and mites which either are known to damage materials of interest to the Quartermaster Corps, or very similar substances, or have been found in buildings and are related to destructive insects. Only a very few species are included which one would assume a priori to be merely scavengers. These organisms are distributed amongst thirteen orders as shown in the table on page 167. Of these species, 103 are cosmopolitan, 64 more are widespread, and another 42 occur throughout the tropics. We might think of these 209 species as constituting the standing army of pests. The remaining, more than 800 species, being in the nature of local militia.

6a2. The most important natural groups of insects are:

Beetles	547 species with	116 in the standing army
Termites	137 " "	1 " " " "
Moths	102 " "	32 " " " "

6a3. The materials discussed in Section 2 are divided into 52 groups, of which only the following 8 show more than 60 species of pests each:

Wood	378 species,	of which 209 are	beetles	and	136 termites.
Grain	246 species,	" " 159 "	beetles	"	39 moths.
Houses and Storehouses	129 species	" " 46 "	beetles	"	46 ants.
Plant Substances	109 species	" " 66 "	beetles	"	15 moths and 15 ants
Other miscellaneous seeds	85 species	" " 54 "	beetles	"	18 moths
Other dried fruits	69 species	" " 39 "	beetles	"	22 moths
Meat or fish, fresh	64 species	" " 46 "	flies		
Wool, fur, feathers	63 species	" " 31 "	beetles	"	23 moths

It will be seen that the beetles on the whole maintain their predominance in each of these groups. Only in the case of fresh meat do the flies play the major role, and only in the case of buildings do the ants challenge the beetles. It will be seen also that each of the main groups of materials is represented except the metals.

6a4. As has been shown in Section 2, a careful examination of damage alone will often give a good indication of the causative organism in the case of paper, textiles, or wood, but much more rarely in the case of foodstuffs. The ultimate diagnosis has always to rest on finding the actual insect, except in a few favored localities where the total fauna of insects is sufficiently well known, a situation which we might consider as never true in the tropics.

6a5. The general group (order) to which a pest insect (mature or immature) belongs is readily determined, but to go further often requires special equipment. It is true that in the north temperate zone a considerable number of pest species have "catch" characters. It is probable that some of these characters might also work in the tropics, but it is unsafe to assume so.

6a6. Protection of food. The protection of food falls under two heads:

a. Protection against food pests proper, that is, those pests whose primary interest is in the foodstuff, itself. A great deal of attention has been given to the origin of insects occurring in packages of dried foodstuffs, such as raisins or cereal products. In many instances it has been possible to show that the insects did not invade the materials after packaging but were sealed up with them perhaps only as eggs. Therefore, the infestation must have begun before the material was finally packaged.

The following procedures should diminish the incidence of such infestation:

1. Selection of stock. The material to be packaged should not only be reasonably free from evidences of insect damage but should, as far as possible, be free of insects themselves. There are various methods of accomplishing this other than inspection. If the material is relatively undamaged but does contain a few insects, it may be gassed with one or another fumigant, the choice of which depends on the type of material, or it may be heated to a temperature and for a time sufficient to kill all stages of insects within it.

2. Good Housekeeping. Once the material comes into the processing plant every effort should be made to see that it is kept free from further insect infestation. This is to a large extent a matter of cleanliness. Bits of material should not be allowed to stay about in cracks or corners where it is possible for insects to breed, nor should bins or other containers be used so continuously as to prevent thorough cleaning at regular and moderate intervals. By thorough cleaning we mean not alone the sweeping out of the evident fragments of materials but the sterilization of the inside of the bins, preferably with live steam.

3. Control. It is probably inevitable that a few insects will get into a processing plant and find some way of maintaining themselves. The speed with which an insect population increases in a bin or a food package is more dependent upon the number of insects present than upon the fecundity of the individual insects. It is, therefore, important that measures be taken to see that an insect population is not allowed to build up in a plant, and aside from good housekeeping this may well involve regular or occasional fumigation of the plant. The intervals can be determined only by proper inspection. In the case of certain moths this can be done by trapping. Then if the number trapped per week rises to a certain level, dependent somewhat upon season and geographic location, fumigation should be undertaken.

4. When the material has been finally packaged and sealed unless it is certain that it is free from insects or any of their stages, it would be best to submit it to a final heating treatment to kill any insects which are still in it.

It is unfortunately true that storage at low temperatures is not an adequate guarantee of freedom from insects. Generally speaking the temperature and time required to kill insects by refrigeration are beyond those usually feasible.

It will be seen that the effect of these procedures upon the nutritive value of the food is rather different. Obviously prevention of infestation by proper handling of food and proper construction of processing plants and so forth, cannot detract from the nutritive value, but it is equally evident that unnecessary heating of food, especially with exposure to air, can hardly fail to affect at least the vitamin content and possibly the composition of fats or oils which may be present. I have not found any clear statements as yet of the effect of fumigants on the nutritive value of foods; it is not inconceivable that they might have some effect, quite aside from any poisoning due to retention of the fumigant.

b. Protection of food packages against known food pests

This is a problem which has been of considerable concern to the Corps for several months at least, and to which I have given a good deal of thought, but I regret that I am yet unable to propose the perfect package. Much depends on what one desires to protect a package against. A merely tight package of heavy paper, for example, will for the most part, under dry conditions, protect against a considerable assemblage of food insects. Aside from a few beetles, it is comparatively easy to construct a package which is proof against invasion by food insects. It is very much more troublesome to protect against rodents or termites. In the case of rodents it seems unlikely that anything except metal, and hard metal at that, would be completely protective. So far as damage to the package, itself, is concerned, most insects can be kept out by multi-wall asphalt laminated paper. However, investigation in the southern United States on the packaging of rice indicated that such multi-wall bags, when the stitching was covered with heavy gummed paper, afforded protection for ten months in storage against everything except termites. I have not had penetration by the eastern subterranean termite of a variety of paper containing asphalt and fine sand, but I have had some injury to the asphalt layer. I cannot, therefore, recommend such paper unreservedly against the much more powerful termites of the tropics. The examinations which I have already made on certain treated textiles indicate the possibility that the impregnation of the outer one or two layers of paper with some material such as copper naphthonate or orthophenylphenol might improve the resistance of such materials. This still does not solve the problem of boxes and crates which, unless they be stored on termite-protective racks, are certain to be attacked unless the wood is treated in some way. Even when so stored, they would probably be somewhat susceptible to attack by wood-boring beetles.

Very recently the Forest Research Institute at Dehra Dun, India, has published two leaflets, 24 and 26, dealing with the construction of plywood containers; these leaflets I have not seen. If such plywood containers could be made resistant to insects, as by the incorporation of insect-resistant plastics or by chemical treatment, the containers might be quite useful.

6a7. Protection of Equipment and Supplies

Protection of such materials depends on two factors:

a. Storage. I have already discussed to a considerable extent the construction of buildings reasonably immune to and unattractive to insects. Other methods in use are well known, such as cold and in the case of textiles, the use of closed containers and paradichlorobenzene. Such methods are naturally satisfactory up to the point where the equipment comes into use. Its further protection will have to depend on -

b. Insect proofing, or the use of materials which are i themselves inedible. I have discussed above the problems of insect proofing and listed some of the materials which have the best reputation the substitution of per se inedible materials; unfortunately, relatively few of the possible materials such as synthetic fibres or plastic substitutes for leather have been tested at all to determine the effect of insects upon them.

6a8. Materials of Construction.

There are evidently three ways in which buildings and materials used in them can be protected against insect attack.

a. Structural methods, that is, the design of storage places and of buildings so that they cannot be reached by insects or other pests.
b, Chemical methods; the treatment of the materials with repellent or poisonous substances, and
c. Environmental methods; the storage of timber under conditions relatively unfavorable to insect attack, the clearing of ground or its treatment with poisonous or repellent substances so that pests tend not to approach buildings.

Wood attacking insects are found almost all over the world there being one report even from Alaska, but there are only a few region in which they are at all numerous and well known. The number of species involved in some of these regions is shown in the table. It is probable however, that similar numbers of species occur in all regions adjacent to those noted in the table except that the number will be lower on islands than on mainlands. There are a few regions about which little is known where peculiar attack is to be anticipated. One of these is New Zealand. In most parts of the world there are a very few wood borin true weevils and these weevils are all rather closely related, and surprisingly enough, particularly numerous in New Zealand, (170 species) and Hawaii, (110) as compared with 66 for the whole of Australia.

	Termites	Beetles	Miscellaneous
North America	19	50	6
Europe	2	46	11
Malaya	12	28	4
Australia	39	17	--
Central America	26	22	--
South America	7	35	2
Dakar to the Cameroons	16	10	--

6a9. Metals

It is evident from what has already been said that the protective effect of metals resides almost entirely in the physical character of the metal, not in its chemical properties. If a metal is soft enough it will be penetrated by insects, and conversely, really hard metals are not penetrated. It would appear that the chemical contact of pests with metals is not so intimate as to cause either poisoning or repulsion.

6a10. Buildings and Storage Places

It is possible to so design and construct buildings and storage places that their invasion, either in respect of the structure or its contents, by pests is reduced to a minimum. So far as the contents are concerned, this involves, to a great extent, the elimination of unnecessary openings, the elimination of harborages, and the protection of necessary openings. It must not be overlooked that while modern concrete buildings are, to a very considerable extent, rat proof, they may be turned over to the users already provided with rats which have invaded the buildings in the course of construction, and it is fairly customary now to have a building fumigated or otherwise treated for rats before it is turned over to the owners.

6a11. Poisons

There are obviously a considerable number of poisonous substances which will in any event kill any insect that we know of, but other circumstances than the mere presence of an insect govern the choice of poisons. Furthermore, the effective use of one poison will not be so readily obtained as the effective use perhaps of some other poison. Under the recommendations, I shall have something to say about methods of obtaining effective use. We must, therefore, have some criteria for choice of poisons. In the discussion of poisons I have made some comment on the hazards in certain cases, and upon safety measures which can be employed. I shall later make some further recommendations along this same line. There also will be found some remarks on the relative efficacy of various poisons against particular groups of animals.

We may point out here that the criteria of choice involve not only the efficacy of the poison in connection with a given method of application to the pest in question, but as well, the disturbance of use of the building which is involved, and finally the toxicity to man. The effective use of poisons requires that, on the whole, this third point shall be subordinated, that is, that such precautions as are necessary shall be taken to prevent poisoning of personnel. If, on the other hand toxicity to man is placed first, then we are committed for the most part to relatively weak poisons or to substances difficult to obtain, and in some cases, very inefficient.

6a12. General Procedures

I will present here some conclusions in regard to the applicability of heat and moisture in the control of insects.

1. Practically all insects and arachnids can be killed by exposure to a temperature of 160°F for 20 minutes. Many insects can be killed at even lower temperatures and generally speaking greater time allows a lower temperature, but in no case should a temperature below 120° be considered fatal. Allowance must also be made for the time required to bring the material up to the requisite temperature. In some cases this is a matter of hours.

2. Storage of materials at a temperature not above 50°F will normally result in preventing an increase in insects present. Unless the temperatures are very much below this, rapid killing is not to be expected.

3. There are not very many records dealing with the minimum moisture required in the food. The span of those available is from 6 to 10 per cent. It should be noted, not only that most of the reports are 8 per cent and below, but also that this moisture content is considerably less than that ordinarily encountered in so-called dried products.

6a13. The Mammals

For obvious reasons of size, the mammals are for the most part handled by methods which are not applicable to insects. They must be attacked by specially prepared and placed baits, or with traps in the case of rodents. Construction of buildings is of primary importance if they are to be maintained free of rodents.

6b. Recommendations.

6b1. Obtaining and Dissemination of information on which control measures may be based.

It appears to me essential that there should be some way in which the problems confronting officers in the field can be brought to the attention of specialists and in which the information obtained from the specialists can be put into a form usable by the officers and conveyed to them. Such procedures, of course, involve certain difficulties In the first place, relatively few officers in the field can be expected to have more than a lay knowledge of zoology, or to have any special knowledge of how the material should be preserved for shipment. In addition, there may be, naturally problems of transportation of any material which might be collected; however, I feel very strongly that definite effort should be made to get back from the field all information and specimens that bear on the pest control problems being encountered. This will involve, of course, the preparation of the necessary instructions to officers and it will involve also the setting up of one of two mechanisms in this country for handling the material.

a. The directions for collection, preservation and shipment of specimens may be taken up under four items.

1. Collection
2. Preservation
3. Shipment
4. Data and Labels

1. Collection. The exact means of laying hold of specimens of pest insects depends in part on the habits of the insect. In many cases the insects may merely be picked out of the infested materials with the fingers or with a pair of forceps. Certain actively flying forms may be best obtained by waiting until one alights and then placing the open mouth of a dry 2- or 4-dram vial over the insect. This vial is quickly lifted and the opening closed with the thumb or finger. The vial then can be placed, mouth down, over the open mouth of a vial of preserving fluid. The insect will either then drop into the fluid or can be shaken into it. If the opportunity offers, killing vials can be prepared, utilizing chloroform or carbon tetrachloride. For this purpose some absorbent material is placed in the bottom of the vial. This can be firmly packed cotton, upon which a piece of fairly stiff paper, slightly larger than the internal diameter of the vial, is forced. Better yet, a quarter inch of plaster of Paris poured in and allowed to set will form an excellent absorbent plug in the bottom of the vial. A few drops of carbon tetrachloride placed in this absorbent material will suffice for killing over a period of from one to several hours. In the last analysis the collection of insect specimens is often a challenge to the ingenuity of the collector.

2. Preservation. Since we are concerned primarily with securing insects in a state suitable for identification but not necessarily suitable for the preparation of first class museum specimens the method of preservation can be greatly simplified. We may, therefore say that all insects except adult moths may be preserved in alcohol of some strength between 70 and 95 per cent. It does not need to be pure alcohol; not only will denatured alcohol do, but medicinal alcohol can be used and, if the volume of fluid is rather great relative to the volume of the specimens, native brandies such as sake and arrack can be employed successfully.

The shipment of dry specimens is attended with such risk of breakage unless special precautions are taken that it should be avoided as far as possible. The exception in the case of adult moths is made because the scales on the wings of moths tend to come off in alcohol and thereby tend to eliminate the pattern of the wings. Adult moths should, therefore, be preserved dry, such specimens when dead being placed in a tiny envelope of paper which is readily made by folding over diagonally an appropriately sized piece of clean paper, and then again folding the edges to keep it closed. It is necessary, in any event, to take great pains in handling adult moths to prevent rubbing of the wings. Examples of the work of insects are best preserved dry.

Lundbled in Sweden has successfully used amyl acetate in fine sawdust as a means both of killing insects and of preserving them during shipment. I have not personally used this method but it would certainly be worth trying.

3. Shipment, Vials of specimens in alcohol are prepared for shipment by filling the vial as nearly to the top as possible before the cork is finally inserted. The same also holds true of any bottles that might be used for larger specimens. It is assumed at this point

that the necessary label has been placed within the vial or bottle (see beyond). Screw caps are not advisable as a method of closure; they are almost certain to leak. The only way that I know to make one tight is to fill the screw cap half full of molten paraffin, and just before the paraffin is thoroughly hard, to screw the cap tightly on to the container. Smoothly cut plugs of soft wood can be used in place of corks, but care must be exercised not to burst the mouth of the vial or bottle. It is always advisable to tie down the cork. This can be done most readily by the use of adhesive tape.

In packing glass containers for shipment, it is necessary to make sure that glass never comes in contact with glass. Each bottle or vial, therefore, is wrapped in several thicknesses of any sort of paper. The vials are placed in the center of the box, completely protected from the walls, top, and bottom by any sort of firm but resilient packing material, crushed paper or excelsior for preference. Specimens of moths in envelopes may be put in a small paper box and that in turn packed within a larger box, the same way as a group of bottles.

Dry cotton is an extremely destructive material to have in contact with insects. If it is necessary to pack dried insects in cotton, they must always be separated from it by a layer of soft paper, such as toilet paper. It is always necessary to make sure that such specimens are sufficiently firmly packed so that they cannot move during shipment. It is less dangerous to use wads of cotton as a packing material in vials of insects.

4. Data and Labels. It is absolutely essential that all specimens be accompanied by adequate information. In many instances this may be too bulky to put on the label that goes within the vial or bottle. In that case a certain minimum must go with the specimen itself. This should include the locality at which the specimen was collected, the date, the collector's initials or name (in this case, the collector means the person responsible for the sending of the material, not necessarily the person who happened to pick up the insect), and some sort of serial number which can be connected with further information sent separately.

Labels should be written on a decent grade of writing paper or typewriting paper, in pencil, with some pressure. (Ink labels are totally unsatisfactory). The size of the label should admit both of its being inserted readily into the vial, and being readily extracted from the vial.

Further data, as far as possible, should include any observations as to the material damaged, the kind of damage, and the habits of the insects. It is even important in many cases to know whether the insects are active by day or by night. The more detail which is provided, the better will be our understanding of the insect and what to do about it. As a matter of information, any native name of the insect is always useful, and also any information which natives are able to give about means of control, because this can be sometimes modified for our own use.

b. Identification and Dissemination of Information

There are two somewhat different ways in which material could be handled for study.

(1) All the work could be done within the United States in which case, I would recommend that a competent zoologist with some experience in problems of pest control and the identification of insects be selected to head up the work. It is not expected that all of the actual work would be done by this one person, although he might do a good deal of it, but it should be understood that he could submit any material to specialists in more limited fields for their views and recommendations and their replies would come to him. It would be the duty then of the zoologist to rework these reports of specialists into a form in which they would be of the greatest use in the field. Obviously this would in many instances demand that the reports be translated out of scientific jargon into plain English. Having prepared the information, then it would be forwarded through the office of the Quartermaster General, not only to the officer with whom the problem originated, but preferably to all Quartermaster officers in the appropriate geographical areas.

(2) An extension of this procedure which would make it more valuable, would be to make provision for actual visits by the man in charge of the program to any area in which serious problems were being encountered. He would then have the opportunity to make first class collections in the field and could, in all probability, make at least preliminary recommendations on the spot.

Either of these procedures presupposes that full reports, in detail, of actual conditions should come back to this country without unnecessary interference by censors.

The distinction in value between the two methods just given resides in the present difference between the consideration of strictly physical or chemical phenomena and biological phenomena. In dealing with physical and chemical problems it is ordinarily possible both to find personnel competent to record the phenomena and to record them in such terms that the conditions can be duplicated elsewhere. In dealing with biological phenomena, on the other hand, not only are the chances very much against the presence of personnel competent to record them, but in addition, it is often impossible to duplicate properly the conditions, which are very complex and often not measurable by available methods, elsewhere. Consequently, a technically trained person on the spot will be able to make a better analysis and acquire far more information than can, at the present time, be put down on paper in usable form by relatively untrained persons.

6b2. Regulations and Manuals

It is strongly urged that regulations and manuals be prepared covering at least the basic items in the performance and supervision of pest control operations. Due to the considerable number of decisions which must be made, based on particular military considerations with regard to the contents of manuals, I shall not attempt here to go into a great deal of detail.

It is evident that the choices to be made as to methods involve the question of effectiveness of one method as compared to another, and so far as most control methods go, there is little experience with them in the tropics. To begin with, decisions would have to be based for the most part on temperate zone experience; however, it cannot be anticipated now that there would be very marked differences in effectiveness. It is also evident that as a practical matter there should be a minimum number of procedures or formulae selected for the control of a particular type of infestation. In addition, there is the very important question of safety involved in the use of any control method employing poisons. The last problem is that of the training of personnel.

The selection of methods to be used under particular conditions requires a consideration of the availability of materials and of transport and issuance of materials. It may be advisable ultimately to divide the methods into two categories: (1) those methods which can be employed at established bases where the problems of local transport and storage are less acute, and (2) those methods which can be used in the field where it is obviously desirable to transport the smallest possible bulk of material and to depend as far as possible upon locally obtainable items.

In spite of the remarks made in the first paragraph above, I will put down a general outline of the Table of Contents for a pest control manual. It should be stressed that any such manual should recommend rather than specify. In other words, no needless restrictions should be placed on the intelligence and ingenuity of the men on the spot. Precise methods, intervals of application, and quantity of materials are too much dependent upon local conditions to be embodied in official regulations.

Suggested Table of Contents for a Pest Control Manual

A, The recognition of the main groups of insects and their work, with a brief notation of the habits and distribution.

B. Methods of control arranged under
   (1) The materials infested.
   (2) Groups of insects.
   (3) Rodent control.

C. Methods of construction of buildings and supply dumps and arrangement of their contents for the prevention and control of insect and rodent attack.

D. Regulations and safety procedures relative to control methods and control equipment.

The regulations should specify the precautions to be taken in the use, handling, and storage of poisons, the personnel to whom poisons may be issued and the qualifications of the personnel who are competent to use poisons or to supervise their use.

It should be noted that item C would, to some extent, affect the specifications of construction set down in the existing Quartermaster manual on the subject, and presumably some of the Engineer manuals, but the changes involved would be for the most part changes of design detail, rather than far reaching changes in structural specifications.

Suggested Regulations with Regard to the Use of Pest Control Materials

1. Regulations on fumigation.

1. No crew to be allowed to fumigate unless properly equipped with gas masks approved by the U. S. Bureau of Mines and which have been properly tested before beginning work on each job.

2. All fumigating crews to be required to carry to each job sufficient warning signs and locks or other safety devices as necessary.

3. No fumigation of any building and reoccupancy of the same to take place within 24 hours and in no event shall a fumigated space be reoccupied without an 8-hour ventilation period. This does not include burrows or harborages in the soil of rats, mice, ants, termites.

4. No partial fumigation of any building to be allowed unless the entire structure be vacated.

5. On each job one or more guards shall be on duty outside the fumigated structure during the entire period from beginning of fumigation until it is safe for an experienced fumigator to enter without mask. All doors and accessible windows should be locked and warning signs placed on all entrances before the fumigant is released.

6. All greasy or damp foodstuffs are to be removed, including milk, butter, green vegetables, meat, eggs, opened and uncorked bottles of liquids, also undeveloped film, fine clocks and other precision instruments, and all living plants and domestic animals. Material in sealed bottles or cans need not be moved.

7. All toilets to be flushed at the completion of the fumigation and if used for disposal of fumigant residue, several flushings should be made.

8. The premises shall be so sealed as to confine the fumigant to the intended space and the crew shall then, by inspection, determine that no person or domestic animal remains in the building before the fumigant is released and the final exit is made.

9. Two or more experienced men to be on every fumigation job, both at the time of releasing fumigant and at time of beginning ventilation. All jobs to be supervised by an experienced fumigator.

10. Notification of time and place of fumigation shall be made to local officers in charge, Quartermaster Corps, Sanitary Corps, and Military Police.

11. All bedding, upholstered material, woolens, and furs should be placed especially for easy penetration by fumigant and ventilation. It is recommended that heat and fans be used where feasible to assist ventilation.

12. The officer in charge of the building or of each section of the building shall be notified in writing of the time to vacate the premises and when reentry may be expected. A copy of the notice should be posted in the building.

13. Each crew should have on the job such safety kit as may be approved and issued by competent authority and shall be adequatel; instructed in its use, and in first aid, Test papers and color chart for cyanide detection will also be provided.

14. No person will be permitted to enter the fumigated premises before the fumigator has satisfied himself by personal inspection without a gas mask that it is safe for reoccupancy.

15. All equipment, warning signs, and gas masks shall be of types approved by competent authority.

16. An extra gas mask and canister shall be available on all jobs. Military gas masks are not protective.

2. Regulations on other poisons.

a. It is strongly recommended that all powdered poisons should be colored. The current practice of those divisions of government which have made regulations in this country is to require that sodium fluoride be colored a distinct light blue or light green. The usual practice is to add nile blue sulphate. Where pyrethrum and fluoride are mixed, nile blue sulphate yields a greenish color. Generally speaking, no other powdered poison is readily available to the public for insecticidal purposes, and consequently, regulations in regard to their coloring are not extant. In my personal opinion it is not of great consequence to attempt to color different poisons differently. It would be far better that personnel should associate a green or blue color with insect powder, rather than that they should try to remember that blue is fluoride, and pink, let us say, is arsenic.

3. On marking and storing of poisons.

Not only should containers of poisons be conspicuously marked, preferably red on white with the word "Poison" and skull and crossbones, but they should bear also the name of the poison and the appropriate antidote. It would probably be advisable that the word, poison, should occur on all four sides of the package. It should be strictly forbidden to transfer poisons from issued packages to other packages for storage. It seems to me far safer to package the material originally in containers of appropriate size, rather than to distribute it in bulk. I recommend that general stores of poison be kept in cabinets or lockers separate from any foodstuffs, and control of such lockers be under the local Quartermaster officer, personally.

Local personnel such as mess sergeants in the field should be required to keep all poisons, whether in raw form or made up into baits or other mixtures for application, separated from food, and their use should be restricted to those personnel who have been certified competent to use particular materials by the pest control section. This point is referred to under recommendation 3.

6b3 - Operations against insects and rodents.

The effective use of pest control methods and materials leads not alone to higher kill of the pests and less frequent repetition of treatment, but, of course, also to the conservation of time and materials. Unfortunately, it is not possible to put down a set of precise rules for the handling of spray or insect powder or poison bait. Unlike the lubrication of automobiles, we cannot say that in a building of such and such a design we spray here or there; the details of each case are peculiar to the case itself; the minutiae of construction differ; therefore the number and kinds of invaders differ. I feel very strongly that the application of insect control methods should be placed to the greatest possible degree in the hands of those who have specific training and experience. It is, of course, evident that in a few stabilized areas as the United States, Great Britain and Australia, this can be accomplished by the employment of existing commercial operators. Outside of the areas mentioned it seems probable that use must be made of military personnel. On this point I have seen a good deal of material circulated by the National Pest Control Association, and I have also some remarks on the subject sent me by their secretary, Mr. Buettner. It should be understood here that the expression I am about to give to these views is my own and not precisely that of the association or its secretary. The agreement is in principle rather than in detail.

First, it is generally agreed that the employment of untrained personnel, who are merely told to put out this or that insect powder or use this or that spray when they see insects, leads on the whole to waste of materials, since the kill is not in proportion to the materials used. Second, that there should be a more definite requirement governing the use of existing commercial facilities. I am personally convinced that this view on the part of the National Association is more motivated by a desire to conserve materials so that there will be a more adequate supply for all pest control uses, than to secure a profit to the business concerns involved. In fact the statement was made informally at one time that if a job was too big for one concern to handle, it would be possible to have it parcelled out through either the national office or one of the regional association offices, the job being undertaken by an association which would tell off the operators who were expected to do the actual work.

Where the use of existing commercial facilities is out of the question, then the most satisfactory procedure appears to me to be the setting up of pest control units analogous to the malaria survey and malaria control units of the Sanitary Corps, these units to handle all operations not primarily involving insects attacking man and animals. There would, consequently, be virtually no overlap between the general pest control unit and the sanitary control unit. It would only remain to decide where the house flies were to be assigned. (I suggest that house flies in buildings be treated as general pests and those associated with garbage dumps or manure piles be considered as sanitary pests.) I suggest, therefore, the following organization for a pest control section. This section would probably ultimately fall not so much under the Quartermaster Corps as under the Army Service Forces as a whole.

Chief of Section
Assistant Chief of Section

One to be a zoologist with a knowledge of pests and pest control, the other to be an experienced pest control operator. With the proper selection of man, it is of no consequence which one is the ranking officer. It would be their function to act as administrators of the program and chief trouble shooters. In addition, this office would require a necessary secretarial staff; perhaps two to four persons would function as secretaries and technicians. Under these there would be ten areas, each under an area chief and assistant chief, again one a zoologist and the other an experienced operator. These men would perform within their area the same general functions as the section chief and his assistant, and would have, preferably, for each headquarters a secretary and a technician. Each area would have, with perhaps two exceptions, two or more pest control units, which would consist of a leader who was experienced in pest control operations, and four men under him, who had had some training in actual operations and who would work under the immediate supervision of the leader. It should be noted that so far as the staffs attached to the offices of the section chief and the area chiefs are concerned, the secretarial and technical staff could consist largely of women.

The ten areas with the number of pest control units assigned to each, and suggested places for headquarters are as follows:

North Africa	3 units	Algiers
West Africa	2 units	Monrovia
United States	0 units	Chicago
South America	2 units	Natal
Caribbean (Central America and the West Indies	2 units	Colon
India	2 units	Calcutta
Southwest Pacific	2 units	Canberra
South Pacific	2 units	Nouméa
Central Pacific	3 units	Honolulu
Europe	0 units	London

With the progress of military operations it is probable that some of these areas would be abandoned and the personnel would be available to shift to other areas. It seems very probable, for example, that ultimately units would have to operate on the European continent both from the London and the Algiers headquarters. It is possible that the West African units could be moved to the northern part of the European theatre. I venture to say that we will find the pest control situation on the European continent pretty thoroughly disorganized, even in those regions in which it was formerly good. In other words, the present detailed recommendations apply to the military situation as I see it at the present time, (August, 1943), and are not intended to be fixed recommendations for the duration.

The training of the personnel is naturally a somewhat troublesome matter, because it would have to be done where actual pest control operations are in progress. That means that it would almost certainly be necessary to farm out the enlisted personnel to a properly selected group of pest control operators for practical training, the difficulty being that one cannot have the actual infestations of appropriate pests wherever and whenever one would like them. I feel sure that the industries in this country would be glad to cooperate.

It would be a further duty of the personnel of these pest control units operating in the field to instruct additional personnel in the technique of using the simpler and less dangerous sprays, baits, and powders. This would be especially useful in cases where repeated applications at intervals of two or three weeks might be needed to eliminate newly hatched young, and thereby ultimately to eliminate the entire infestation, or in those cases where continual reinfestation from the outside is likely to be a serious problem. This is frequently true of silverfish infestations in the tropics.

Ultimately there would be a very considerable personnel competent in the simpler techniques of pest control and the pest control section would have largely supervisory duties and the operation of special and dangerous procedures, like fumigation.

I admit freely that this recommendation seems very radical, but I have given it a good deal of thought and I am convinced that with proper selection of personnel it would work in actual practice.

Some months ago, I asked Mr. William O. Buettner his general reaction to the problem of pest control in the armed forces. He has no knowledge of the recommendation which I have just made; it had not, in fact, been drafted at the time I wrote him. The gist of his reply is that the approach to insect and rodent control should be removed from the general field of purchase of supplies and transferred to the proper application of control methods. This, of course, agrees with a remark I made about ground treatments for termites - that the efficacy of the treatment depends much more upon the skill of its application than upon the mere toxicity of the substances employed. He further expressed the opinion that both the pest control operator and the zoologist have a place in the program and that the program is not complete without both, that is to say, he recognizes that the zoologist has knowledge of the habits and activities of insects and a facility with the literature which the pest control operator does not; by the same token, the pest control operator has experience in techniques of application that most zoologists know only by description. This applies not only to the actual pest control operations but to the teaching of personnel. He and I agree that the mere purchase of insecticides and their issuance to completely untrained personnel is a tremendous waste, especially when some of the most important insecticides are critical materials. We need name here only sodium fluoride, pyrethrum, and rotenone. The situation in regard to pyrethrum is especially critical because of the somewhat conflicting demands of the armed forces, the home front, and agriculture. These difficulties are well known to the War Production Board and to the Department of Agriculture, but they are not minimized by the existing regulations of the Medical Corps of the army, which, for example, require pyrethrum instead of fluoride in mess halls and kitchens. It is perfectly true that there have been serious accidents in the use of fluoride in kitchens, but it is safe to say that these accidents have occurred only when uncolored fluoride was left to be applied or misapplied by untrained personnel. I am convinced, for example, that it can be safely used in place of pyrethrum under the supervision of trained personnel. This should be particularly true of the fluoride crayon, which I have earlier described

In this connection it is important to remember that trained personnel have knowledge not only of precautions to be taken, but, as well, of the methods and materials most effective against special groups of animals. For example, fluoride is much more effective against roaches than phosphorus; one uses dilute poisons against ants; one fumigates for control of textile insects; one varies the poison and the bait base against rats but one traps mice; and so on.

6b4. Specifications on food.

It is my intention to bring together here a number of general recommendations, most of which are individually perfectly well known and obvious, but I believe it will be helpful to have them put together in one section. They deal almost entirely with food and are directed toward minimizing the development of infestations in packaged and stored food.

A. Production Specifications

These are applicable for the most part only to the United States since the chance of control of insects in fields and orchards will evidently be less in foreign countries.

(1) Dried Fruits

The most important point in preventing infestations of dried fruit by insects is sanitation of orchards. This means the prompt gathering and disposal of windfalls, culls, and other fruit waste which is commonly allowed to lie around on the ground for considerable periods.

(2) Leguminous seeds.

The chief problem here is spraying or other field measures against pea and bean weevils (Mylabris pisorum, M. obtectus, and allied species). These insects are significant because they show up for the most part as an infestation of dried leguminous seeds, but the infestations originate almost entirely in the field.

(3) Other vegetable products.

So far as other vegetable products are concerned, the problem is one of general insect control in the field, rather than a control directed at specific types of insects.

B. Processing specifications.

Certain additional insects can be introduced as infestants during the processing of foods preserved in the dry state. These specifications involve:

(1) Requirements as to sanitation of processing plant
(2) Maximum quantities of insects permissible in a given weight of a product. Compare my remarks on page 10, regarding the significance of the number of infestants present in relation to the speed with which an infestation builds up.
(3) Permissible maximum moisture contents. Compare conclusion 12.
(4) Sealing of containers. This involves not only the perfection of the seal so that young larvae are excluded, but also the promptness of sealing. It obviously does no good to have insect-free material placed in containers and then let the containers sit around until the material has been reinfested. In regard to sealing, the complete closure of the ears of bags is necessary. This is frequently an overlooked point.

C. Storage specifications prior to delivery.

It is my opinion that all foods which have not been heat processed benefit not only by storage under cool conditions, not necessarily refrigeration, but also by storage under dry conditions; therefore, these specifications would deal primarily with temperature and moisture conditions of storage. Here also the reader should refer to conclusion 12. The obvious ideal is storage below 50°F with a relative humidity below 40 or 50 per cent. There is not a great deal of data on the relation between the relative humidity and moisture content of stored materials, but from what information I have seen, 40 to 50 per cent humidity appears to be reasonable.

D. Permissible treatments against insects present.

This has been, to some extent, discussed in conclusion 6 and also in section 4a, particularly under fumigation. It is evident from what has been said already that the choice of fumigation, for example, versus heat, will depend in part on the conservation of vitamins and in part on fat content. It will also depend on the relative tendency of the materials to absorb the fumigant; therefore, individual specifications would have to be made out for all of the chief items.

E. Storage specifications after delivery.

The specifications noted under C would hold for Quartermaster depots, in any event in this country. In the field in many instances, moisture and temperature could not be regulated and, in addition, it would be more important to prevent damage to the packages by rodents or insects. This problem has already been discussed in sections 4d and 4e.

6b5. Testing procedures.

I recommend that the section of Test and Review, as well as the Development section, give consideration to having materials and packaging and storage methods consistently examined with regard to insect attack. Some examination of this sort is already being done. From what I can learn of it, it tends to be inconsistent and there is an insufficient amount of data, particularly on field results. It must be stressed that laboratory and field testing with regard to insects are likely to be two quite distinct matters. Laboratory testing may give much more numerical results than field testing, but it has the disadvantage that it can be done only with such insects as are available, and these may or may not be the ones that would prove to be important at a given area in a field. Furthermore, laboratory testing tends rather strongly to be analogic, that is to say, we test against the available insect, which may be comparatively unimportant in the field, and then assume that the results bear a definite relation to what will be obtained in the field. However, with a proper selection of test insects and test methods, laboratory testing is a necessary first step in the evaluation of new control substances and methods, and in the evaluation of new materials, as for example sythetic plastics.

There are a considerable number of university laboratories in this country which are equipped to perform at least some of the necessary tests. I doubt whether any one laboratory could perform all of these necessary tests. If the testing program were also headed up by the zoologist called for in recommendation 1, it would be his duty to parcel out the work to the laboratories best fitted to undertake it, and to specify to a certain degree the insects and the methods of test. This is to insure comparability of the various tests, but should not be carried to the extreme of suppressing the development of new test methods or advisable changes in old methods. The field testing could be administered jointly by the zoologist and the Test and Review section. This would insure an adequate comparison between the field tests and the laboratory tests, and a consistent interpretation of the field results insofar as attack by animals is involved. What I have just said is not intended to minimize the work of Test and Review or of Research and Development, but to assure a more comprehensive consideration of the data obtained and obtainable.

Since most of the above was written there has come to hand the A.A.A.S. Symposium on Laboratory Procedures in Studies of the Chemical Control of Insects. This volume contains a large amount of useful information.

7. INDEXES

There are certain difficulties in arranging an index to a report of this sort. I have attempted to overcome these by, for the most part, indexing all entries under nouns, with the adjectives placed as subheads. In a few instances where it was inconceivable to invert a phrase, it has been entered in the way in which it is always used. In addition, I have given a considerable number of cross references where nearly synonymous words are used interchangeably in the text. Where both scientific and common names are used in the text, the scientific name is given following the common name in the index, but the page references follow the actual usage of the text. Scientific names are indexed with the generic name first, this being in fact the noun of the name. The names of chemicals have been indexed simply as names, it being understood that numbers are spelled out in their ordinary Greek form. The materials and orders of animals noticed in 7a1 are again indexed in 7a2 and 7b. Part 8 is not indexed, but with one exception, it follows the order of Part 3

There are four indexes given.

7a. The names of animals. This in turn is divided into two portions:

1. A list of insects and mites for each group of materials as taken up in Section 2. There are no page references in this index, but the species are arranged in the same order in which they appear in the Appendix (Section 8) so that an animal may be found and the rest of the information on it obtained. In those cases in which the animal is referred to in the text, 7a2 should be consulted and there the page reference will be found.

2. This includes both popular and scientific names as used in the text itself (Sections 1 to 7a1) with page references.

7b. The substances attacked which are referred to in the text but I have not listed all substances which may be mentioned in the Appendix.

7c. Methods and materials used in the control of insects and referred to in the text,

7d. Other items in the text.

Index A. Animals
1. By groups of materials.

A. Foods and closely related materials.
1. Grain, including rice and buckwheat, and its products.

Thysanura
- Lepisma saccharina

Orthoptera
- Gryllulus desertus
- Gryllulus domesticus
- Gryllus assimilis
- Blatta orientalis
- Blattella germanica
- Pycnoscelus surinamensis

Isoptera
- Termitidae
  - Termes formosanus

Embioptera
- Embia vayssierei

Psocoptera
- Caecilius nigrotuberculatus
- Lachesilla pedicularia
- Psoquilla marginepunctata
- Troctes corrodens
- Troctes divinatorius
- Trogium pulsatorium

Lepidoptera
- Aglossa caprealis
- Aglossa dimidiata
- Aglossa pinguinalis
- Alucita sp.
- Anchonoma xeraula
- Aristotelia austeropa
- Borkhausenia pseudospretella
- Celama sorghiella
- Cirphis zeae
- Corcyra cephalonica
- Dolessa viridis
- Ephestia cahiritella
- Ephestia cautella
- Ephestia elutella
- Ephestia figulilella
- Ephestia glycinivora
- Ephestia kuehniella
- Epithectis studiosa
- Hysopygia costalis
- Mussidia nigrivenella
- Nemapogon granella
- Paralipsa gularis
- Plodia interpunctella
- Pyralis farinalis

Lepidoptera
- Pyralis lienigialis
- Pyralis manihotalis
- Pyralis pictalis
- Pyroderces rileyi
- Santuzza kuwanii
- Setomorpha insectella
- Setomorpha rutella
- Sitotroga cerealella
- Thagora figurans
- Tinea cloacella
- Tinea ditella
- Tinea misella
- Tinea pallescentella
- Tinea personella
- Tinea secalella
- Tineola bisselliella

Coleoptera
- Anobiidae
  - Catorama herbarium
  - Catorama mexicana
  - Catorama punctulata
  - Catorama zeae
  - Lasioderma serricorne
  - Sitodrepa panicea
- Anthicidae
  - Anthicus elegans
  - Anthicus floralis
- Bostrichidae
  - Dinoderus bifoveolatus
  - Dinoderus minutus
  - Prostephanus truncatus
  - Rhizopertha dominica
  - Rhizopertha hordeum
  - Sinoxylon anale
  - Sinoxylon conigerum
- Calandridae
  - Calandra granaria
  - Calandra oryzae
  - Calandra sasakii
  - Myocalandra elongata
- Cleridae
  - Necrobia rufipes
  - Thaneroclerus buquet
- Colydiidae
  - Murmidius ovalis

Colydiidae
- Thaumaphrastus karanisensis

Cryptophagidae
- Cryptophagus affinis
- Cryptophagus cellaris
- Cryptophagus dentatus
- Cryptophagus distinguendus
- Cryptophagus fowleri
- Cryptophagus pallidus
- Cryptophagus scanicus
- Henoticus californicus
- Henoticus germanicus

Cucujidae
- Laemophloeus ater
- Laemophloeus ferrugineus
- Laemophloeus janeti
- Laemophloeus minutus
- Laemophloeus pusillus
- Laemophloeus turcicus
- Laemotmetus rhizophagoides

Curculionidae
- Caulophilus latinasus

Dermestidae
- Aethriostoma gloriosae
- Anthrenus scrophulariae
- Anthrenus verbasci
- Attagenus byturoides
- Attagenus pellio
- Attagenus piceus
- Dermestes frischi
- Dermestes lardarius
- Dermestes sp.
- Eucnocerus anthrenoides
- Trogoderma granarium
- Trogoderma inclusum
- Trogoderma ornatum
- Trogoderma tarsale
- Trogoderma versicolor

Endomychidae
- Mycetaea hirta

Languriidae
- Pharxonotha kirschi

Lathridiidae
- Adistemia rileyi
- Cartodere argus
- Cartodere costulata
- Cartodere filum
- Cartodere ruficollis
- Coninomus subfasciatus
- Corticaria fenestralis
- Corticaria pubescens
- Enicmus histrio

Lathridiidae
- Enicmus minutus
- Eufalloides holmesi
- Holoparamecus caularum
- Holoparamecus depressus
- Holoparamecus singularis
- Melanophthalma americana
- Magneauxia orientalis

Lyctidae
- Lyctus africanus
- Lyctus brunneus
- Minthea obsita
- Minthaa rugicollis

Monotomidae
- Monotoma quadrifoveolata

Mycetophagidae
- Litargus balteatus
- Mycetophagus bipustulatus
- Mycetophagus quadriguttatus
- Typhoea stercorea

Nitidulidae
- Carpophilus bipustulatus
- Carpophilus decipiens
- Carpophilus dimidiatus
- Carpophilus hemipterus
- Carpophilus humeralis
- Carpophilus ligneus
- Carpophilus nitens
- Carpophilus obsoletus
- Carpophilus pallipennis
- Stelidota geminata
- Urophorus humeralis

Ostomatidae
- Temnochila caerulea
- Tenebroides corticalis
- Tenebroides mauritanicus
- Tenebroides nanus
- Lophocateres pusillus

Platystomidae
- Araecerus fasciculatus
- Brachytarsus alternatus
- Brachytarsus sticticus

Ptinidae
- Eurostus hilleri
- Bibbium boieldieui
- Biggium psylloides
- Mezium affine
- Mezium americanum
- Niptus hololeucus
- Ptinus bicinctus
- Ptinus fur
- Ptinus japonicus

Ptinidae
- Ptinus latro
- Ptinus raptor
- Ptinus tectus
- Ptinus villiger
- Tipnus unicolor
- Trigonogenius globulus

Scolytidae
- Pagiocerus frontalis
- Pagiocerus zeae

Silvanidae
- Ahasverus advena
- Cathartus cassiae
- Cathartus quadricollis
- Nausibius clavicornis
- Oryzaephilus bicornis
- Oryzaephilus surinamensis

Staphylinidae
- Atheta trinotata
- Xylodromus concinnus

Tenebrionidae
- Alphitobius diaperinus
- Alphitobius laevigatus
- Alphitobius ovatus
- Alphitobius piceus
- Alphitophagus bifasciatus
- Aphanotus parallelus
- Blaps lethifera
- Blaps mortisaga
- Blaps mucronata
- Cynaeus angustus
- Gnathocerus cornutus
- Gnathocerus maxillosus
- Gonocephalum hoffmannseggi
- Hypophloeus floricola
- Laetheticus oryzae
- Martianus dermestoides
- Palorus depressus
- Palorus ratzeburgi
- Palorus subdepressus
- Platydema ruficorne
- Sitophagus hololeptoides
- Tenebrio molitor
- Tenebrio obscurus
- Tenebrio picipes
- Tenebrio syriacus
- Tribolium castaneum
- Tribolium confusum
- Tribolium destructor
- Tribolium madens
- Uloma culinaris

Thorictidae
- Thorictodes heydeni

Diptera
- Calliphora augur
- Calliphora stygia

Hymenoptera

Formicidae
- Atta sexdens
- Iridomyrmex humilis

Arachnida
- Aleuroglyphus ovatus
- Blomia kulagini
- Blomia thori
- Caloglyphus rodionovi
- Carpoglyphus anonymus
- Chortoglyphus arcuatus
- Eberhardia krameri
- Eberhardia rodikorzewi
- Ferminia fusca
- Glycyphagus cadaverum
- Glycyphagus domesticus
- Glycyphagus fustifer
- Glycyphagus michaeli
- Glycyphagus ornatus
- Kuzinia rhizoglyphoides
- Lepidoglyphus destructor
- Lepidoglyphus destructor mixtus
- Moniezиella entomophaga
- Rhizoglyphus echinopus
- Tarsonemus hordei
- Tyroglyphus americanus
- Tyroglyphus farinae
- Tyroglyphus literi
- Tyroglyphus siro
- Tyrophagus bulleri
- Tyrophagus infestas
- Tyrophagus mycophagus
- Tyrophagus noxius
- Tyrophagus putrescentiae

2. Meat and fish, fresh or inspecified.

Orthoptera
Blattariae
Blatta orientalis
Lepidoptera
Dysmosia parietariella
Tinea misella
Coleoptera
Cleridae
Necrobia ruficollis
Necrobia rufipes
Necrobia violacea
Dermestidae
Dermestes cadaverinus
Dermestes carnivorus
Dermestes peruvianus
Thylodrias contractus
Nitidulidae
Nitidula bipunctata
Tenebrionidae
Uloma culinaris
Diptera
Calliphora augur
Calliphora erythrocephala
Calliphora stygia
Calliphora vomitoria
Fannia pusio
Fannia scaloris
Helicobia australis
Hydrotaea dentipes
Lucilia caesar
Lucilia sericata
Muscina pabulorum
Muscina stabulans
Phormia caerulea
Phormia regina
Piophila casei
Sarcophaga annandalei
Sarchophaga aurifrons
Sarcophaga beta
Sarcophaga bullata
Diptera
Sarcophaga calicefera
Sarcophaga carnaria
Sarcophaga cirrhurs
Sarcophaga cooleyi
Sarcophaga depressa
Sarcophaga dux
Sarcophaga eta
Sarcophaga falculata
Sarcophaga froggatti
Sarcophaga fuscicanda
Sarcophaga haemorrhoidalis
Sarcophaga impar
Sarcophaga impatiens
Sarcophaga kappa
Sarcophaga knabi
Sarcophaga kohla
Sarcophaga misera
Sarcophaga nemoralis
Sarcophaga orientaloides
Sarcophaga peltata
Sarcophaga peregrina
Sarcophaga robusta
Sarcophaga ruficornis
Sarcophaga texana
Sarcophaga tryoni
Sarcophaga tuberosa
Tephrochlamys canescens
Hymenoptera
Formicidae
Iridomyrmex detectus
Iridomyrmex humilis
Solenopsis geminata
Solenopsis xyloni
Monomorium pharaonis
Arachnida
Tyrophagus mycophagus

3. Dried and smoked meat and fish

Thysanura
Lepisma saccharina
Lepidoptera
Endrosis lacteella
Tineola bisselliella
Coleoptera
Anobiidae
Lasioderma serricorne
Coleoptera
Cleridae
Corynetes caeruleus
Dermestidae
Anthrenocerus australis
Anthrenus fasciatus
Anthrenus pimpinellae
Attagenus pellio

Coleoptera
Dermestidae
Attagenus piceus
Dermestes cadaverinus
Dermestes frischi
Dermestes lardarius
Dermestes vulpinus
Nitidulidae
Nitidula bipunctata
Ptinidae
Ptinus tectus

Silphidae
Silpha lapponica
Silpha rugosa
Silvanidae
Oryzaephilus surinamensis
Diptera
Piophila casei
Sarcophaga spp.
Arachnida
Carpoglyphus passularum
Eriophyes domesticus

4. Peas, beans, and lentils.

Lepidoptera
Athetis clavipalpis
Corcyra cephalonica
Endrosis lacteella
Ephestia calidella
Ephestia kuehniella
Paralipsa gularis
Plodia interpunctella
Pyralis manihotalis
Sitotroga cerealella
Tinea misella
Coleoptera
Anobiidae
Sitodrepa panicea
Calandridae
Calandra oryzae
Cryptophagidae
Cryptophagus cellaris
Cucujidae
Laemophloeus ferrugineus
Curculionidae
Chalcodermus angulicollis
Dermestidae
Attagenus piceus
Dermestes coarctatus
Trogoderma granarium
Trogoderma sternale
Trogoderma tarsale
Mylabridae
Mylabris analis
Mylabris dentipes
Mylabris ervi
Mylabris impressithorax
Mylabris incarnatus
Mylabris lentis
Mylabris maculatus
Mylabris obtectus
Mylabris ornatus

Mylabridae
Mylabris phaseoli
Mylabris pisorum
Mylabris prosopis
Mylabris quadrimaculatus
Mylabris rufimanus
Mylabris tristis
Spermaophagus pectoralis
Spermophagus subfasciatus
Nitidulidae
Carpophilus hemipterus
Ostomatidae
Lophocateres pusillus
Platystomidae
Araecerus fasciculatus
Brachytarsus alternatus
Brachytarsus sticticus
Ptinidae
Ptinus fur
Scolytidae
Hypothenemus sp.
Silvanidae
Ahasverus advena
Tenebrionidae
Tenebrio obscurus
Tribolium castaneum
Tribolium confusum
Hymenoptera
Formicidae
Cardiocondyla britteni

5. Peanuts.

Thysanura
- Thermobia domestica

Embioptera
- Embia vayssierei

Lepidoptera
- Corcyra cephalonica
- Ephestia cautella
- Homoeosoma vagella
- Nemapogon granella
- Paralipsa gularis
- Plodia interpunctella

Coleoptera
- Anobiidae
  - Lasioderma serricorne
  - Lasioderma testaceum
- Calandridae
  - Calandra oryzae
- Dermestidae
  - Dermestes lardarius
  - Trogoderma sternale
  - Trogoderma tarsale
  - Trogoderma tricolor
- Mycetophagidae
  - Typhoea stercorea
- Mylabridae
  - Pachymerus acaciae
  - Pachymerus cassiae
- Nitidulidae
  - Carpophilus dimidiatus
  - Carpophilus ligneus
  - Carpophilus unimaculatus
- Silvanidae
  - Oryzaephilus gossypii
  - Oryzaephilus surinamensis
- Tenebrionidae
  - Alphitobius diaperinus
  - Homala polita
  - Palorus subdepressus
  - Pimelo angulosa
  - Pimela senegalensis
  - Tribolium castaneum
  - Tribolium confusum
  - Zophosis elineata

6. Other leguminous seeds.

Lepidoptera
- Borkhausenia pseudospretella
- Etiella zinckenella
- Herculia psammoxantha
- Myelois ceratoniae
- Paralipsa gularis
- Plodia interpunctella
- Trachylepidia fructicassiella

Coleoptera
- Dermestidae
  - Trogoderma sternale
- Mycetophagidae
  - Typhoea stercorea
- Mylabridae
  - Mylabris analis
  - Mylabris chinensis
  - Mylabris dentipes
  - Mylabris dolichosi
  - Mylabris ferrugineipennis
  - Mylabris glaber
  - Mylabris halodendri
  - Mylabris maculatus
  - Mylabris phaseoli
  - Mylabris pruininus
  - Mylabris rhodesianus
  - Mylabris rufimanus
  - Mylabris obtectus
  - Mylabris rufipes
  - Mylabris signaticornis
  - Mylabris trabuti
  - Mylabris tristis
  - Mylabris ulicis
  - Pachymerus fuscus
  - Pachymerus gonager
  - Pachymerus pallidus
  - Phelomerus lineola
  - Phelomerus ochropygus
  - Pseudopachymerus brasiliens
  - Pseudopachymerus grammicus
  - Pseudopachymerus lallemanti
  - Spermophagus subfasciatus
  - Spermophagus thomasi
- Nitidulidae
  - Meligethes aeneus
- Platystomidae
  - Araecerus fasciculatus
- Ptinidae
  - Gibbium psylloides
  - Ptinus tectus
- Tenebrionidae
  - Alphitobius piceus
  - Tribolium castaneum

7. Edible Nuts.

Lepidoptera
- Achroia grisella
- Dolessa viridis
- Ephestia cahiritella
- Ephestia calidella
- Ephestia cautella
- Ephestia elutella
- Ephestia figulilella
- Ephestia kuehniella
- Myelois ceratoniae
- Nemapogon granella
- Paralipsa gularis
- Plodia interpunctella
- Pyralis pictalis

Coleoptera
- Anobiidae
  - Lasioderma testaceum
- Anthicidae
  - Anthicus floralis
- Bostrichidae
  - Dinoderus minutus
- Cucujidae
  - Laemophloeus janeti
- Nitidulidae
  - Carpophilus dimidiatus
- Nitidulidae
  - Carpophilus flavidus
  - Carpophilus hemipterus
- Ostomatidae
  - Tenebroides mauritanicus
- Platystomidae
  - Araecerus fasciculatus
- Ptinidae
  - Ptinus tectus
- Scolytidae
  - Coccotrypes dactyliperda
  - Hypothenemus arecae
  - Neodryocoetes sp.
  - Peocilips nuciferus
- Silvanidae
  - Ahasverus advena
  - Oryzaephilus surinamensis
- Tenebrionidae
  - Aphanotus parallelus
  - Tribolium castaneum
  - Tribolium confusum

Hymenoptera
- Formicidae
  - Solenopsis xyloni

Arachnida
- Tyroglyphus lintneri

8. Cacao

Dermaptera
- Prolabia arachidis

Psocoptera
- Chaetopsocus richardsi
- Deipnopsocus spheciophilus disparilis
- Psoquilla marginepunctata
- Stenotroctes minor
- Troctes divinatorius
- Troctes virgulatus

Lepidoptera
- Corcyra cephalonica
- Ephestia cahiritella
- Ephestia cautella
- Ephestia elutella
- Ephestia kuehniella
- Mussidia nigrivenella
- Setomorpha rutella
- Setomorpha tineoides
- Tineopsis theobromae

Coleoptera
- Anobiidae
  - Lasioderma serricorne
- Bostrichidae
  - Dinoderus minutus
- Cleridae
  - Necrobia rufipes
  - Thaneroclerus buquet
- Cryptophagindae
  - Henoticus californicus
- Cucujidae
  - Laemophloeus ferrugineus
  - Laemophloeus janeti
  - Laemophloeus turcicus
- Curculionidae
  - Spermologus rufus
- Dermestidae
  - Dermestes carnivorus
  - Dermestes lardarius
  - Dermestes peruvianus

Dermestidae
Dermestes vulpinus
Mycetophagidae
Typhoea stercorea
Nitidulidae
Carpophilus decipiens
Carpophilus ligneus
Ostomatidae
Tenebroides mauritanicus
Tenebroides oblongus
Plastystomidae
Araecerus fasciculatus
Ptinidae
Niptus hololeucus
Ptinidae
Ptinus fur
Ptinus hirtellus
Ptinus tectus
Silvanidae
Ahasverus advena
Cathartus cassiae
Oryzaephilus surinamensis
Tenebrionidae
Alphitobius diaperinus
Gnathorcerus cornutus
Palorus subdepressus
Tribolium castaneum
Tribolium confusum

9. Raisins

Psocoptera
Trogium pulsatorium
Lepidoptera
Achroia grisella
Ephestia calidella
Ephestia elutella
Ephestia figulilella
Ephestia kuehniella
Ephestiodes nigrella
Myelois ceratoniae
Plodia interpunctella
Titula serratilineella
Coleoptera
Anobiidae
Lasioderma serricorne
Cleridae
Necrobia rufipes
Cryptophagidae
Cryptophagus affinis
Cryptophagus cellaris
Cryptophagus dentatus
Cryptophagus inscitus
Cryptophagus saginatus
Cryptophagus scanicus
Cryptophagus validus
Cucujidae
Laemophloeus ferriegineus
Lathridiidae
Enicmus protensicollis
Enicmus suspectus
Mycetophagidae
Typhoea stercorea
Ostomatidae
Tenebroides mauritanicus
Ptinidae
Ptinus gandolphei
Trigonogenius globulus
Silvanidae
Oryzaephilus surinamensis
Tenebrionidae
Apsena rufipes
Blapstinus dilatatus
Blapstinus rufipes
Cnemeplatia sericea
Gnathocerus cornutus
Tribolium castaneum
Tribolium confusum
Diptera
Meoneura obscurella
Sciara annulata
Arachnida
Carpoglyphus passularum

10. Dates.

Lepidoptera
Arenipses sabella
Borkhausenia psuedospretella
Ephestia afflatella
Ephestia calidella
Lepidoptera
Ephestia cautella
Ephestia figulilella
Ephestia kuehniella
Euzophera sp.

Lepidoptera
Myelois ceratoniae
Myelois phoenicis
Myelois zellerella
Syria sp.
Coleoptera
Anobiidae
Lasioderma serricorne

11. Copra

Psocoptera
Psocuilla marginepunctata
Lepidoptera
Corcyra cephalonica
Dolessa viridis
Ephestis cautella
Coleoptera
Anobiidae
Lasioderma serricorne
Calandridae
Calandra oryzae
Cleridae
Necrobia rufipes
Cucujidae
Laemophloeus pusillus
Laemophloeus turcicus
Dermestidae
Aethriostoma undulata
Dermestes cadaverinus

12. Other dried fruits

Orthoptera
Gryllulus domesticus
Psocoptera
Lepinotus inquilinus
Lepidoptera
Achroia grisella
Athetis clavipalpis
Borkhausenia pseudospretella
Cacoecia franciscana
Corcyra cephalonica
Endrosis lacteella
Ephestia cahiritella
Ephestia calidella
Ephestia elutella
Ephestia figulilella
Ephestia kuehniella
Ephestiodes nigrella
Eulia velutinana
Myelois ceratoniae
Myelois turkheimiella

Coleoptera
Nitidulidae
Carpophilus dimidiatus
Ptinidae
Ptinus fur
Silvanidae
Oryzaephilus surinamensis

Nitidulidae
Carpophilus dimidiatus
Carpophilus flavipes
Carpophilus hemipterus
Ostomatidae
Tenebroides mauritanicus
Silvanidae
Ahasverus advena
Oryzaephilus surinamensis
Tenebrionidae
Alphitobius diaperinus
Alphitobius laevigatus
Alphitobius ovatus
Palorus subdepressus
Tribolium castaneum
Ulomo foveicollis
Arachnida
Rhizoglyphus callae
Tyrophagus putrescentiae

Lepidoptera
Nemapogon granella
Paralipsa gularis
Plodia interpunctella
Pyralis manihotalis
Tinea fuscipunctella
Tinea vastella
Vitula serratilineella
Coleoptera
Anobiidae
Lasioderma serricorne
Anthicidae
Anthicus australis
Anthicus elegans
Bostrichidae
Apata monachus
Dinoderus minutus
Calandridae
Calandra granaria
Calandra oryzae

Coleoptera
    Cleridae
        Corynetes caeruleus
        Necrobia rufipes
    Colydiidae
        Murmidius ovalis
    Cryptophagidae
        Atomaria atricapilla
        Cryptophagus affinis
        Cryptophagus cellaris
        Cryptophagus croceus
        Cryptophagus dentatus
        Cryptophagus distinguendus
        Cryptophagus pilosus
        Cryptophagus scanicus
        Henoticus californicus
    Cucujidae
        Laemophloeus ferrugineus
        Laemophloeus turcicus
    Dermestidae
        Dermestes lardarius
    Nitidulidae
        Carpophilus aterrimus
        Carpophilus decipiens
        Carpophilus dimidiatus
        Carpophilus hemipterus
    Nitidulidae
        Carpophilus ligneus
        Haptoncus luteolus
    Ostomatidae
        Tenebroides mauritanicus
        Lophocateres pusillus
    Platystomidae
        Araecerus fasciculatus
    Ptinidae
        Ptinus tectus
        Trigonogenius globulus
    Silvanidae
        Ahasverus advena
        Cathartus quadricollis
        Oryzaephilus bicornis
        Oryzaephilus surinamensis
    Tenebrionidae
        Apsena rufipes
        Tribolium castaneum
Arachnida
        Carpoglyphus anonymus
        Carpoglyphus lactis
        Carpoglyphus passularum
        Glycyphagus domesticus
        Tyroglyphus siro
        Tyrophagus putrescentiae

13. Other miscellaneous seeds.

Orthoptera
        Gryllus assimilis
Psocoptera
        Lepinotus patruelis
Lepidoptera
        Achroia grisella
        Auxinobasis normalis
        Borkhausenia minutella
        Borkhausenia pseudospretella
        Dolessa viridis
        Endrosis lacteella
        Ephestia cautella
        Mampava bipunctella
        Monopis crocicapitella
        Monopis ferruginella
        Myelois solitella
        Nemapogon granella
        Pyroderces rileyi
        Paralipsa gularis
        Setomorpha rutella
        Tinea fuscipunctella
        Tinea misella
        Tineola bisselliella
Coleoptera
    Anobiidae
        Lasioderma serricorne
        Sitodrepa panicea
    Calandridae
        Calandra oryzae
    Carabidae
        Harpalus rufipes
    Cerambycidae
        Lophopoeum timbouvae
    Cucujidae
        Laemophloeus ferrugineus
        Laemophloeus janeti
        Laemophloeus minutus
        Laemophloeus modestus
    Curculionidae
        Apion crotalariae
        Caulophilus latinasus
    Dermestidae
        Anthrenus verbasci
        Attagenus piceus
        Dermestes lardarius
        Eucnocerus anthrenoides

Coleoptera
- Dermestidae
  - Orphinus aethiops
  - Trogoderma ornatum
  - Trogoderma sternale
  - Trogoderma tarsale
  - Trogoderma versicolor
- Mycetophagidae
  - Typhoea stercorea
- Mylabridae
  - Mylabris ademptus
  - Mylabris bixae
  - Mylabris chinensis
  - Mylabris incarnatus
  - Mylabris pygmaeus
  - Pachymerus acaciae
  - Pachymerus fuscus
  - Pachymerus gonager
  - Pachymerus nucleorum
  - Pachymerus pallidus
- Ostomatidae
  - Tenebroides mauritanicus
- Platystomidae
  - Araecerus fasciculatus
- Ptinidae
  - Gibbium psylloides
  - Mezium affine
  - Niptus hololeucus
  - Ptinus fur
  - Trigonogenius globulus
- Scolytidae
  - Coccotrypes dactyliperda
  - Coccotrypes moreirai
- Scolytidae
  - Hypothenemus sp.
  - Paglocerus frontalis
- Silvanidae
  - Ahasverus advena
  - Oryzaephilus gossypii
  - Oryzaephilus surinamensis
- Tenebrionidae
  - Al hitobius diaperinus
  - Gr thocerus maxillosus
  - Palorus depressus
  - Tenebrio molitor
  - Tenebrio obscurus
  - Tribolium castaneum
  - Tribolium confusum
  - Tribolium destructor
- Thorictidae
  - Thorictodes heydeni

Hymenoptera
- Formicidae
  - Solenopsis geminata

Arachnida
- Aleuroglyphus ovatus
- Caloglyphus rodianovi
- Glycyphagus michaeli
- Glycyphagus obesus
- Glycyphagus robustus
- Tyroglyphus americanus
- Tyroglyphus farinae
- Tyroglyphus lintneri
- Tyrophagus dimidiatus
- Tyrophagus mycophagus

14. Dried vegetables

Orthoptera
- Gryllulus domesticus

Psocoptera
- Troctes divinatorius

Lepidoptera
- Aphomia sociella
- Athetis clavipalpis
- Bactra lanceolana
- Ephestia kuehniella
- Erechthias zebrina
- Oegoconia quadripunctata
- Plodia interpunctella
- Symmoca signatella
- Tinea fuscipunctella

Coleoptera
- Calandridae
  - Calandra granaria
- Ptinidae
  - Gibbium psylloides
  - Mezium affine
  - Ptinus fur
- Tenebrionidae
  - Tribolium confusum

15. Fresh potatoes

Lepidoptera
- Acrolepia manganeutis
- Ephestia kuehniella

Lepidoptera
- Opogona subcervinella
- Phthorimaea operculella
- Phthorimaea plaesiosoma
- Xylomyges eridania

Coleoptera
- Bostrichidae
  - Dinoderus oblongopunctatus
  - Dinoderus porcellus
- Calandridae
  - Calandra oryzae
- Curculionidae
  - Caulophilus latinasus
  - Cossonus suturalis
  - Cylas formicarius
- Ostomatidae
  - Lophocateres pusillus
- Platystomidae
  - Araecerus fasciculatus
- Scolytidae
  - Hypothenemus ritchei
- Silvanidae
  - Ahasverus advena
- Tenebrionidae
  - Tenebrio obscurus

Diptera
- Drosophila funebris

Arachnida
- Rhizoglyphus echinopus
- Tyrophagus mycophagus

16. Spices, condiments, etc.

Orthoptera
- Blattariae
  - Blabera sp.
  - Periplaneta americana
  - Periplaneta australasiae

Dermaptera
- Prolabia arachidis

Lepidoptera
- Borkhausenia pseudospretella
- Ephestia cautella

Coleoptera
- Anobiidae
  - Lasioderma serricorne
  - Sitodrepa panicea
- Bostrichidae
  - Dinoderus minutus
- Calandridae
  - Calandra granaria
- Carabidae
  - Plochionus pollens
- Cleridae
  - Necrobia rufipes
  - Thaneroclerus buquet
- Cryptophagidae
  - Henoticus californicus
- Cucujidae
  - Laemophloeus ferrugineus
  - Laemophloeus minutus
  - Laemophloeus turcicus
- Curculionidae
  - Caulophilus latinasus
- Dermestidae
  - Attagenus piceus
  - Dermestes cadaverinus
  - Dermestes lardarius
  - Trogoderma sternale
  - Trogoderma tarsale
- Lyctidae
  - Lyctus africanus
- Nitidulidae
  - Carpophilus dimidiatus
- Ostomatidae
  - Tenebroides mauritanicus
  - Lophocateres pusillus
- Platystomidae
  - Araecerus fasciculatus
- Ptinidae
  - Gibbium psylloides
  - Mezium americanum
  - Ptinus fur
  - Ptinus tectus
  - Sphaericus gibboides
- Scolytidae
  - Stephanoderes buscki
- Silvanidae
  - Ahasverus advena
  - Oryzaephilus surinamensis
- Staphylinidae
  - Atheta coriaria
  - Philonthus sordidus
- Tenebrionidae
  - Gnathocerus cornutus
  - Gnathocerus maxillosus
  - Sitophagus hololeptoides
  - Tribolium castaneum
  - Tribolium confusum

Diptera
Drosophila funebris
Fannia scaloris
Leptocera sp.
Limosina heteroneura
Mydaea sp.
Diptera
Scatopse fuscipes
Sciara annulata
Arachnida
Glycyphagus domesticus

17. Oils, fats, waxes, edible or inedible.

Thysanura
Thermobia domestica
Orthoptera
Blattariae
Blatta orientalis
Periplaneta australasiae
Lepidoptera
Achroia grisella
Coleoptera
Anobiidae
Lasioderma serricorne
Cleridae
Necrobia ruficollis
Necrobia rufipes
Necrobia violacea
Dermestidae
Dermestes lardarius
Ptinidae
Gibbium psylloides
Niptus hololeucus
Diptera
Sarcophaga spp.
Hymenoptera
Formicidae
Monomorium floricola
Monomorium pharaonis
Solenopsis geminata
Solenopsis molesta
Solenopsis xyloni
Arachnida
Tyrophagus mycophagus

18. Dried eggs.

Coleoptera
Cleridae
Necrobia rufipes
Coleoptera
Dermestidae
Attagenus pellio

19. Dried milk.

Coleoptera
Anobiidae
Sitodrepa panicea
Cleridae
Necrobia rufipes
Dermestidae
Anthrenocerus australis
Attagenus piceus
Dermestidae
Trogoderma versicolor
Diptera
Drosophila buscki
Drosophila repleta
Leptocera caenosa

20. Cheese

Orthoptera
Blattariae
Blatta orientalis
Coleoptera
Cleridae
Necrobia ruficollis
Necrobia rufipes
Necrobia violacea
Coleoptera
Dermestidae
Anthrenus fasciatus
Anthrenus vorax
Dermestes cadaverinus
Dermestes frischi
Dermestes lardarius
Dermestes vulpinus

Coleoptera
- Ptinidae
  - Gibbium boieldieui

Diptera
- Fannia canicularis
- Piophila casei
- Sarcophaga spp.

Arachnida
- Carpoglyphus anonymus

Arachnida
- Glycyphagus domesticus
- Tyroglyphus farinae
- Tyroglyphus lintneri
- Tyroglyphus siro
- Tyroglyphus terminalis
- Tyrophagus mycopyagus
- Tyrophagus putrescentiae

21. Chocolate

Lepidoptera
- Corcyra cephalonica
- Ephestia elutella
- Ephestia kuehniella
- Plodia interpunctella
- Pyralis manihotalis

Coleoptera
- Anobiidae
  - Sitodrepa panicea

Coleoptera
- Dermestidae
  - Dermester lardarius
- Lathridiidae
  - Holoparamecus depressus
- Ptinidae
  - Ptinus tectus
- Tenebrionidae
  - Alphitobius diaperinus

B. Equipment and supplies and their raw materials.

1. Textiles and other materials from natural cellulose fibres.

Thysanura
- Ctenolepisma urbana
- Thermobia aegyptiaca
- Thermobia domestica

Orthoptera
- Gryllacris sechellensis
- Gryllodes sigillatus
- Gryllus assimilis
- Blattella germanica
- Leucophaea maderae
- Periplaneta americana

Dermaptera
- Forficula auricularia

Isoptera
- Mastotermitidae
  - Mastotermes darwiniensis
- Rhinotermitidae
  - Reticulitermes flavipes
- Termitidae
  - Nasutitermes ephratae

Trichoptera
- Anabolia laevis
- Anabolia nervosa
- Grammataulius atomarius
- Limnophilus flavicornis
- Limnophilus lunatus
- Limnophilus rhombicus

Lepidoptera
- Athetis clavipalpis
- Borkhausenia pseudospretall

Coleoptera
- Anobiidae
  - Anobium punctatum
  - Neogastrallus librinocens
  - Sitodrepa panicea
- Bostrichidae
  - Dinoderus minutus
- Dermestidae
  - Anthrenus fasciatus
  - Orphinus aethiops
- Ptinidae
  - Niptus hololeucus
  - Ptinus fur
  - Ptinus tectus

Diptera
- Syrphid larvae

Hymenoptera
- Formicidae
  - Monomorium destructor
  - Solenopsis geminata
  - Solenopsis xyloni
  - Solenopsis xyloni var. maniosa
  - Tapinoma melanocephalum

2. Paper and books.

Thysanura
- Ctenolepisma longicaudata
- Ctenolepisma targionii
- Ctenolepisma urbana
- Lepisma saccharina
- Thermobia domestica

Orthoptera
- Gryllacris sechellensis
- Gryllulus domesticus
- Blatta concinna
- Blattella germanica
- Neostylopyga rhombifolia
- Periplaneta americana
- Periplaneta australasiae
- Supella supellectilium

Isoptera
- Hodotermitidae
  - Hodotermes spp.
- Rhinotermitidae
  - Coptotermes truncatus
  - Prorhinotermes inopinatus
  - Reticulitermes flavipes
  - Rhinotermes transluceus

Psocoptera
- Lepinotus inquilinus
- Troctes divinatorius

Lepidoptera
- Borkhausenia pseudospretella
- Ephestia cautella
- Ephestia elutella
- Plodia interpunctella

Coleoptera
- Anobiidae
  - Anobium punctatum
  - Catorama bibliothecarum
- Anobiidae
  - Catorama herbarium
  - Ernobius mollis
  - Gastrallus indicus
  - Dorcatoma bibliophagum
  - Dorcatoma spp.
  - Lasioderma serricorne
  - Neogastrallus librinocens
  - Nicobium castaneum
  - Sitodrepa panicea
- Bostrichidae
  - Psoa dubia
  - Rhizopertha dominica
- Calandridae
  - Calandra granaria
  - Calandra oryzae
- Dermestidae
  - Anthrenus museorum
  - Attagenus piceus
  - Thylodrias contractus
- Mylabridae
  - Mylabris maculatus
  - Mylabris obtectus
- Ostomatidae
  - Tenebroides mauritanicus
- Ptinidae
  - Niptus hololeucus
  - Ptinus hirtellus
- Tenebrionidae
  - Alphitobius ovatus
  - Tenebrio molitor

3. Artificial silk and rayon.

Thysanura
- Ctenolepisma lineata
- Ctenolepisma longicaudata
- Ctenolepisma urbana
- Thermobia domestica

Orthoptera
- Gryllulus domesticus
- Gryllulus servillei

Lepidoptera
- Athetis clavipalpis

Coleoptera
- Dermestidae
  - Anthrenus fasciatus
- Ptinidae
  - Niptus hololeucus

4. Cellophane

Thysanura
- Ctenolepisma quadriseriata

Isoptera
- Rhinotermitidae
  - Reticulitermes flavipes

Coleoptera
- Anobiidae
  - Lasioderma serricorne
- Ptinidae
  - Ptinus tectus

5. Wool, fur and feathers.

Orthoptera
- Gryllulus domesticus
- Gryllulus servillei
- Gryllus assimilis
- Blatta orientalis

Dermaptera
- Forficula auricularia

Psocoptera
- Trogium pulsatorium

Lepidoptera
- Athetis clavipalpis
- Borkhausenia pseudospretella
- Endrosis lacteella
- Monopis crocicapitella
- Monopis dicycla
- Monopis ethelella
- Monopis ferruginella
- Monopis imella
- Monopis monachella
- Monopis rusticella
- Setomorpha insectella
- Setomorpha rutella
- Setomorpha tineoides
- Tinea fuscipunctella
- Tinea lapella
- Tinea opsigona
- Tinea pachyspila
- Tinea pallescentella
- Tinea semifulvella
- Tinea vastella
- Tineola bisselliella
- Tineola walsinghami
- Trichophaga tapetzella

Coleoptera

Anobiidae
- Catorama herbarium
- Lasioderma serricorne

Dermestidae
- Aethriostoma gloriosae
- Anthrenocerus australis
- Anthrenus fasciatus
- Anthrenus fuscus
- Anthrenus museorum
- Anthrenus nebulosus
- Anthrenus pimpinellae
- Anthrenus scrophulariae
- Anthrenus verbasci
- Anthrenus vorax
- Attagenus japonicus
- Attagenus pellio
- Attagenus piceus
- Attagunus plebejus
- Dermestes cadaverinus
- Dermestes frischi
- Dermestes murinus
- Thylodrias contractus
- Trogoderma ornatum
- Trogoderma sternale
- Trogoderma tarsale
- Trogoderma versicolor

Ptinidae
- Gibbium psylloides
- Mezium americanum
- Niptus hololeucus
- Ptinus fur
- Ptinus hirtellus

Tenebrionidae
- Tenebrio molitor
- Tribolium castaneum

Diptera
- Piophila casei

Hymenoptera

Formicidae
- Solenopsis xyloni

Arachnida
- Glycyphagus domesticus

6. Leather

Orthoptera
- Gryllulus desertus
- Blatta orientalis

Isoptera

Mastotermitidae
- Mastotermes darwiniensis

Lepidoptera
- Tinea fuscipunctella

Coleoptera

Anobiidae
- Sitodrepa panicea

Bostrichidae
- Rhizopertha dominica

Dermestidae
- Anthrenus fasciatus
- Attagenus byturoides

Coleoptera
Dermestidae
Attagenus piceus
Dermestes cadaverinus
Dermestes lardarius
Trogoderma ornatum
Trogoderma sternale

Dermestidae
Trogoderma versicolor
Ptinidae
Gibbium psylloides
Niptus hololeucus
Ptinus fur.

7. Hides.

Isoptera
Mastotermitidae
Mastotermes darwiniensis
Lepidoptera
Blastobasis lignea
Borkhausenia pseudospretella
Endrosis lacteella
Monopis ethelella
Monopis monachella
Tinea misella
Tinea pallescentella
Trichophaga tapetzella
Coleoptera
Cleridae
Corynetes caeruleus
Necrobia rufipes
Cryptophagidae
Cryptophagus acutangulus
Dermestidae
Anthrenocerus australis

Dermestidae
Anthrenus fasciatus
Anthrenus museorum
Dermestes carnivorus
Dermestes frischi
Dermestes lardarius
Dermestes murinus
Dermestes oblongus
Dermestes vulpinus
Trogoderma tarsale
Ptinidae
Gibbium boieldieui
Ptinus fur
Ptinus hirtellus
Tipnus unicolor
Tenebrionidae
Alphitobius diaperinus
Diptera
Piophila casei

8. True silk.

Thysanura
Thermobia domestica
Dermaptera
Forficula auricularia
Isoptera
Mastotermitidae
Mastotermes darwiniensis
Lepidoptera
Tinea pellionella
Coleoptera
Anobiidae
Lasioderma serricorne
Dermestidae
Anthrenus fasciatus
Anthrenus verbasci
Anthrenus vorax

Dermestidae
Attagenus japonicus
Attagenus piceus
Dermestes cadaverinus
Dermestes frischi
Dermestes oblongus
Dermestes undulatus
Thylodrias contractus
Trogoderma sternale
Ostomatidae
Tenebroides mauritanicus
Ptinidae
Niptus hololeucus
Hymenoptera
Formicidae
Solenopsis xyloni

9. Natural sponges.

9. Natural sponges.

Coleoptera
Dermestidae
Anthrenus fasciatus
Dermestes frischi
Dermestidae
Dermestes lardarius
Ptinidae
Niptus hololeucus

10. Starch pastes and finishes.

Thysanura
Ctenolepisma longicaudata
Ctenolepisma quadriseriata
Lepisma saccharina
Thermobia domestica
Orthoptera
Blattella germanica
Orthoptera
Parcoblatta pensylvanica
Periplaneta americana
Periplaneta australasiae
Coleoptera
Ptinidae
Gibbium psylloides

11. Glue and casein pastes and finishes.

Thysanura
Ctenolepisma quadriseriata
Orthoptera
Pycnoscelus surinamensis
Psocoptera
Trogium pulsatorium
Lepidoptera
Nemapogon granella
Tineola bisselliella
Coleoptera
Anobiidae
Gastrallus laticollis
Cleridae
Corynetes caeruleus
Dermestidae
Anthrenus vorax
Attagenus pellio
Attagenus piceus
Dermestes vulpinus
Lathridiidae
Eufallia unicostata
Ptinidae
Niptus hololeucus
Ptinus tectus

12. Plastic and resin pastes and finishes.

Thysanura
Lepisma saccharina
Coleoptera
Anobiidae
Sitodrepa panicea

13. Vegetable ivory.

Coleoptera
Scolytidae
Coccotrypes dactyliperda
Coccotrypes moreirai

14. Rubber

Isoptera
Rhinotermitidae
Coptotermes niger
Termitidae
Nasutitermes ephratae
Coleoptera
Ptinidae
Gibbium psylloides
Hymenoptera
Formicidae
Monomorium destructor
Monomorium gracillimum var.
Monomorium latinode (mayri
Solenopsis geminata
Solenopsis xyloni

15. Felt.

Isoptera
  Termitidae
    Microtermes sudanensis
    Termes pauperans

16. Photographic emulsions.

Thysanura
    Ctenolepisma longicaudata

17. Nylon.

Lepidoptera
    Tinea pellionella

C. Materials of construction.
  1. Wood and wood products, including plywood.

Orthoptera
    Gryllulus desertus
    Gryllulus domesticus

Isoptera
  Kalotermitidae
    Kalotermes fairchildi
    Kalotermes brevis
    Kalotermes buxtoni
    Kalotermes cynocephalus
    Kalotermes domesticus
    Kalotermes havilandi
    Kalotermes lamanianus
    Kalotermes pallidus
    Kalotermes piceatus
    Kalotermes pseudobrevis
    Kalotermes secundus
    Kalotermes (Cryptotermes) sp.
    Kalotermes (Cryptotermes) sp.
    Kalotermes (Glyptotermes) pubescens
    Kalotermes approximatus
    Kalotermes clevelandi
    Kalotermes condonensis
    Kalotermes flavicollis
    Kalotermes hubbardi
    Kalotermes marginipennis
    Kalotermes minor
    Kalotermes platycephalus
    Kalotermes repandus
    Kalotermes schwarzi
    Kalotermes snyderi
    Kalotermes longicollis

  Kalotermitidae
    Kalotermes assmuthi
    Kalotermes castaneus
    Kalotermes simplicicornis
    Kalotermes dudleyi
    Porotermes adamsoni
    Zootermopsis augusticollis
  Mastotermitidae
    Mastotermes darwiniensis
  Rhinotermitidae
    Coptotermes acinaciformis
    Coptotermes amanii
    Coptotermes ceylonicus
    Coptotermes crassus
    Coptotermes formosanus
    Coptotermes frenchi
    Coptotermes grandiceps
    Coptotermes havilandi
    Coptotermes heimi
    Coptotermes javanicus
    Coptotermes lacteus
    Coptotermes marabitanus
    Coptotermes niger
    Coptotermes parvulus
    Coptotermes raffrayi
    Coptotermes sjostedti
    Coptotermes solomonensis
    Coptotermes testaceus
    Coptotermes travians
    Coptotermes truncatus
    Coptotermes vastator
    Leucotermes aureus

Isoptera
  Rhinotermitidae
    Leucotermes ceylonicus
    Leucotermes convexinotatus
    Leucotermes ferox
    Leucotermes indicola
    Leucotermes philippinensis
    Leucotermes tennis
    Prorhinotermes canalifrons
    Prorhinotermes inopinatus
    Prorhinotermes luzonensis
    Psammotermes allocerus
    Reticulitermes chinensis
    Reticulitermes claripennis
    Reticulitermes flaviceps
    Reticulitermes flavipes
    Reticulitermes hageni
    Reticulitermes hesperus
    Reticulitermes humilis
    Reticulitermes lucifugus
    Reticulitermes speratus
    Reticulitermes tibialis
    Reticulitermes virginicus
    Rhinotermes intermedius
    Rhinotermes malaccensis
    Rhinotermes putorius
    Rhinotermes translucens
  Termitidae
    Acanthotermes militaris
    Acanthotermes minor
    Amitermes capito
    Amitermes elongatus
    Amitermes minimus
    Amitermes obeuntis
    Amitermes wheeleri
    Ancistrotermes amphidon
    Ancistrotermes guineensis
    Ancistrotermes periphrasis
    Cornitermes striatus
    Macrotermes bellicosus
    Macrotermes natalensis
    Macrotermes nigeriensis
    Macrotermes swaziae
    Macrotermes ukuzii
    Macrotermes usutu
    Macrotermes gilvus
    Microcerotermes havilandi
    Microcerotermes heimi
    Microcerotermes los-baniensis
    Microcerotermes nervosus
    Microtermes obesi
    Microtermes sudanensis
    Mirotermes melvillensis
  Termitidae
    Mirotermes langi
    Nasutitermes olidus
    Nasutitermes usambariensis
    Nasutitermes yandiniensis
    Nasutitermes ceylonicus
    Nasutitermes corniger
    Nasutitermes costalis
    Nasutitermes ephratae
    Nasutitermes exitiosus
    Nasutitermes lacustris
    Nasutitermes luzonicus
    Nasutitermes matangensis
    Nasutitermes nigriceps
    Nasutitermes rippertі
    Nasutitermes voeltzkowi
    Nasutitermes leucops
    Nasutitermes mexicanus
    Nasutitermes zeteki
    Nasutitermes ibidanicus
    Synacanthotermes zanziberer
    Termes sp.
    Termes badius
    Termes transvaalensis
    Termes formosanus
    Termes redemanni
    Termes obscuriceps
    Termes ceylonicus
    Termes feae
    Termes horni
    Termes latericius
    Termes pauperans
Trichoptera
    Hydropsyche lepida
    Hydropsyche ornatula
    Hydropsyche pellucida
    Nerueclipsis bimaculata
Coleoptera
  Anobiidae
    Anobium magnum
    Anobium punctatum
    Calymmaderus capucinus
    Calymmaderus incisus
    Calymmaderus oblongus
    Catorama herbarium
    Coelostethus truncatus
    Dorcatoma spp.
    Ernobius mollis
    Eupactus oblongus
    Hadrobregmus carinatus
    Hadrobregmus destructor
    Hadrobregmus gibbicollis
    Hedobia imperialis

Coleoptera
Anobiidae
Nicobium castaneum
Ochina ptinoides
Oligomerus obtusus
Oligomerus ptilinoides
Platybregmus canadensis
Ptilinus pectinicornis
Trypopitys carpini
Trypopitys punctatus
Xestobium rufavillosum
Xyletinus peltatus
Bostrichidae
Amphicerus anobioides
Amphicerus hamatus
Apatides fortis
Apoleon edax
Bostrychoplites cornutus
Bostrychoplites productus
Bostrychopsis bengalensis
Bostrychopsis parallela
Bostrychus capucinus
Bostrichus cylindricus
Calopertha truncatula
Dinoderus biforveolatus
Dinoderus brevis
Dinoderus favosus
Dinoderus minutus
Dinoderus ocellaris
Dinoderus sp.
Heterobostrychus aequalis
Heterobostrychus brunneus
Heterobostrychus hamatipennis
Heterobostrychus pileatus
Heterobostrychus unicornis
Micrapate brasiliensis
Micrapate puncticollis
Polycaon stouti
Prostephanus punctatus
Prostephanus truncatus
Psoa viennensis
Rhizopertha dominica
Scobicia declivis
Sinoxylon anale
Sinoxylon ceratoniae
Sinoxylon conigerum
Sinoxylon crassum
Sinoxylon indicum
Sinoxylon pubens
Sinoxylon pugnax
Sinoxylon senegalense

Bostrichidae
Sinoxylon sexdentatum
Sinoxylon sudanicum
Sinoxylon tignarium
Tetrapriocera longicornis
Xylion adustus
Xylion cylindricum
Xylobiops basilare
Xylopertha crinitarsis
Xylopertha picea
Xylopertha nitidipennis
Xylopsocus capucinus
Xylopsocus radula
Xylopsocus sellatus
Xylothrips flavipes
Xylothrips religiosus
Buprestidae
Buprestis aurulenta
Buprestis fasciata
Buprestis laeviventris
Buprestis rufipes
Chrysobothris octocola
Chrysochroa sp.
Chrysophana placida
Prosopheres aurantiopictus
Trachykele spp.
Calandridae
Myocalandra elongata
Cerambycidae
Acanthocinus aedilis
Acolesthes holosericea
Ambeodontis tristis
Asemum striatinum
Callidium antennatum
Callidium violaceum
Chion cinctus
Chlorophorus annularis
Criocephalus rusticus
Cyllene caryae
Dihammus elongatus
Diorthus cinereus
Eburia quadrigeminata
Ergates faber
Ergates spiculatus
Gracilia minuta
Hylotrupes bajulus
Leptidea brevipennis
Leptura rubra
Megaderus stigma
Merium proteus
Mesosa indica

Coleoptera
Cerambycidae
Necydalis indica
Neoclytus caprea
Neoclytus erythrocephalus
Neoclytus rufus
Oeme costata
Oeme rigida
Oeme strangulata
Orthosoma brunneum
Parandra brunnea
Phymatodes dimidiatus
Phymatodes lividum
Phymatodes testaceus
Prionus californicus
Smodicum cucujiforme
Sphenostethus taslei
Stromatium barbatum
Stromatium fulvum
Stromatium longicorne
Tetropium castaneum
Trachyderes succinctus
Tragosoma harrisii
Cleridae
Opilo domesticus
Cryptophagidae
Cryptophagus acutangulus
Curculionidae
Cossonus parallelopipedus
Dryotribus mimeticus
Eremotes porcatus
Gononotus angulicollis
Hexarthrum ulkei
Pselactus spadix
Rhyncolus culinaria
Stenoscelis brevis
Xenocnema spinipes
Dermestidae
Dermestes lardarius
Dermestes peruvianus
Dermestes vulpinus
Lyctidae
Lyctoxylon convictor
Lyctoxylon japonum
Lyctus africanus
Lyctus brunneus
Lyctus carbonarius
Lyctus caribeanus
Lyctus cavicollis
Lyctus linearis

Lyctidae
Lyctus malayanus
Lyctus opaculus
Lyctus planicollis
Lyctus pubescens
Lyctus sinensis
Lyctus tomentosus
Lyctus villosus
Minthea rugicollis
Minthea squamigera
Trogoxylon aequale
Trogoxylon auriculatum
Trogoxylon impressum
Trogoxylon parallelopipedu
Trogoxylon spinifrons
Lymexylonidae
Lymexylon navale
Atractocerus brevicornis
Atractoceros brasiliensis
Melandryidae
Serropalpus barbatus
Micromalthidae
Micromalthus debilis
Oedemeridae
Calopus serraticornis
Copidita bicolor
Ditylus laevis
Ditylus quadricollis
Nacerda melanura
Ostomatidae
Tenebroides mauritanicus
Platypodidae
Crossotarsus grevilleae
Platypus alternans
Platypus lepidus
Platypus mulsanti
Platypus omnivorus
Platypus ratzeburgi
Platypus suffodiens
Ptinidae
Gibbium psylloides
Mezium affine
Ptinus tectus
Ptinus villiger
Tipnus unicolor
Scolytidae
Hylocurus langstoni
Xyleborus affinis
Xyleborus badius
Xyleborus cognatus
Xyleborus confusus
Xyleborus fornicatus

Scolytidae
Xyleborus fuscatus
Xyleborus interjectus
Xyleborus intersetosus
Xyleborus kraatzi
Xyleborus laticollis
Xyleborus obraeus
Xyleborus semigranosus
Xyleborus tegalensis
Xyleborus torquatus
Xyloterus lineatus
Silvanidae
Silvanus trivialis
Tenebrionidae
Strongylium erythrocephahum
Tenebrio molitor
Hymenoptera
E. lades nigricornis
Lithurgus albofimbriatus
Sirex areolatus
Sirex gigas
Sirex noctilio
Stigmus fulvicornis

Hymenoptera
Xylocopa aeneipennis
Xylocopa aestuans
Xylocopa auripennis
Xylocopa californica
Xylocopa dissimilis
Xylocopa iridipennis
Xylocopa latipes
Xylocopa orpifex
Xylocopa sp.
Xylocopa tenuiscapa
Xylocopa verticalis
Xylocopa violacea
Xylocopa virginica
Formicidae
Camponotus herculeanus
Camponotus levigatus
Camponotus maculatus
Camponotus rufipes
Camponotus senex var. mus
Lasius fuliginosus

2. Compo board and wall board.

Isoptera
Kalotermitidae
Kalotermes brevis

Hymenoptera
Formicidae
Monomorium destructor

3. Concrete

Isoptera
Rhinotermitidae
Coptotermes truncatus
Leucotermes tennis

4. Asphalt.

Coleoptera
Bostrichidae
Scobicia declivis

D. Metals.
1. Lead

Isoptera
Rhinotermitidae
Coptotermes niger
Leucotermes tennis
Reticulitermes flavipes

Coleoptera
Bostrichidae
Amphicerus bimaculatus
Bostrychopsis jesuita
Bostrychus capucinus

Coleoptera
  Bostrichidae
    Bostrichus cylindricus
    Micrapate brasiliensis
    Scobicia declivis
    Scobicia pustulata
    Sinoxylon ruficorne
    Sinoxylon sexdentatum
    Xylopertha sp.
    Xylopsocus gibbicollis
  Buprestidae
    Buprestis japonensis
  Cerambycidae
    Callidium antennatum
    Eburia quadrigeminata
    Hylotrupes bajulus
    Megaderus stigma
    Monochamus confusor
    Pyrrhidium sanguineum
    Tetropium gabrieli

Coleoptera
  Dermestidae
    Dermestes lardarius
    Dermestes peruvianus
  Lyctidae
    Lyctus brunneus
    Lyctus canaliculatus
    Lyctus spp.
    Minthea rugicollis
  Ptinidae
    Ptinus sexpunctatus
  Scolytidae
    Micrasis hirtellus
Hymenoptera
    Sirex gigas
    Xylocopa latipes
    Xylocopa sp.
  Formicidae
    Monomorium destructor

2. Aluminum.

Lepidoptera
    Ephestia cautella
    Ephestia elutella
    Plodia interpunctella

3. Copper

Coleoptera
  Bostrichidae
    Scobicia declivis

Coleoptera
  Lyctidae
    Lyctus brunneus

4. Tin

Isoptera
  Rhinotermitidae
    Reticulitermes flavipes

Lepidoptera
    Ephestia cautella
    Ephestia elutella
    Plodia interpunctella
Coleoptera
  Bostrichidae
    Heterobostrychus aequalis

Coleoptera
  Dermestidae
    Dermestes lardarius
    Dermestes peruvianus
Hymenoptera
    Sirex gigas

5. Other metals.

Hymenoptera
    Sirex gigas

E. Houses and storage buildings, etc.

Thysanura
- Acrotelsa collaris
- Ctenolepisma ciliata
- Ctenolepisma longicaudata
- Ctenolepisma targionii
- Lepisma latithoracica

Orthoptera
- Amphiacusta caribbea
- Gryllus oceanicus
- Blattella vaga
- Cutilia soror
- Eoblatta notulata
- Leucophaea maderae
- Neostylopyga rhombifolia
- Pycnoscelus surinamensis

Dermaptera
- Prolabia arachidis

Psocoptera
- Dorypteryx pallida
- Lachesilla pedicularia
- Lepinotus inquilinus
- Lepinotus patruelis
- Lepinotus reticulatus
- Myopocnema annulata
- Nymphopsocus destructor
- Psyllipsocus ramburi
- Pteroxanium squamosum
- Rhyopsocopsis peregrinus
- Troctes corrodens
- Troctes virgulatus

Lepidoptera
- Dryadaula pactolia
- Hadena basilinea
- Tinea lapella

Coleoptera
- Anobiidae
  - Trypopitys carpini
- Bostrichidae
  - Heterobostrychus pileatus
- Cryptophagidae
  - Cryptophagus acutangulus
- Dermestidae
  - Attagenus alfierii
- Lathridiidae
  - Cartodere elegans
  - Cartodere elongata
  - Coninomus constrictus
  - Coninomus nodifer
  - Corticaria ciliata
  - Corticaria crenicollis

Coleoptera
- Lathridiidae
  - Corticaria crenulata
  - Corticaria elongata
  - Corticaria fulva
  - Corticaria impressa
  - Corticaria longicollis
  - Corticaria pubescens
  - Corticaria serrata
  - Enicmus minutus
  - Euchionellus albofasciatus
  - Lathridius bergrothi
  - Lathridius rugicollis
- Lyctidae
  - Minthea rugicollis
- Ptinidae
  - Gibbium boieldieui
  - Gibbium psylloides
  - Mezium affine
  - Mezium americanum
  - Niptus hololeucus
  - Ptinus bicinctus
  - Ptinus exulans
  - Ptinus fur
  - Ptinus hirtellus
  - Ptinus latro
  - Ptinus pusillus
  - Ptinus raptor
  - Ptinus sexpunctatus
  - Ptinus subpilosus
  - Ptinus tectus
  - Ptinus villiger
  - Tipnus unicolor
  - Trigonogenius globulus
- Silvanidae
  - Nausibius clavicornis
- Staphylinidae
  - Oligota granaria
  - Xylodromus concinnus
- Tenebrionidae
  - Blaps mucronata
  - Mesomorphus villiger
  - Palorus depressus

Diptera
- Byomya sorbeus
- Drosophila immigrans
- Drosophila obscura
- Musca nebulo
- Musca vetustissima
- Musca yerburyi

Hymenoptera
  Formicidae
    Camponotus compressus
    Camponotus consobrinus
    Camponotus herculeanus
    Camponotus irritans
    Camponotus langi
    Camponotus nigripes
    Camponotus punctulatus
    Crematogaster lineolata
    Dolichoderus bituberculatus
    Dorymyrmex pyramicus
    Formica cinerea
    Iridomyrmex analis
    Iridomyrmex anceps var. papuana
    Iridomyrmex domestica
    Iridomyrmex glaber
    Iridomyrmex iniquus var. nigellus
    Lasius interjectus
    Liometopum apiculatum occidentale
    Monomorium floricola
    Monomorium fraterculum
    Monomorium ilia
    Monomorium latinode

Formicidae
    Monomorium minimum
    Monomorium minutum
    Monomorium pharaonis
    Paratrechina bourbonica bengalensis
    Paratrechina longicornis
    Paratrechina obscura
    Paratrechina vaga
    Paratrechina vividula
    Pheidole javana
    Pheidole megacephala
    Pheidole oceanica
    Prenolepis fulva
    Solenopsis corticalis amazonica
    Solenopsis molesta
    Solenopsis xyloni
    Solenopsis xyloni var. maniosa
    Tapinoma melanocephalum
    Tapinoma sessile
    Tapinoma simrothi
    Technomyrmex detorquens
    Tetramorium caespitum
    Tetramorium guineense
    Tetramorium simillimum
    Triglyphothrix striatidens
Arachnida
    Dermanyssus gallinae
    Glycyphagus domesticus

F. Miscellaneous
  1. Drugs.

Lepidoptera
    Plodia interpunctella
Coleoptera
  Anobiidae
    Lasioderma serricorne
    Sitodrepa panicea
  Bostrichidae
    Dinoderus bifoveolatus
    Dinoderus minutus
    Rhizopertha dominica
  Lathridiidae
    Cartodere argus
    Cartodere costulata
    Euchionellus albofasciatus
  Lyctidae
    Lyctus africanus
  Nitidulidae
    Carpophilus decipiens
    Carpophilus dimidiatus
    Carpophilus mutilatus
  Platystomidae
    Araecerus fasciculatus
  Ptinidae
    Niptus hololeucus
    Ptinus hirtellus
    Ptinus tectus
  Silvanidae
    Oryzaephilus surinamensis
  Tenebrionidae
    Aphanotus parallelus
Arachnida
    Glycyphagus domesticus

2. Animal Substances.

Thysanura
- Ctenolepisma longicaudata

Dermaptera
- Anisolabis annulipes

Isoptera
- Mastotermitidae
  - Mastotermes darwiniensis

Psocoptera
- Troctes divinatorius

Lepidoptera
- Ephestia calidella
- Monopis rusticella
- Myelois ceratoniae
- Setomorpha insectella
- Setomorpha rutella
- Tinea fuscipunctella
- Trichophaga abruptella

Coleoptera
- Anobiidae
  - Sitodrepa panicea
- Cleridae
  - Corynetes caeruleus
  - Necrobia ruficollis
  - Necrobia rufipes
  - Necrobia violacea
  - Opilo domesticus
- Dermestidae
  - Anthrenus fuscus
  - Anthrenus museorum
  - Anthrenus nebulosus
  - Anthrenus verbasci
  - Anthrenus vorax
  - Attagenus byturoides
  - Attagenus japonicus
  - Dermestes cadaverinus
  - Dermestes coarctatus
  - Dermestes frischi
  - Dermestes lardarius
  - Dermestes vorax
- Dermestidae
  - Dermestes vulpinus
  - Entomotrogus megatomoides
  - Megatoma varia
  - Trinodes hirtus
  - Trogoderma versicolor
- Nitidulidae
  - Nitidula bipunctata
- Ostomatidae
  - Tenebroides mauritanicus
- Ptinidae
  - Gibbium boieldieui
  - Gibbium psylloides
  - Mezium affine
  - Mezium americanum
  - Niptus hololeucus
  - Ptinus fur
  - Ptinus hirtellus
  - Ptinus tectus
- Tenebrionidae
  - Alphitobius diaperinus
  - Alphitobius ovatus
  - Gnathocerus maxillosus
  - Tribolium castaneum

Diptera
- Piophila casei

Hymenoptera
- Formicidae
  - Camponotus compressus
  - Monomorium destructor
  - Plagiolepis custodiens
  - Plagiolepis longipes
  - Solenopsis geminata
  - Wasmannia auropunctata

Arachnida
- Pediculoides tritici
- Tyroglyphus lintneri
- Tyrophagus mycophagus

3. Plant substances.

Thysanura
- Ctenolepisma longicaudata
- Lepisma saccharina

Isoptera
- Mastotermitidae
  - Mastotermes darwiniensis

Psocoptera
- Trogium pulsatorium

Lepidoptera
- Aphomia sociella
- Decadarchis minuscula
- Endrosis lacteella

Lepidoptera
- Eois ptelearia
- Ephestia calidella
- Ephestia elutella
- Hypsopygia costalis
- Nemapogon granella
- Oenophila v-flavum
- Plodia interpunctella
- Setomorpha insectella
- Setomorpha rutella
- Tinea cloacella
- Tinea misella
- Tortilia viatrix

Coleoptera
- Anobiidae
  - Anobium magnum
  - Anobium punctatum
  - Catorama herbarium
  - Catorama meieri
  - Catorama tabaci
  - Sitodrepa panicea
- Bostrichidae
  - Dinoderus bifoveolatus
  - Dinoderus distructus
  - Dinoderus minutus
  - Dinoderus porcellus
  - Prostephanus truncatus
  - Sinoxylon anale
  - Sinoxylon malaccanum
  - Sinoxylon rugicanda
  - Xylopsocus capucinus
  - Xylothrips flavipes
  - Xylothrips religiosus
- Calandridae
  - Calandra linearis
  - Calandra oryzae
- Cerambycidae
  - Perissus laetus
  - Pterolophia melanura
- Colydiidae
  - Bothrideres andrewesi
  - Murmidius ovalis
- Cryptophagidae
  - Cryptophagus acutangulus
  - Cryptophagus pilosus
  - Henoticus californicus
  - Cryptophagus saginatus
- Curculionidae
  - Caulophilus latinasus
- Dermestidae
  - Anthrenus caucasicus
  - Anthrenus fasciatus
  - Dermestes cadaverinus
- Dermestidae
  - Dermestes lardarius
  - Dermestes vulpinus
  - Trogoderma granarium
  - Trogoderma tarsale
  - Trogoderma versicolor
- Endomychidae
  - Mycetaea hirta
- Languriidae
  - Pharaxonotha kirschi
- Lathridiidae
  - Cartodere beloni
  - Corticaria pubescens
  - Corticaria subtilissima
  - Lathridius nodifer
  - Metophthalmus hispidus
  - Methophthalmus serripennis
- Lyctidae
  - Minthea rugicollis
- Mycetophagidae
  - Typhoea stercorea
- Ptinidae
  - Ptinus fur
  - Ptinus hirtellus
  - Ptinus tectus
  - Sphaericus gibboides
  - Tipnus unicolor
  - Trigonogenius globulus
- Scolytidae
  - Coccotrypes dactyliperda
  - Cryphalomorphus stierlini
  - Hypothenemus eruditus
  - Pityophthorus peregrinus
  - Xyleborus semigranosus
- Silvanidae
  - Ahasverus advena
  - Cathartus excisus
  - Cathartus quadricollis
  - Monanus concinnulus
  - Oryzaephilus surinamensis
- Tenebrionidae
  - Alphitobius diaperinus
  - Alphitobius laevigatus
  - Alphitobius piceus
  - Mesomorphus villiger

Diptera
- Meoneura obscurella

Hymenoptera
- Formicidae
  - Camponotus langi
  - Camponotus nigriceps var. obniger
  - Camponotus punctulatus

Hymenoptera
    Formicidae
        Camponotus caryae var. rasilis
        Crematogaster lineolata
        Formica cinerea
        Iridomyrmex analis
        Iridomyrmex detectus
        Iridomyrmex humilis
        Iridomyrmex rufoniger
        Liometopum apiculatum occidentale
        Monomorium destructor
        Monomorium pharaonis
    Formicidae
        Solenopsis geminata
        Tapinoma simrothi
Arachnida
        Carpoglyphus taiwanensis
        Chortoglyphus gracilipes
        Eberhardia kremeri
        Glycyphagus domesticus
        Glycyphagus michaeli
        Glycyphagus spinipes
        Rhizoglyphus echinopus
        Tyroglyphus farinae
        Tyroglyphus lintneri

4. Miscellaneous

Isoptera
    Rhinotermitidae
        Reticulitermes flavipes - damages electrical insulation
Lepidoptera
        Ephestia kuehniella - jelly cubes
Coleoptera
    Cryptophagidae
        Henoticus californicus - jam
Diptera
        Drosophila funebris - marmalade, preserved fruit, fruit juices, catsup, milk, wine, beer, vinegar
        Fannia pusio - dead fish
Hymenoptera
    Formicidae
        Atta moelleri meinerti var. globoculis - foodstuffs
        Camponotus caryae var. rasilis - jam
        Monomorium floricola - all kinds of human food
        Pheidole megacephala - stored food
        Tapinoma melanocephalum - all kinds of human food.
Arachnida
        Pediculoides tritici - a predator found with other mites causing dermatitis

7a2. Names of Animals

7b. Damage and Materials Attacked.

7c. Control Methods and Materials.

7d. Other Items in the Text.

8. APPENDIX

Data on all the species arranged in zoological order.

Thysanura - silverfish, bristletails, German: Wohnungsfischchen.

Acrotelsa collaris
Tropicopolitan.
The house silverfish of the tropics. No specific information on damage

Ctenolepisma ciliata - Brasilian: traça dos livros, lepisma.
Brasil.
In houses.

Ctenolepisma lineata
Victoria, Australia.
Starch, artificial silk. Unsoiled silk and wool are not attacked.

Ctenolepisma longicaudata - Australian: common silverfish.
Australia; South Africa; ? New Guinea.
Paper, especially chemical pulp papers containing less than 45% mechanical pulp; bookbindings; artificial silks with starch and dextrin sizes. Clean silk and wool are rarely damaged and other fabrics chiefly because of gelatinous or starch sizing. Gelatin emulsion on photographs; plant and animal remains.
Optimum temperature 77°F but active down to 52°F.

Ctenolepisma targionii
Italy.
Paper, gum, glue.

Ctenolepisma urbana
California.
Bookbindings; paper, preferring refined chemical pulp papers while mechanical pulp papers are, on the whole, immune. Textiles, in descending order of preference, linen, rayon, cotton, and it avoids silk and wool.

Ctenolepisma quadriseriata - U. S.: Four-striped silverfish.
Eastern United States.
Wallpaper paste; protein-sized paper; cellophane.
Optimum temperature 80°F or higher, survives to about 115°F. Readily killed at 32°F.

Lepisma latithoracica
Italy.
In bakeries.

Lepisma saccharina - U. S.: silverfish, fishmoth.
Cosmopolitan.
Wallpaper paste; glazed paper, protein-sized paper; books; cellophane; starch-sized cotton-rayon mixture, certain resin-sized cloths; glue; cereals; freshly dried beef; dried plants.
Optimum temperature about 80°F, prefers 85-90% relative humidity. Readily killed at 98°F and at 32°F.

Thermobia aegyptiaca
Egypt; Victoria, Australia.
Covers of linenbound books.

Thermobia domestica - U. S.: Firebrat
Cosmopolitan.
Wallpaper paste; protein-sized paper, typewriter paper; cellophane; rayon, linen, will feed on pure rayon but is attracted by starch, gum, oils, rayon containing sulphonated compounds not very attractive, feeds less often on cotton and silk; peanuts.
Optimum temperature about 98°F, develops between 81° and 111°F. Requires 48-100% relative humidity. Killed at 32°F and about 130°F.

Orthoptera - Grasshoppers, crickets, roaches, etc.

Saltatoria - Grasshoppers, crickets.

Gryllacris sechellensis
Seychelles.
"Adults and nymphs cut holes in paper and cloth with the object of making a shelter by folding over the cut piece and sticking it down."

Amphiacusta caribbea
West Indies.
In houses.

Gryllodes sigillatus - West Indian: Brown house cricket.
Jamaica.
In clothing.

Gryllodes spp.
Africa.
In houses.

Gryllomorpha spp.
Africa.
In houses.

Gryllulus desertus
Southwest Asia.
Cereals, stored products, leather, wood.

Gryllulus domesticus - U. S.: house cricket; German: Heimchen, Hausgrille.
Cosmopolitan.
Attacks clothing, feeds freely on any material containing wool; paper; fruit, vegetables, prepared dough, upholstery, curtains, bread, silk, stored flour. Damaging artifical silk in a textile mill.
Life cycle 38-45 weeks at about 65°F.

Gryllulus servillei
Australia.
Clothing, particularly containing artifical silk.

Gryllus assimilis - U. S.: field cricket.
Western Hemisphere.
Seeds, corn, cloth, clothing, carpets, curtains.

Gryllus oceanicus
Pacific Islands.
In houses.

Gryllus spp.
Africa.
In houses.

Phaeophilacus spp.
East Africa.
In houses.

Blattariae - U. S.: roaches, cockroaches; German: Schaben; French blattes; Brasilian: baratas; Spanish: cucurachas.

Blabera sp.
Neotropics.
Ginger.

Blatta concinna
Japan.
Damages foreign books,

Blatta orientalis - U. S.: Oriental roach; German: gemeine Küchenschabe, Kakerlak; English: black beetle.
Cosmopolitan.
Starchy food, cheese, meat, woollen cloth, old leather, wax.
Killed in 10 minutes at 131°F.

Blattella germanica - U. S.: German roach; German: Franzosen, Russen.
Widespread.
Bookbindings, clothing and fabrics; flour, flour paste, water color paints.

Blattella vaga - U. S.: Field roach.
S. W. United States.
Habits similar to German roach indoors.

Cutilia soror
Tropicopolitan.
In houses.

Eoblatta notulata
Tropicopolitan.
In houses.

Leucophaea maderae
Tropicopolitan.
In houses, clothing and fabrics, ginger.

Neostylopyga rhombifolia
Tropicopolitan.
In houses, books.

Parcoblatta pensylvanica - U. S.: Pennsylvania woodroach.
Eastern United States.
Wallpaper for the paste.

Periplaneta americana - U. S.: American roach.
Cosmopolitan.
Books, clothing, fabrics, nutmegs, gum tragacanth. Prefers 79-82°F, rather quickly killed at 15-20°F; and numbed at 40°F.

Periplaneta australasiae - U. S.: Australian roach.
Cosmopolitan.
Books, nutmegs, gum tragacanth, wax.

Periplaneta brunnea
Tropicopolitan.
Not recorded as economic.

Periplaneta fuliginosa - U. S.: smoky brown roach.
United States.

Pycnoscelus surinamensis - U. S.: Surinam roach; German: Gewächshausschabe.
Tropicopolitan, occasional in temperate regions indoors.
Dextrine paste, cereals, bread. In a greenhouse in New Hampshire went down into soil by day.

Supella supellectilium - U. S.: brown-banded roach; German: Möbelschabe.
Tropicopolitan but less often on islands - is extending its range indoors into temperate regions.
Books. Food habits said to be similar to those of Blattella. Flies very readily.

Dermaptera - Earwigs

Forficula auricularia - U. S.: European earwig; French: Perce oreille; German: Ohrwurm.

Widespread.
Damages cotton and silk cloth, probably very minor. Capable of drawing blood.

<u>Anisolabis annulipes</u> - U. S.: Ring-legged earwig.
Almost cosmopolitan.
Abundant, damages stored products, prefers animal food.

<u>Anisolabis colossea</u>
Southern Asia to Australia.
Capable of drawing blood.

<u>Prolabia arachidis</u> - U. S.: brown earwig.
Tropicopolitan.
Disgusting greasy household pest of the subtropical and tropical regions which has been carried around the world by commerce. Cacao, nutmegs, ginger.

Isoptera - Termites. German: Termiten; Brasilian: cupins; Spanish: polillas, hormigas blancas; Philippine: anay; Central America and West Indian: comejenes; Mozambique: formigas brancas.

<u>Hodotermitidae</u>

<u>Hodotermes</u> spp.
South Africa.
Can destroy thatch or wall paper but not wood.

<u>Kalotermitidae</u>

<u>Kalotermes (Calcaritermes) fairchildi</u>
Central America.
Very destructive to the dry woodwork of buildings. Also in furniture.

<u>Kalotermes (Cryptotermes) brevis</u> - U. S.: powderpost termite; Spanish: polilla.
Tropicopolitan except Australasia.
Masonite pressboard. Wall board is protected by a layer of glazed paper. Colonies not established in stacks of glazed paper magazines.

<u>Kalotermes (Cryptotermes) buxtoni</u>
Tropical Australia to Samoa.
Does damage in Fiji.

<u>Kalotermes cynocephalus</u> - Philippine: dog-headed powderpost termite.
Luzon, Java.
In timber.

<u>Kalotermes domesticus</u>
S. Asia to Sumatra.
In Malaya is often found eating away wooden structures in houses.

Kalotermes havilandi
Tropical Africa.
Beech timber in the Gold Coast, timber in Tanganyika, Nigeria

Kalotermes lamanianus
Central and Western tropical Africa.
In timber.

Kalotermes pallidus
Mauritius.
In building timbers.

Kalotermes piceatus - Hawaiian: powderpost termite.
South China, Marquesas, Hawaii.
In timber.

Kalotermes pseudobrevis
Natal, Africa.
In woodwork.

Kalotermes secundus
Tropical Australia.
In timber.

Kalotermes (Cryptotermes) sp.
Trinidad.
In timber.

Kalotermes (Cryptotermes) sp.
Trinidad, Tobago.
In timber.

Kalotermes (Glyptotermes) pubescens
Puerto Rico.
Timber in old cottages.

Kalotermes approximatus
Gulf States and Bermuda.
Attacks living Juniperus bermudiana; timber.

Kalotermes flavicollis
Mediterranean Basin.
In timber.

Kalotermes condonensis
Australia.
In timber.

Kalotermes clevelandi
Panama.
In timber.

Kalotermes hubbardi - U.S.: Southern drywood termite.
Arizona, California, West Mexico, south to Colima.
The evidences of its attack are everywhere visible in the coastal or low-lying cities of the west coast of Mexico.

Kalotermes marginipennis - U.S.: mountain dry-wood termite.
Mexico and Guatemala.
In timber.

Kalotermes minor - U.S.: common drywood termite.
S. W. United States, North Mexico.
The economically important drywood termite of the Pacific Coast.

Kalotermes platycephalus
S. W. Mexico.
Once in a pine post in a railway cattle guard which it was riddling in a manner to indicate at least potential economic importance.

Kalotermes repandus
Fiji and Samoa.
Flooring in Fiji, furniture.

Kalotermes schwarzi
Cuba, Jamaica, Florida, Yucatan.
In timber.

Kalotermes snyderi
Gulf states, East Mexico, Central America.
Common, widely distributed, and economically important species.

Kalotermes longicollis
Central America.
In timber.

Kalotermes assmuthi
India.
In timber.

Kalotermes castaneus
Florida and West Indies.
In timber.

Kalotermes simplicicornis - U.S.: desert damp-wood termite.
S. W. United States and N. W. Mexico.
In timber near ground.

Kalotermes dudleyi
Costa Rica, Ceylon, Java, Philippines, Trinidad.
In timber.

Porotermes adamsoni
S. E. Australia, Tasmania.
In woodwork.

Zootermopsis augusticollis - U.S.: common damp-wood termite.
British Columbia south to lower California.
In timber when not too dry.

Mastotermitidae

Mastotermes darwiniensis - Australian: big termite.
North Australia.
Serious pest of timber; manufactured sugar; cotton, silk wool fibre; ivory, horn, leather, hides, bone.

Rhinotermitidae

Coptotermes acinaciformis
Tropical Australia, New Zealand.
In timber.

Coptotermes amanii
Tropical East Africa.
In timber.

Coptotermes ceylonicus
Indo-China, Ceylon, India.
Attacks tea bushes in South India, living tea and cacao in Ceylon; timber in Ceylon.

Coptotermes crassus
Central America.
Once in the dead heartwood of a living mango. The nest was located in the base of a fence post.

Coptotermes formosanus - Hawaiian: subterranean termite.
South China, Formosa, Japan, Hawaii, Riu-Kiu, South Africa.
Is responsible for most of the destruction of property.

Coptotermes frenchi
S. E. Australia, New Zealand.
In timber and living trees.

Coptotermes grandiceps
Solomons, Tulagi I.
Damages timber.

Coptotermes havilandi
Java, Malaya, Siam, Mauritius, Barbadoes.
Attacks buildings.

Coptotermes heimi.
India.
In timber.

Coptotermes javanicus
Jamaica, Java.
Causes damage in Jamaica.

Coptotermes lacteus
Australia, New Zealand.
The most common, and at the same time, the most destructive, of the Australian termites.

Coptotermes marabitanus
Brasil, British Guiana, Trinidad, Panama.
Does considerable damage to buildings in Georgetown, British Guiana.

Coptotermes niger
Central America, Columbia.
The insects had eaten into the lead sheathing of the duplex cable. This damage was first noted about November 1, when the telephone service was unsatisfactory. They chewed away the insulating material, including the rubber.

Coptotermes parvulus
India.
In timber.

Coptotermes raffrayi
W. Australia
In timber.

Coptotermes sjostedti
Tropical Africa.
In buildings.

Coptotermes solomonensis
Solomons, Malaita Id.
In timber.

Coptotermes testaceus
Lesser Antilles to Trinidad, Panama.
In timber.

Coptotermes travians
Malaya and Luzon to Java.
Destructive in houses.

Coptotermes truncatus
Madagascar, Seychelles, Gold Coast.
In Seychelles damages timber; occasionally books and papers; can penetrate concrete.

Coptotermes vastator
Luzon.
In timber.

Leucotermes aureus - U. S.: desert subterranean termite.
S. W. United States; N. W. Mexico.
In timber.

Leucotermes ceylonicus
Ceylon.
In buildings.

Leucotermes convexinotatus
Panama, Jamaica.
In timber.

Leucotermes ferox
Australia.
In timber, particularly poles and piers, often found in connection with other species of termites.

Leucotermes indicola
India.
In timber.

Leucotermes philippinensis - Philippine: Philippine subterranean termite.
Luzon, Mauritius.
In timber.

Leucotermes tennis
West Indies, Panama, South America, St. Helena.
Infesting redwood window sills and frames at Ancon; also damaged lead-sheathed underground cables.

Prorhinotermes canalifrons
Madagascar, Comores, Seychelles, Aldalera, Mauritius.
In timber.

Prorhinotermes inopinatus
Samoa, Ellice Is., Fiji, Rennel Id.
A damp wood species; paper in a damp cupboard.

Prorhinotermes luzonensis - Philippine: Philippine damp-wood termite.
Philippines.
In timber.

Psammotermes allorcerus
South Africa.
Houses, damaging timber.

Reticulitermes chinensis
South and West China.
Very destructive when they once become established but this seems to be the case in few localities.

Reticulitermes claripennis
Arizona, Kansas, Texas, Mexico.
In timber.

Reticulitermes flaviceps
Japan, South China, Formosa.
Very destructive when they once become established but this seems to be the case in few localities.

Reticulitermes flavipes - U.S.: eastern subterranean termite.
Eastern United States to Great Plains and Texas; Eastern Mexico.
Reported to perforate lead foil; electric insulation; timber.

Reticulitermes hesperus - U.S.: western subterranean termite.
British Columbia to California and Nevada.
In timber.

Reticulitermes hageni
Maryland, Indiana, Illinois, South to Mexico.
In timber.

Reticulitermes humilis
Arizona, New Mexico; Mexico, Tepic, Guadalajara.
The colony at Nogales was attacking a pole in the ground.

Reticulitermes lucifugus
Mediterranean Region.
In timber.

Reticulitermes speratus
Japan, Korea, Formosa, Riu-Kiu.
Timber, bamboo.

Reticulitermes tibialis - U.S.: barren-lands subterranean termi
N. W. Mexico.
In timber.

Reticulitermes virginicus
Maryland, Illinois, southward.
In timber.

Rhinotermes intermedius
Australia.
In timber.

Rhinotermes malaccensis
Indo-China, Malaya.
A common species, favors floor boards of houses and also wooden posts.

Rhinotermes putorius
Western and Central Tropical Africa.
In building.

Rhinotermes translucens
Borneo, Java, Celebes, New Guinea, Malaya.
In papers.

Termitidae

<u>Acanthotermes militaris</u>
Cameroon, Belgian Congo, Nyasaland.
Attacks living tea bushes in Nyasaland, fence of bamboo.

<u>Acanthotermes minor</u>
Congo and Gold Coast to South Africa.
In timber.

<u>Amitermes capito</u>
W. Australia.
In timber.

<u>Amitermes elongatus</u>
Congo Belge.
From galleries constructed between the bark and the wood of a pole in the station of Zambi. The space between the bark evidently had been gnawed away by the termites and filled in again with black, very hard soil, in which rather broad galleries and chambers were left; the galleries also extended into the wood itself.

<u>Amitermes minimus</u>
Arizona, California, Nevada, Texas.
It seems more prone to attack upright pieces of wood including fence posts and poles than are the other <u>Amitermes</u> species of California and is the only species of the genus in that area which penetrates the wood extensively and therefore the one most likely to be of economic significance.

<u>Amitermes obeuntis</u>
W. Australia.
Telephone poles, fence posts, jarrah ties.

<u>Amitermes wheeleri</u> - U. S.: Wheeler's desert termite.
Texas, Arizona, California, Nevada, W. Mexico.
In timber.

<u>Amitermes perniger</u>
Queensland, W. Australia.
Also the workers were attacking my fingers and biting with their jaws. The soldiers were actually digging in their sharp jaws so deeply that the blood was oozing out.

<u>Ancistrotermes amphidon</u>
Gold Coast.
In timber.

<u>Ancistrotermes guineensis</u>
W. Africa.
In building.

Ancistrotermes periphrasis
Gold Coast.
Very destructive to houses.

Cornitermes striatus
Argentina, Uruguay, Paraguay, Brasil.
In woodwork.

Macrotermes swaziae
S. Africa.
In timber.

Macrotermes ukazii
S. Africa.
In timber.

Macrotermes usutu
South Africa.
In timber.

Macrotermes bellicosus
Cameroon - Dakar, Fr. Congo - Eritrea, Belgian Congo and Angola south to Natal, Ethiopia.
Reported destructive to timber in Nigeria.

Macrotermes natalensis
Dakar - Eritrea south to Cape Provice, Madagascar.
Reported destructive to timber in Nigeria.

Macrotermes nigeriensis
S. Nigeria, Lagos, Ivory Coast, Dahomey.
Reported destructive to timber in Nigeria.

Macrotermes gilvus
Malaya, Indo-China, Dutch East Indies, Philippines to Timor.
Bamboo and wood posts.

Microcerotermes havilandi
Sumatra, Borneo.
In timber.

Microcerotermes heimi
Ceylon, India.
In timber.

Microcerotermes los-baniensis
Philippines.
Woodposts.

Microcerotermes nervosus
North Australia.
In timber.

Microtermes obesi
India.
In timber.

Microtermes sudanensis
French Sudan, Nigeria, Gold Coast.
Timber - Nigeria, Gold Coast, can damage felt impregnated with 60% tar.

Mirotermes melvillensis
North Australia.
In timber.

Mirotermes langi
Congo Belge.
Lang states that the specimens from Medje were found attacking the house in which he was living.

Nasutitermes olidus
Fiji.
Does damage to wood.

Nasutitermes usambariensis
South Africa.
In timber.

Nasutitermes vandiniensis
Solomons, Bismarcks, New Hebrides.
Damages timber.

Nasutitermes ceylonicus
Ceylon.
In timber.

Nasutitermes corniger
Central America.
Very abundant on fence posts.

Nasutitermes costalis
West Indies, Central America, northern South America.
In timber.

Nasutitermes ephratae
Central America and N.E. South America.
The cloth and rubber insulation were eaten, as was the weather-proofed braid from the wires leading to the overhead lights. The thickness of the rubber protection is almost 1.5 millimeters. Did not attack lead or copper.

Nasutitermes exitiosus
New South Wales, Victoria, South Australia, West Australia.
In timber.

Nasutitermes lacustris
Ceylon.
Attacks wood.

Nasutitermes luzonicus
Luzon, Philippines.
In timber.

Nasutitermes matangensis
Indo China, Malaya to Java.
In Indo China, a wood-gnawing species which frequently installs itself in houses and causes serious damage.

Nasutitermes nigriceps - U. S.: Haldeman's black nasute.
N. W. Mexico
While not responsible for any large proportion of the termit damage of the region, it was found on several occasions attacking poles, posts and even wood of houses.

Nasutitermes ripperti
N. W. Indies
In timber.

Nasutitermes voeltzkowi
Mauritius
Building timbers.

Nasutitermes leucops
Malaya, Sumatra.
In timber.

Nasutitermes mexicanus - U. S.: Mexican yellow-headed nasute.
Mexico.
In numerous instances this species was found building covered ways over buildings to wooden structures and in some cases a certain amount of damage was noted, but the very incomplete observations did not lead me to believe that they were of any considerable economic importance.

Nasutitermes zeteki
Panama.
In timber.

Nasutitermes ibidanicus
Nigeria.
In timber.

Synacanthotermes zanzibarensis
Zanzibar, Tangangika.
In timber.

Termes sp.
Nigeria.
In timber.

Termes badius
S. Rhodesia.
In buildings.

Termes transvaalensis
S. Rhodesia.
In buildings.

Termes formosanus
S.E. Asia from C. China and Formosa.
Timber, rice, sugar cane.

Termes redemanni
Ceylon.
Buildings.

Termes obscuriceps
Indo-China, Ceylon.
In Ceylon damage in houses.

Termes ceylonicus
Ceylon.
In buildings.

Termes feae
India, Burma.
Attacks seedlings of _Eucalyptus rostrata_ in South India.
Timber; wool; books; covers its food with plaster.

Termes horni
Indo-China, Ceylon;
Timber; living _Coix lachryma-jobi_.

Termes latericius
Africa s. of Senegal and the Belgian Congo.
Timber.

Termes panperans
Senegal to Rhodesia.
Buildings in S. Rhodesia; can attack felt impregnated with 60% tar.

Embioptera - Embiids.

Embia vayssierei
West Africa.
Stored cereals, peanuts (by webbing and fermentation).

Ephemeroptera - Mayflies
Siam.
Nymphs of two species damaging submerged wood.

Psocoptera - Booklice, barklice; German: Staublause; Dutch: houtluize

<u>Caecilius nigrotuberculatus</u>
Argentina
Corn.

<u>Chaetopsocus richardsi</u>
England, West Africa.
Cacao.

<u>Deipnopsocus spheciophilus dispsrilis</u>
West Africa, England.
Cacao.

<u>Dorypteryx pallida</u>
North America, Europe.
In houses.

<u>Lachesilla pedicularia</u>
Europe, Australia, North America.
On hangings in new houses, on old wood, in stables; sometimes in buildings in large swarms; grain products.

<u>Lepinotus inquilinus</u>
Central Europe, Australia.
In houses between old papers, in pillows; figs.

<u>Lepinotus patruelis</u>
California, Netherlands, England.
Once in a house; also in spinach seed.

<u>Lepinotus reticulatus</u>
Central Europe.
In houses.

<u>Myopocnema annulata</u>
Central Europe.
In houses.

<u>Nymphopsocus destructor</u>
Europe.
In new buildings, on walls and especially on hangings; a mold eater.

<u>Psoquilla marginepunctata</u>
Malaya, West Africa, England.
Copra, cacao; granaries.

<u>Psyllipsocus ramburi</u>
Central Europe.
In new buildings, on walls and especially on hangings; a mold eater.

Pteroxanium squamosum
Central Europe.
In houses.

Rhyopsocopsis peregrinus
England.
Stone.

Stenotroctes minor
West Africa, England.
Cacao.

Troctes corrodens
Europe.
Houses, warehouses; grits, buckwheat flour.

Troctes divinatorius
Cosmopolitan.
Attacks eggs of Angoumois grain moth; feeds on molds; pest of books, ground feed, dried vegetable materials, cacao, flour, cornmeal.
Development 25-130 days; 30 days at 80°F, 65% relative humidity; killed at 140°F.

Troctes virgulatus
Europe, West Africa.
Houses, warehouses; cacao.

Trogium pulsatorium - U. S.: Book louse.
Cosmopolitan.
Feeds on molds, dried plants, paste, carpets, upholstery, grain, raisins.

Trichoptera

Anabolia laevis
Europe.
Cuts fishing nets.

Anabolia nervosa
Europe.
Cuts fishing nets.

Grammataulius atomarius
Northern Europe.
Cuts fishermen's nets.

Hydropsyche ornatula
Europe.
Boring in submerged wood.

Hydropsyche lepida
Europe.
Boring in submerged wood.

Hydropsyche pellucida
Europe.
Boring in submerged wood.

Limnophilus flavicornis
Northern Europe.
Cuts fishing nets.

Limnophilus lunatus
Europe.
Cuts fishing nets.

Limnophilus rhombicus
Northern Europe.
Cuts fishing nets.

Neureclipsis bimaculata
Europe.
Boring in submerged wood.

Trichoptera sp.
Great Lakes.
Damaging submerged wood.

Lepidoptera

Achroia grisella
Cosmopolitan.
Seeds of Polygonatem officinale, walnut, rape seed, pine seed, beeswax in hive, dried apples, raisins.

Acrolepia manganeutis
India.
Stored yams.

Aglossa caprealis
Cosmopolitan.
Corn, chaff, etc.

Aglossa dimidiata
Japan, Korea, China.
Grain, rice, stored products.

Aglossa pinguinalis
Europe, Central Asia, India.
Stored barley.

Alucita sp.
Algeria.
Stored grain.

Anchonoma xeraula
Japan.
Stored grain and plant products.

Aphomia sociella
Europe, North America.
Nests of wasps, bumblebees, dried vegetable products.

Arenipses sabella
Iraq.
Dried dates.

Aristotelia austeropa
India.
Rice.

Athetis clavipalpis
Europe and Northern Asia..
Wool, cotton, artificial silk but not linen - said only to occur in houses in first summer following a new straw thatching. Normally in ricked grain or peas; a field pest which emerges indoors; stored apples, peaches, cucumbers, squashes.

Auximobasis normalis
England, South America.
In seeds.

Bactra lanceolana
Europe and near East.
In stored chufa.

Batodes angustiorana
England.
Stored, wrapped apples.

Blastobasis lignea
England, Australia.
Dry skins.

Borkhausenia minutella
Europe.
In seeds.

Borkhausenia pseudospretella - U. S.: seed moth; English: Americ clothes moth; German: Samenmotte; English: Brown house moth false clothes moth.
Temperate regions.
Attacks books, dried mint, wool, grain refuse, seeds, skins, etc., cloth, insects, stored hops, carpets, wine corks but those covered with lead foil are protected; baled human hair, legume seeds, barley, fur, figs, dates, upholstery, Larva prefers damp, dark, unheated places.

Cacoecia franciscana
California.
Apples in storage.

Celama sorghiella
Southern United States.
Rare in stored grain.

Cirphis zeae
Mediterranean Region to Turkestan.
Stored corn.

Corcyra cephalonica - Dutch: rijstmot; English: rice moth, wolf moth.
Cosmopolitan.
Rice, cacao, corn, copra, manufactured chocolate, locust beans, pigeon peas, tamarind pods, dried currants, army biscuits, peanuts.
Development in summer 28-42 days; killed at 120°- 130°F.

Decadarchis minuscula
Tropicopolitan.
Dry stems, leaves, pods, etc.; not recorded as economic.

Dolessa viridis
Borneo, Malaya.
Illipe nuts, rice, copra, oil palm kernels.

Dryadaula pactolia
England, New Zealand.
In house.

Dysmosia parietariella
Europe.
Normally feeds on molds but is recorded as attacking sausages. Two generations a year.

Endrosis lacteella - English: white-shouldered house moth; German: Kleistermotte.
Cosmopolitan.
Stored grain, dried anemone roots, seeds, etc., dried peas, rye cabbage seed, horsebeans, fruits, dried skins, dried meat, wool. Killed at 122°-140°F.

Eois ptelearia
S. W. United States to Pennsylvania.
In herbarium specimens.

Ephestia afflatella
Italy.
Dates.

Ephestia cahiritella (This may be the same as *E. cautella*).
Tropicopolitan.
Meal, grain, rice, flour, dried fruits, almonds, nuts, cacao, corn, figs.

Ephestia calidella
Europe and the near East, North Africa.
Almonds, cork, dried figs, currants, etc., dates, raisins, dried insects, carob beans.

Ephestia cautella - West African: cacao moth; U. S.: fig moth; U. S. official: almond moth; German: Dattelmotte; Australian: dried fruit moth; Dutch: chocolademot.
Cosmopolitan.
In cacao, copra, rice, cottonseed meal, peanuts, stored grain, corn, sawarie nuts, figs, dates, almonds, nutmegs. Larvae can penetrate tinfoil, aluminum foil, greased paper, but not 18-mesh gauze.
Development about 82 days at 80oF; five to six generations a year in tropics,

Ephestia elutella - U.S.: chocolate moth; U. S. official: tobacc moth; German: Kakaomotte.
Cosmopolitan.
Tobacco, chocolate, walnuts, cacao, stored grain, dried fruit, lima beans, currants, raisins. Larvae can penetrate tinfoil, aluminum foil, greased paper, but not 18-mesh wire gauze.
Developed at 75°-80°F in 60 days; optimum temperature 86° - 88°F, minimum 59-68°F, moisture 10%, killed at 113°F.

Ephestia figulilella - U. S.: raisin moth.
Cosmopolitan.
Dried fruit, cereals, walnut meats, hazel nuts, cashew nuts, dates, raisins, figs.

Ephestia glycinivora
Japan.
In grain.

Ephestia kuehniella - U.S.: Mediterranean flour moth; German: Mehlmotte; French: papillon gris de la farine; Dutch: meelmotje. (The correct scientific name of this species is E. sericarium, but I use the name found in the economic literature.)
Like many other important species this one is cosmopolitan.
Although best known as a grain and flour pest, its attack on other foods is not unimportant. I find reported: dates, chufa, figs, almonds, nuts, raisins, cacao, chocolate, army biscuits, beans, dried peppers, dried banana, dried vegetables, "jelly cubes", stored potatoes, in addition to grain and meal. The larvae do not penetrate paper but can pass through tiny openings.
Development requires 8 to 9 weeks in summer. The eggs hatch only between 53°F and 90°F although the lowest temperature for development is said to be 46 F. I have found no data on moisture requirements.

This flour moth is killed at 115°F in 3 hours and at 10°-15°F in 4 days, but old larvae and pupae withstand 32°F for several months.

Ephestiodes nigrella
California.
Dried fruit, raisins.

Epithectis studiosa
India.
Rice.

Erechthias zebrina
Tropicopolitan.
Probably in any dry vegetable material, not recorded as economic.

Etiella zinckenella
Widespread.
Legumes (This is apparently an accidental pest.)

Eulia velutinana - U. S.: Red-banded leaf-roller.
United States.
Surface injury to stored apples.

Euzophera sp.
Oases of Biharia and Siwa.
Dates.

Hadena basilinea
Northern Europe and Asia.
Granaries, but does not continue to breed in stored grain.

Herculia psammoxantha
North America.
Soybeans.

Homoeosoma vagella
Queensland.
Peanuts.

Hypsopygia costalis - U. S.: clover hay worm.
Central and South Europe, West Asia, North America.
In hay, grain.

Mampava bipunctella
Formosa.
Italian millet.

Monopis crocicapitella
Cosmopolitan.
Seeds, wool refuse, etc.

Monopis dicycla
India.
Wool.

Monopis ethelella
South Australia, New Zealand.
Soiled stored fleeces, skins.

Monopis ferruginella
Europe, North Africa.
Seeds, wool refuse, etc.

Monopis imella
Palaearctic.
Fur scrap, felt, etc.

Monopis monachella
Cosmopolitan.
Dry skins, wool, refuse.

Monopis rusticella - German: Fellmotte
Northern hemisphere.
Excrement, wool.

Mussidia nigrivenella
West Africa, England.
Cacao, stored corn, cereals.

Myelois ceratoniae - German: Johannisbrotzünsler
Europe, Africa, Central and South America, Madagascar.
Leguminous seeds, dried dates, etc., tamarinds, carob bean, figs, raw cork bark, almonds, raisins, quince, dried insects.

Myelois phoenicis
Algeria, West Europe.
Dried dates.

Myelois solitella
Brasil.
Coffee seed.

Myelois turkheimiella
Southern Europe.
Figs.

Myelois zellerella
Europe (imported).
Dates.

Nemapogon granella - U. S.: wolf moth: U. S. official: European grain moth; German: Kornmotte.
Cosmopolitan.

Stored grain, chestnuts, dried anemone roots, rye, wheat, corn almonds, hazel nut, peanut, rice, bran, sharps, dried mushrooms, dried bilberries, dried cherries, dried peaches, clover seed, ergot, cigars, dextrin paste, biscuits, figs, pistache nuts.
Two generations a year in Germany, developmental zero 43½°F.

Oegoconia quadripunctata
Northern Hemisphere and New Zealand.
Dry vegetable refuse.

Oenophila v-flavum - German: Weinmotte.
S. W. Europe.
Wine corks.

Opogona subcervinella
Seychelles and other islands adjacent to Africa.
Stored potatoes.

Paralipsa gularis - U.S.: bean moth, rice moth; German: Samenzunsler.
Cosmopolitan.
Stored grain, prunes, but not other dried fruits; almonds, rice, rye, soybeans, flaxseed, peanuts, beans.

Phthorimaea operculella - U.S.: potato tuber moth; French: teigne de la pomme de terre; Spanish: polilla de la patata; Portuguese: traça da batatinha; German: Kartoffelmotte; Dutch: aardappel knollenrups; Italian: tignuola della pata
Widespread, largely tropical.
In stored potatoes, successive generations in same stored tubers, eggs may be laid directly on tubers, eggplant; it i probable that this species does not attack the tomato.
Life cycle 27-50 days; 37 days at 66°F.

Phthorimaea plaesiosoma
Peru, Chile, New Zealand, Australia.
Potatoes, eggplant.

Plodia interpunctella - U.S.: Indian-meal moth; German: Dörrobstmotte; English: dried fruit moth; Australian: lesser dried fruit moth; Japanese: noshime-koguga.
Cosmopolitan.
In coffee substitutes, chocolate, drugs, walnuts, corn, etc. dried fruit of all kinds, nuts, flour, cereals, chick peas, table beans, peanuts, tea, coffee, cottonseed meal, dates, sawarie nuts, seeds of Scorzonera tau-saghyz, chestnuts, currants, rice, chestnut flour, soybean flour, raisins, dried bananas, dried nectarines, prunes, dried pears, dried peas, dried radishes, dried carrots and other dried vegetables, almonds, hazelnuts, pine nuts, linseed, palm seed, sesame, soybeans, chillies, nougat.
Killed in fruit by a temperature of 145°F for 10-15 minutes. It is recommended to heat packages of fruit to 125-130° for one hour after packaging.

Mature larvae can penetrate tin foil, aluminum foil, greased paper, but not 18-mesh wire gauze. Eulan treated fabrics not touched. Chocolate does not attract females and a thick coat protects fruit cakes, marzipan, etc., but an old coating is not protective. Can gnaw out through walnut shells.

One to six generations a year, upper limit of egg hatching about 89°F. Adults die at once at 117°F or in 30 minutes at 113°F. Larvae can develop in floor dust. May develop at 54°F. Optimum temperature 83°F, development zero 52°F. Development about four weeks in summer. Killed at 10-15°F in five days.

Pyralis farinalis - U.S.: meal moth; German: Mehlzünsler.
Cosmopolitan.
Stored grain, bean cakes. Development in summer about 7 weeks

Pyralis lienigialis
Northern Europe.
Grain.

Pyralis manihotalis
Central and South America, India, Japan.
Meal, peas, dried fruit, chocolate.

Pyralis pictalis
Indo-Malaya, India.
Illipe nuts, grain.

Pyroderces rileyi - U. S.: pink corn worm.
Southern United States to Brasil.
Sometimes in stored corn, not usually serious; cottonseed.

Santuzza kuwanii
Japan.
Stored grain.

Setomorpha insectella - U. S.: insect moth.
Tropicopolitan.
Cassava, animal and vegetable matter, wool, grain.

Setomorpha rutella - Dutch East Indies: tabaksmot.
Tropicopolitan.
Great variety of dry animal and vegetable substances, cacao, tobacco, wool, seeds, grain.

Setomorpha tineoides
Java.
Damp stored coca, wool.

Sitotroga cerealella - U. S.: Angoumois grain moth; German: Getreidemotte; Italian: vera tignolo del grano; Dutch: rijstmot; Spanish: polilla del trigo or polilla del grano; Mexican: palomilla.
Cosmopolitan.
Stored corn, sorghum; also in fields; wheat, rice, beans, peas

Reproduces between 64° and 95°F. Egg to adult about 55 days. 23 days at 82½°F to 60 days at 61°F. Does not mature at 8% moisture in wheat but can at 12%. Minimum temperature abov 59°F, development zero 50½°F; killed at 176°F in 15-20 minutes; killed at 140°F in 7½ hours.

Symmoca signatella
W. & S. Europe, North Africa.
Dry vegetable refuse.

Syria sp.
Oases of Baharia and Siwa.
Dates.

Thagora figurana
Japan and Dutch East Indies.
Rice, corn.

Tinea cloacella - U. S.: cork moth; German: Schleusenmotte.
Northern Hemisphere.
Stored grain, dried anemone roots, bottle corks, dried mushrooms. Prefers high moisture content.

Tinea ditella
Great Britain.
Stored grains.

Tinea fuscipunctella - German: Nestermotte.
Cosmopolitan.
Animal, vegetable refuse; leather, seeds, dried fruit. This is a clothes moth in Australia and New Zealand; common clothes moth of India.

Tinea lapella
Central and Southern Europe, Asia Minor, England.
Wool, rugs, warehouses.

Tinea misella - German: Rülsenfruchtmotte.
Northern Hemisphere.
Tobacco seed, skins, dried plants, flesh, corn, grain, peas.

Tinea opsigona
India.
Horn.

Tinea pachyspila
Tropical Africa and Asia.
Domestic, probably in wool.

Tinea paliescentella - English: large pale clothes moth.
Europe.
Grain, skins, wool.

Tinea pellionella - U.S.: case bearing clothes moth; German: Pelzmotte.
Cosmopolitan.
Wool and other animal fibres. Can use silk and nylon to some extent but does not attack clean silk.

Tinea personella
Europe.
Stored grain.

Tinea secalella
Europe.
Stored grain, rye. Three generations a year.

Tinea semifulvella
Europe.
Wool.

Tinea vastella - French: Teigne des cornes; German: Gehornmotte.
Tropical Africa.
Dried fruit, horn.

Tineola bisselliella - U.S.: webbing clothes moth; French: teigne des vêtements; German: Kleidermotte: English: common clothes moth.
Cosmopolitan.
Wool; wool without fat is not a very satisfactory diet. In casein, fish meal, baled human hair, groats, vetch seed, grain, wheat, corn, fur, does not attack clean silk.
One to four generations per year. Optimum temperature 77°F. Eggs killed at 32°F and larvae at 16°F. Temperature range 17½°-95°F. Eggs do not develop below 50°F. Newly hatched larvae can pass through openings of .004 inch.

Tineola walsinghami - U. S.: plaster bagworm.
Florida.
Feeds on wool.

Tineopsis theobromae
United States.
Cacao.

Tortilia viatrix
Sudan (introduced in United States)
Dried senna leaves.

Trachylepidia fructicassiella
Germany.
Seeds of Cassia fistula.

Trichophaga abruptella
India.
Clothes moth.

Trichophaga tapetzella - U.S.: tapestry moth; U. S. official: carpet moth; German: Tapetenmotte; English: white tip clothes moth.
Cosmopolitan.
Wool, fur, hair, feathers, skins.

Vitula serratilineella - U. S.: dried fruit moth
Western United States.
Figs, raisins, prunes. Development about 38 days at about 72°F.

Xylomyges eridania - U. S.: semitropical armyworm.
S. E. United States.
Sweet potatoes during curing.

Coleoptera

Anobiidae - German: Pochkafer

Anobium magnum
New Zealand.
Causes severe damage to spruce and rimu.

Anobium punctatum - U.S.: furniture beetle; German: Totenuhr, gestreiffe Holzbohrkäfer; Dutch: klopkevertje.
Widespread - temperate regions.
Infestations generally in sapwood; attacks books, perforation of linen cloth; does not attack *Eucalyptus* timber in Tasmania. Development 2-3 years.

Calymmaderus capucinus
Chile.
Furniture.

Calymmaderus incisus - Australian; Queensland pine beetle.
Australia, Queensland.
Wood borer in *Araucaria cunninghami* (hoop pine).

Calymmaderus oblongus - U. S.: Mexican deathwatch beetle.
United States, Mexico.
Wood borer.

Eupactus oblongus - U. S.: Mexican deathwatch beetle.
Mexico.
Timber.

Catorama bibliothecarum
Tropicopolitan.
Books.

Catorama herbarium
Tropicopolitan.
Upholstery, books, corn brooms, wood, nutmegs.

Catorama meieri
Germany.
In tobacco and other stores.

Catorama mexicana
Hawaii, Mexico.
Grain.

Catorama punctulata
Southern United States.
Corn, corn meal, flour.

Catorama tabaci - U.S.: Larger tobacco beetle.
Holarctic and Neotropical.
Tobacco.

Catorama zeae
England, Barbados.
Corn.

Coelostethus pertinax - German: Trotzkopf
Palaearctic.
Stored products.

Coelostethus truncatus - U.S.: Pine deathwatch beetle.
Pacific States.
Pine.

Dorcatoma bibliophagum
Tropicopolitan.
Books.

Dorcatoma spp.
Tropics.
Timber, books, papers.

Ernobius mollis
Cosmopolitan.
Wood borer, sapwood under bark only; paper; sulphite paper near unbarked wood.

Gastrallus indicus
India.
Books.

Gastrallus laticollis
Java.
Books, actually the paste.

Hadrobregmus carinatus
United States.
Wood borer.

Hadrobregmus destructor
Alaska.
Wood borer.

Hadrobregmus gibbicollis - U.S.: California deathwatch beetle
Pacific States, British Columbia.
Wood borer, Douglas fir.

Hadrobregmus rufipes
Palaearctic.
Stored products.

Hedobia imperialis
Europe.
Wood borer.

Lasioderma serricorne - U.S.: cigarette beetle; Italian: tarlo del tabacco; German: Kleiner Tabakkäfer; Dutch East Indies: tabaksboeboek.
Cosmopolitan.
Stored tobacco, rice, corn, cacao, dried fish, saffron, sugar, cottonseed meal, can perforate linen, adults wil gnaw out through various fabrics, young larvae can penetrate twill, packing paper, cellophane, sisalkraft paper. Stored wax of Cocoa coronata, cottonseed, bean, dried figs, cayenne pepper, ginger, dried dates, orris root, curry powder, starch, dried yeast, opium, paprika turmeric, spices, liquorice, belladona, pyretherum powd cane and rattan work, books, gun wads, raisins, upholstery, rugs, tapestry, silk, grain and cereal products, copra, peanuts, curcuma roots, rhubarb roots, ergot, stramonium hyoscyamus, coffee beans, cumin seeds, prepared fish food, dried bananas, nutmegs, aniseseed, pumpkins, tamarind seed.
Controlled in books by 140°-145° for six hours. Development 6-7 weeks in tropics. Killed at 130°-140° in two hours, at 25°F in seven days, 15 minutes at 140°F. Optimum temperature 90°, 75% relative humidity, minimum 30% r.h., minimum temperature 55°F.

Lasioderma testaceum
India.
Peanut cake, coconut cake.

Neogastrallus librinocens
Florida (introduced), Cuba.
Books, especially cloth and binding.

Nicobium castaneum
Holarctic.
Wood borer in furniture and yellow pine lumber; attacks books in Spain.

Ochina ptinoides
Central and South Europe, England.
Wood borer.

Oligomerus obtusus
Bermuda, United States.
Damaging woodwork.

Oligomerus ptilinoides
Europe, North Africa.
Wood borer in furniture.

Platybregmus canadensis
Canada.
Wood borer.

Ptilinus pectinicornis
Europe and the Caucasus.
Wood borer.

Sitodrepa panicea - U.S.: drugstore beetle; German: Brotkäfer
Cosmopolitan.
Cloth containing glue, paste or casein; coriander seed, ginger, leather, flour, ice cream powder, grain and cereal products, books; bamboo and a little damage to ivory, glue primary attractant; onion seed, lettuce seed, baker's goods, dried plants, rhubarb, chamomile, boneset, liquorice, peppermint, breakfast foods, dried beans, dried peas, chocolate, pepper, coffee, drugs, strychnine.
Development 66-230 days; optimum temperature 79°-82½°.

Trypopitys carpini
Europe, Asia Minor.
House roots.

Trypopitys punctatus - U.S.: western deathwatch beetle.
S. W. States and Rockies.
Timber.

Xestobium rufavillosum - U. S.: deathwatch beetle; German: bunte Klopfkäfer.
Cosmopolitan.
Wood borer, oak, willow, Requires at least 8% moisture and some rot in the wood; generally found in the lower part of buildings.

Xyletinus peltatus
United States.
Timber.

Anthicidae

Anthicus australis
Australia - very rare.
Dried pears.

Anthicus elegans
Australia.
Stored wheat.

Anthicus floralis
Cosmopolitan.
Water chestnuts, wheat, dried fruits.

Bostrichidae

Amphicerus anobioides
Arabia, Iraq to Indo-China.
Wood borer, timber, bamboo, tent pegs.

Amphicerus bimaculatus
Mediterranean region.
Wood borer, also in lead.

Amphicerus cornutus
Neotropical, Hawaii.
Fence posts, stakes.

Amphicerus hamatus.
North America.
Wood borer, oak.

Apate monachus
Germany, Tropical Africa, Mediterranean region, Antilles.
Dried bananas.

Apatides fortis
Southern United States.
Mesquite wood.

Apoleon edax
India and Indo-China to Java.
Timber.

Bostrychoplites cornutus
Africa, Madagascar, Mauritius.
Timber.

Bostrychoplites productus
Congo to Sierra Leone.
Timber

Bostrychopsis bengalensis
India.
Timber, bamboo, tent poles and pegs.

Bostrychopsis jesuita
Australia.
Lead Cables.

Bostrychopsis parallela
India to Formosa and South to Java.
Timber, bamboo, tent poles and pegs.

Bostrychus capucinus
Europe, South Africa, S. W. Asia.
Wood borer, rare in oak; lead to 14 mm thick.

Bostrichus cylindricus
New South Wales.
Damages telephone cables, timber.

Calopertha truncatula
India, North Africa.
Fuel wood.

Dinoderus biforeolatus
Tropicopolitan.
In drugs, cassava, derris, grain, flour, timber.

Dinoderus brevis
India to Philippines, Sunda Is., Jamaica.
Bamboo, furniture, timber tent pins.

Dinoderus distructus
Philippines.
In dried roots of Jatrorhiza palmata.

Dinoderus favosus
India, Assam, Indo-China, Audamaus.
Timber.

Dinoderus minutus - U.S.: bamboo borer.
Southern United States, Tropicopolitan.
Occasional in drugs, spices, tobacco, grains, etc,, rattan rice, derris roots, attacks sone species of bamboo, cotton goods crated in bamboo, corn, ginger, cacao, chestnuts, dried bananas.

Dinoderus oblongopunctatus
French Guinea.
Dried sweet potatoes.

Dinoderus ocellaris
Burma, Indo-Malaya, Assam, India, Ceylon.
Bamboo, teak.

Dinoderus porcellus
Guinea.
Dried sweet potatoes, raffia.

Dinoderus sp.
Mauritius (imported from Indo-China).
Wood.

Heterobostrychus aequalis
India to Philippines, Madagascar, United States (in box boards from India), Mauritius (introduced), Bhutan, New Guinea.
Wood borer, boring from wood into tin (so-called).

Heterobostrychus brunneus
Africa, Madagascar.
Wood borer.

Heterobostrychus hamatipennis
India to Indo-China, Madagascar.
Timber.

Heterobostrychus pileatus
India to the Philippines.
Rare, in stores; timber.

Heterobostrychus unicornis
India, Indo-China, Madagascar, Assam.
Rare in timber.

Micrapate puncticollis
Germany, South America, Antilles.
In wood.

Micrapate brasiliensis
South America, Uruguay, Brasil
Wood borer, also in lead.

Polycaon stouti - U. S.: Black polycaon.
Western United States.
Wood borer, furniture.

Prostephanus punctatus
North America, Central America.
Wood borer, oak.

Prostephanus truncatus - U.S.: larger grain borer; German: grosse Kornbohrer.
California, Brasil.
Corn, edible roots, tubers, wood, grains.

Psoa dubia
Mediterranean region.
Attacking books.

Psoa viennensis
Central Europe.
Dry wood.

Rhizopertha dominica - U.S.: lesser grain borer, woodbug; German: Getreide-Kapuziner.
Cosmopolitan.
Stored grain, flour, leather, wooden ware, rice, cassava, a library pest; stored drugs, paper, ship and army biscuits, bookbindings, corn, Lonchocarpus sp., pith helmets made with flour paste.

Egg to adult about one month in summer. May be killed in 3 minutes at 112°F and at 146°F; optimum temperature about 95°F, minimum about 60°F. Minimum moisture less than 8% in grain.

Rhizopertha hordeum
Formosa.
Grain.

Scobicia declivis - U.S.: lead cable borer.
Western United States.
Bored through a four layer asphalt roof with a cap sheet of mineral surfaced roofing; lead aerial cables; wood borer; thin sheets of copper.

Scobicia pustulata
Mediterranean region.
Boring into lead gas pipe.

Sinoxylon anale
New Zealand, Palaeotropics.
In tent pegs, derris root, cassava roots.

Sinoxylon ceratoniae
Senegal eastward to Red Sea.
Leguminous timbers.

Sinoxylon conigerum
Tropicopolitan except Australasia.
Cassava, timber, lead.

Sinoxylon crassum
India to Indo-China south to Dutch East Indies.
Timber, tent pins.

Sinoxylon indicum
India, Burma, Iraq.
Tent pins, small wood.

Sinoxylon malaccanum
Malaya.
Derris.

Sinoxylon pubens
India.
Timber.

Sinoxylon pugnax
India.
Timber, tent pins.

Sinoxylon ruficorne
Senegal to Ethiopia and south to the Cape.
Boring into lead aerial cables.

Sinoxylon rugicanda
Malaya.
Derris roots.

Sinoxylon senegalense
Senegambie, Egypt.
Wood borer.

Sinoxylon sexdentatum
Mediterranean region.
Wood borer, also in lead.

Sinoxylon sudanicum
India, North Africa.
Timber, tent pins.

Sinoxylon tiguarium
India.
Timber.

Tetrapriocera longicornis
Central America and Antilles, Columbia, Venezuela.
Wood of mora.

Xylion adustum
South Africa, West Africa, Madagascar.
Wood borer.

Xylion cylindricum
Australia, Tasmania.
Wine casks.

Xylobiops basilare
United States, England (imported).
Wood borer, ash, hickory, persimmon, continuous.

Xylopertha crinitarsis
West Africa, Uganda.
Wood borer.

Xylopertha picea
Sudan, Madagasçar, tropical Africa, Brasil, western Mediterranean.
Timber, bamboo.

Xylopertha sp.
Australia.
Lead Cables.

Xyloperthodes nitidipennis
Senegal to Kenya and Angola; S. E. Africa.
Timber.

Xyloosocus capucinus
Tropicopolitan.
Wood of mora, derris root.

Xylopsocus gibbicollis
New South Wales, New Guinea.
Bores into lead.

Xylopsocus sellatus
East and South Africa, Madagascar.
Wood borer.

Xylopsocus radula
India, Burma, Ceylon, Sumatra.
Timber.

Xylothrips flavipes
Philippines, Madagascar, tropical Asia.
Derris roots, timber.

Xylothrips religiosus
Hawaii, Polynesia, Australasia.
In posts of *Cynometra*, derris root.

Buprestidae

Buprestis aurulenta - U.S.: Golden buprestid.
British Columbia, Pacific States.
Timber.

Buprestis fasciata
Temperate North America.
Timber.

Buprestis japonensis
Japan.
Lead piping.

Buprestis laeviventris
N. W. United States.
Old logs.

Buprestis rufipes
United States.
In various timbers.

Chrysobothris octocola
S. W. United States.
Posts.

Chrysochroa sp.
India.
In plywood.

Chrysophana placida
California.
Coniferous timber.

Prosoheres aurantiopictus
Queensland, New Caledonia.
Emerges from logs and timber of hooppine.

Trachykele spp.
Western United States.
In coniferous wood.

Calandridae

Calandra linearis - German: Tamarindenfruchtrüssler.
West Indies, Brasil, Florida.
Tamarind pods.

Calandra granaria - U.S.: granary weevil; Spanish: gorgojo; German: Kornkäfer.
Cosmopolitan.
In stored grain, ginger, chufa, corn, rice, acorns, buckwheat, grain, currants, figs. Can eat out through kraft paper.
Optimum temperature is 77°F and 93% relative humidity; most rapid development 35 days; no maturing of larvae below 44% relative humidity; no development and high mortality below 50°F; Minimum in wheat 9½%; 2-3 generations per year in grain in Germany - 29 days at 81°F; established north to Stockholm; may survive a summer without food; killed at 131°F in 30 minutes; adults will survive up to six weeks at 31°F.

Calandra oryzae - U.S.: rice weevil; South African: maize weevil; German: Reiskäfer; Australian: common grain weevil.
Cosmopolitan.
Stored corn, sorghum, rice, macaroni; also in fields; peanuts, cassava, dried sweet potatoes, oats, dried banana, can eat through kraft paper; copra, soybeans, peas, tapioca.
Relative humidity below 36% and above 56% very unfavorable to the insects at 20°C; egg to adult under favorable conditions 6-7 weeks; female bores oviposition hole with beak; killed at 122°F in 2 hours and at 140°F in 45 minutes; killed at 131°F in 30 minutes. Minimum moisture in wheat about 10%; in corn 8%; is killed in absolutely airtight containers; no reproduction below 55°F; Optimum temperature 84°F; may survive a summer without food. Not established in Sweden.

Calandra sasakii
Japan.
Rice.

Myocalandra elongata
Japan.
Bamboo, flour, macaroni.

Carabidae

Harpalus rufipes
Holarctic.
A nuisance but not doing damage - seed eater.

Plochionus pollens
Cosmopolitan.
Nutmegs.

Cerambycidae

Acanthocinus aedilis
Northern Europe, Siberia.
Coniferous wood.

Aeolesthes holosericea
India to Indo-China and Malaya.
Dead wood.

Ambeodontis tristis
New Zealand (native)
Damages timber in buildings.

Asemum striatinum
Palaearctic.
Coniferous timber.

Brothylus conspersus
Pacific States.
Partly seasoned ash.

Callidium antennatum
United States, British Columbia.
Sapwood under bark; buildings in British Columbia; underground lead cable.

Callidium violaceum - German: Veilchenbock.
Palaearctic.
Sapwood under bark, woodwork of coniferous wood.

Chion cinctus
Eastern United States.
Partly seasoned hickory lumber.

Chlorophorus annularis
Japan and India to New Guinea.
Dry bamboo.

Criocephalus rusticus
Europe.
In coniferous timber.

Cyllene caryae
United States.
Partly seasoned hickory.

Dihammus elongatus
India, Burma.
Dead and felled wood.

Diorthus cinereus
West Africa, Siam, Mauritius.
Felled trees.

Eburia quadrigeminata
North America.
Oak, probably continuous, rare, perforating lead pipe in Florida.

Ergates faber - German: Mulmbock.
Europe, North Africa, West Asia.
In old pine floors.

Ergates spiculatus - U.S.: spined pine borer.
British Columbia, Western United States.
Wood of Douglas fir.

Gracilia minuta
Holarctic.
In wicker, willow.

Hylotrupes bajulus - U.S.: house beetle, porter beetle; German: Hausbock.
Holarctic.
Wood borer, prefers coniferous sapwood, not in oak, attacks lead of telephone cables in Spain; has penetrated 1/6" lead.
Controlled by heating buildings to about 140°F for a few hours, development 4-5 years; can use wood at 7½% moisture.

Leptidea brevipennis
Central and Southern Europe.
Wicker bottle covers.

Leptura rubra - German: Rothalsbock.
Palaearctic, except Great Britain.
Timber.

Lophopoeum timbouvae
Brasil.
In tamarind seeds.

Megaderus stigma
Continental Neotropics.
Perforates lead sheathing of aerial cables, more wood.

Merium proteus
Western North America.
Sapwood under bark.

Mesosa indica
India.
Sapwood of logs, dry sticks.

Monochamus confusor
Europe.
Lead.

Necydalis indica
India.
Dry wood.

Neoclytus caprea
North America.
Probably continuous infestant in timber.

Neoclytus erythrocephalus
North America.
Probably continuous infestant in timber.

Neoclytus rufus
Trinidad, Venezuela.
Mora wood.

Oeme costata
S. E. United States.
Pine rustic work.

Oeme rigida
Eastern United States.
Cypress and juniper rustic work.

Oeme strangulata
S. E. United States.
Cedar and juniper rustic work.

Orthosoma brunneum
Eastern United States.
Timber.

Parandra brunnea
Eastern United States.
Chestnut poles.

Perissus taetus
Assam - Java, Indo-China.
Derris roots.

Phymatodes dimidiatus
United States.
Coniferous logs.

Phymatodes lividum
Southern Europe, North Africa.
Wicker.

Phymatodes testaceus
Holarctic.
Oak wood.

Prionus californicus
Western North America.
Decaying bridge timbers, balsam fir.

Pterolophia melanura
Malaya.
Derris roots.

Pyrrhidium sanguineum
Europe.
Lead.

Smodicum cucujiforme - U.S.: flat powderpost beetle.
North America.
Continuous infestant in timber, rare.

Sphenostethus taslei
Eastern United States.
Dead wood.

Stromatium barbatum
Palaeotropics.
Wood of various kinds.

Stromatium fulvum
Tropicopolitan.
Furniture, timber.

Stromatium longicorne
Paleotropics, except Australasia.
Timber in buildings, furniture. Development 2-3 years.

Tetropium gabrieli
Europe.
Lead lining of wooden vats.

Tetropium castaneum
Palaearctic, except England.
Spruce.

Trachyderes succinctus
Neotropical.
Mora wood.

Tragosoma harrisii
Mountains of United States.
Dead wood.

Cisidae

Cis pygmaeus
Europe.
Ginger (abnormal habitat).

Cleridae

Corynetes caeruleus - German: blaue Fellkäfer.
Cosmopolitan.
Bones, skins, dried fruits, glue, bacon, meat, insects.

Necrobia ruficollis - German: rothalsige Kolbenkäfer.
Cosmopolitan.
Salt provisions, lard, suet, cheese, salt fish, attracted to decaying animal matter, especially rancid fat.

Necrobia rufipes - U. S.: copra beetle, red-legged ham beetle; German: rotfussige Schinkenkäfer, blaue Schinkenkäfer.
Cosmopolitan.
Rice bran, meat, currants, cassava, raisins, bacon, skins, cheese, kernels of oil palm, fish, figs, dried egg yolk, silkworm cocoons, raw silk waste, attracted to decaying animal matter, especially rancid fat, bone meal, copra, cacao, spices, dried fruit, figs, salt fish, ham, oats, corn, dried milk, stearine candles, dog biscuit, nutmegs. Development in warm weather 34 days.

Necrobia violacea
Cosmopolitan.
Attracted to decaying animal matter, especially rancid fat, salt provisions, lard, suet, cheese.

Opetiopalpus scutellaris
Central and South Europe, West Asia, Africa.
Detritivorous, perhaps not a household insect.

Opilo domesticus
Europe and North America.
Normally a predator on other insects but the larvae may gnaw wood.

Tarsostenus univittatus
Cosmopolitan.
This may be only a predator on wood borers, detritivorous in various goods.

Thaneroclerus buquet
India, China, East Indies.
Rice, cacao, ginger. This species is probably predacious.

Colydiidae

Bothrideres andrewesi
Malaya, East Indies, Burma.
Derris.

Murmidius ovalis
United States, Europe, Japan, East Indies.
Rare, in stores of rice, hay, etc., dried apples, Aleppo galls, corn, wheat.

Ocholissa humeralis
Widespread in Old World Tropics, Pacific Islands.

Thaumaphrastus karanisensis
United States, Egypt
Rice.

Cryptophagidae

Atomaria atricapilla
Europe, Siberia.
Figs.

Cryptophagus acutangulus
Holarctic.
In houses and cellars, actually a feeder on mold spores; in grain, tobacco, hides, furniture. Development 30 days.

Cryptophagus affinis
Europe, Madeira, North Africa, Australia.
Granaries; dried fruit, raisins.

Cryptophagus cellaris
Holarctic and Peru.
Pearl barley, raisins, pea-meal, grain; in granaries, mills; beehives, bread, dried fruit, rice.

Cryptophagus croceus
United States.
Stored apples.

Cryptophagus dentatus
Europe, Madeira, Japan.
Flour, dried fruit, raisins.

Cryptophagus distinguendus
Europe, North Africa.
Granaries; dried fruit.

Cryptophagus fowleri
Europe.
Grain products.

Cryptophagus inscitus
United States.
Raisins.

Cryptophagus pallidus
Europe.
Barley.

Cryptophagus pilosus
Europe, Japan.
Figs; corks in wine cellars.

Cryptophagus saginatus
Europe, North America, North Africa.
Hops, raisins.

Cryptophagus scanicus
Europe.
Grain, dried fruit, figs, dried pears, raisins.

Cryptophagus validus
Europe, Greenland.
Raisins.

Henoticus californicus
Europe, North America.
Dried fruit, jam, corks, bread, cacao, spice.

Henoticus germanicus
Northern Europe.
Moldy bread.

Cucujidae

Laemophloeus ater
Europe, North Atlantic Islands.
Bran, flour.

Laemophloeus fasciatus
United States.
Bites workers in saw mills.

Laemophloeus ferrugineus - U.S.: Rust-red grain beetle.
Cosmopolitan.
Grain, raisins, oil seeds, cassava, dried fruits, bean cakes, cacao, chillies.

Laemophloeus janeti
England, Belgian Congo, Madagascar, India.
Grain, rice, cottonseed, flour, coconuts, cacao. Fly at dusk only, will bite man, larvae coprophagous, adults carnivorous.

Laemophloeus minutus - U.S.: flat grain beetle.
Cosmopolitan.
Stored grain and flour, attacks the germ especially, not a primary pest of uninjured grain, rice, nutmegs, filberts.
Development 5-9 weeks.

Laemophloeus modestus
United States.
Hempseed.

Laemophloeus pusillus
Japan, Samoa, Malaya, Europe, United States, Burma.
Grain beetle, copra.

Laemophloeus turcicus
Cosmopolitan.
Copra, grain, cacao, spices, dried fruits, nutmegs, chillies.

Laemotmetus rhizophagoides
Germany, Africa, Ceylon and Formosa to New Guinea.
In stored rice.

Curculionidae

Apion crotalariae
Brasil.
Crotalavia seed.

Caulophilus latinasus - U.S.: broad-nosed grain weevil; German: breitrüsselige Kornkäfer.
Western Hemisphere and Europe.
Breeds in fields and in stored grain, cannot attack whole, hard, ripe grain; acorns, avocado seed, sweet potatoes, corn, dasheen roots, ginger. Egg to adult about 1 month in summer.

Chalcodermus angulicollis
Brasil.
Beans, probably not normal in stored leguminous seeds.

Cossonus parallelopipedus - German: Rindenrüssler.
Europe.
Wood in damp situations.

Cossonus suturalis
Tropical and south Africa, Madagascar, Seychelles.
Stored sweet potatoes.

Cylas formicarius - U.S.: sweet potato weevil; Cuba: tetuan del boniato; Puerto Rico: gorgojo de la batata.
Widespread.
Stored sweet potatoes.

Dryotribus mimeticus
S. E. United States.
Along the coast in old boards.

Eremotes porcatus
Europe.
In spruce, beans, floor boards.

Gononotus angulicollis
Cuba, Florida.
Old boards, etc., on sea coast.

Hexarthrum ulkei
N. E. United States.
Damages buildings.

Pselactus spadix
Europe, North Africa, Eastern United States, Australia, New Zealand.
Wood borer, floor boards.

Rhyncolus culinaris
Europe.
Infests periodically dampened wood, especially floor boards.

Spermologus rufus
Brasil.
Cacao.

Stenoscelis brevis
Eastern United States.
In rotten wood, a secondary infestant.

Xenocnema spinipes
New Zealand.
Lives in kauri timber.

Dermestidae - German: Speckkäfer.

Aethriostoma gloriosae
Java, Jamaica, India.
Horse hair.

Aethriostoma undulata
Madagascar, Mauritius, India, Dutch East Indies.
Coconut press cake, wheat.

Anthrenocerus australis
England, Australia.
Hides, fish meal, flannel, dried milk.

Anthrenus caucasicus
Transcancasia, Austria.
Dried insects.

__Anthrenus__ __fasciatus__ - German: Polstermöbelkäfer.
Europe, East Indies, Middle East.
Horn, brushes, wool, leather, skins, hair, dried meat, and less readily cotton, silk, artificial silk, sponges, dried cheese, stored clothing. Optimum temperature about 95°F; eggs do not hatch at 104°F, high mortality below 68°F.

__Anthrenus__ __fuscus__
Europe, North America.
Not economic in Germany; much prefers insects to wool; rare; life cycle as in __A.__ __museorum__.

__Anthrenus__ __museorum__ - German: Museumskäfer.
New Zealand, Holarctic.
In museum collections, much prefers insects to wool. Attacks books, skins, Development 7-14 months, hibernates as larvae. Not common in Germany.

__Anthrenus__ __nebulosus__
S. Brasil, S. Europe.
Bone, horn, dead insects.

__Anthrenus__ __pimpinellae__
Gambia, Java, Japan, Australia, Palaearctic.
In Germany, occasional in dwellings, prefers wool; dried fish, horse hair, plush. Life cycle about a year, mostly hibernating as adults.

__Anthrenus__ __scrophulariae__ - U. S.: common carpet beetle; German: Kabinettkäfer, Teppichkäfer.
Cosmopolitan.
The chief pest of woolens and furs in Germany, apparently more often associated with carpets in North America; also in flour; adults commonly found outdoors on various flowers. Life cycle apparently annual, the insects overwintering as pupae or young adults in the north temperate zone.

__Anthrenus__ __verbasci__ - U.S.: varied carpet beetle; German: Wollkrautblutenkafer.
Cosmopolitan.
In Germany mostly in dwellings and warehouses, slightly prefers dead insects to wool. Back says this may be a seed-eater; rice, all materials of animal origin, silk, corn, grain, seeds, flour. Dormant below 39°F. Life cycle 6½ to 12 months, hibernates only in larval stage.

__Anthrenus__ __vorax__ - U.S.: furniture carpet beetle.
Eastern United States, India, Sudan.
Wool, hair, feathers, horn, silk, vegetable fibres stained with excrement, dried cheese, glue in bookbindings, upholstery.

Attagenus alfierii
Egypt.
Drug shop.

Attagenus byturoides
Tashkent.
Flour, bran, wheat, corn, rice, leather, dead insects. Survives down to 40°F.

Attagenus japonicus
Japan.
Dried insects, wool, occasionally silk. One generation per year.

Attagenus pellio - German: gefleckte Pelzkäfer.
Holarctic.
Furs, woollens, grain, textiles, dead insects, flour, groats, casein, dried egg yolk, smoked meat, smoked fish, may attack bolting silk of flour mills.

Attagenus piceus - U.S.: black carpet beetle; German: schwarze Pelzkäfer.
Holarctic, Cosmopolitan.
Attacks raw silk, wool, seeds, grain and their products, hair, fur, feathers, horn, dried meat, casein, dried milk, silk-worm cocoons, rice; may perforate cartons and other containers; leather, cayenne pepper, beans, peas, paper, books, silk.
One-third to two generations per year. Dormant below 50°F; optimum temperature 75-79°.

Attagenus plebejus
Hawaii.
Wool.

Dermestes cadaverinus - U.S.: incinerator beetle; German: Aasspeckkäfer.
Cosmopolitan.
Dried fish, cheese, copra, hog bristles, dried mushrooms, dried insects, silk, leather, wool, cacao, ginger.

Dermestes carnivorous - German: amerikanische Speckkäfer.
Cosmopolitan.
Meat, cacao, hides.

Dermestes coarctatus
Japan, Manchuria.
Dried insects, bean cakes.

Dermestes frischi - German: Frischs Speckkäfer.
Widespread.
Dried meat, silkworm cocoons, sponges, hides, smoked meat, dried cheese, dried fish, wool, dog biscuits, cowries.
Development 31-32 days at 28-30°C, up to 6 generations per year.

Dermestes lardarius - U.S.: larder beetle; German: gemeine Speckkafer.
Cosmopolitan.
Dried crabs, skins, peanuts, chocolate with puffed rice, salt pork, sponges, can penetrate 0.2 mm lead in 4 hrs. and tin in 36 hours, but not Al, Zn, brass; prefers ham, bacon, cheese, meat; lard and fat avoided; dried fish, beeswax, leather, grain products, nuts, dog biscuits, cacao, nutmegs, dried pears, tobacco; will bore into spruce for pupation.
Development 32-58 days; optimum temperature 64°-68°F.

Dermestes murinus - German: mausgraue Speckkäfer.
Palaearctic.
Skins, furs.

Dermestes oblongus
Europe, Chile.
Hides, raw silk waste, sisal.

Dermestes peruvianus - German: peruvianische Speckkäfer.
South America, Central America, South Africa, Europe.
In spruce, cacao, meat, can penetrate 0.2 mm lead in four hours and tin in 36 hrs., but not Al, Zn, brass.

Dermestes sp.

Noodles.

Dermestes undulatus
Tashkent, Mediterranean region.
Silkworm cocoons.

Dermestes vorax
Japan.
Animal matter. Development about 90 days.

Dermestes vulpinus - U.S.: hide beetle; German: Dornspeckkäfer; South African: skin beetle.
Cosmopolitan.
Raw hides, bones, offal, cacao, meat, cheese, bristles, gl[illegible] smoked meat, dried fish, cowries, tobacco; prefers hides and skins; bores into soft wood for pupation.
Development 5 weeks to 8 months; up to 6 generations per year. Development 42-46 days at 82½-86°F. Hides protected by storage at 40°F or lower.

Entomotrogus megatomoides
Mexico, Europe.
Dead insects.

Eucnocerus anthrenoides
Hawaii, Mexico, Panama.
Seeds, corn.

Megatoma varia
Japan.
Dried insects.

Orphinus aethiops
Java.
Tobacco seed, also cloth binding of portfolios.

Thylodrias contractus - U.S.: tissue paper beetle.
Holarctic.
Injures paper, silk, chicken feathers, fish meal.
Development very slow.

Trinodes hirtus
Japan.
Animal matter. One generation per year, overwinters as larva.

Trogoderma granarium - Indian: Khapra.
Europe, Asia, North Africa, Australia.
Stored wheat, barley, peas, malt at moisture of 3½%.
One generation per year: optimum temperature about 87°F, can thrive at 113°F. Development between 41° and 118½°F. Killed in 30 seconds at 185°F and in 5 hours at 122°F. (This last figure is doubtful.)

Trogoderma inclusum
United States, Europe.
Grain; omnivorous. Lethal temperature 119°F.

Trogoderma ornatum - U. S.: large cabinet beetle.
United States, Western Europe.
Fur, wool, leather, grain, seeds. Optimum temperature 89°F.

Trogoderma sternale
United States, western Europe.
Fur, wool, leather, linseed, castor beans, red clover seed, silk, cayenne pepper, peanuts.

Trogoderma tarsale
Southern United States, western Europe.
Cottonseed meal, furs, skins, woollens, seeds, tobacco, stored cereals, red pepper, castor beans, peanut press cake.
Larvae have survived 1884 days without food.

Trogoderma tricolor
Yaman, Holland.
Peanuts.

Trogoderma versicolor - U.S.: varied cabinet beetle.
Cosmopolitan.
Flour, bran, wheat, corn, rice, leather, dead insects, sun-flower seeds, rusks, wool, silkworm cocoons; in dried milk plants.

Most active at 77°-86°F, minimum for development 53°F, killed at 137°F in 12-15 minutes.

Endomychidae

Mycetaea hirta
Cosmopolitan.
On moldy materials; corks in wine cellars; grain.

Languriidae

Pharaxonotha kirschi - U.S.: Mexican grain beetle.
North America, Central America, Europe.
Stored grain and milled cereal products, corn, edible tubers.

Lathridiidae

Adistemia rileyi
Peru
Nepal barley.

Adistemia watsoni
Europe, Madeira, Canaries, Africa, North America, South America.
On several moldy substances.

Cartodere argus
Europe, North Africa, North America.
In ground cereals, drugs.

Cartodere belani
Europe, West Indies.
Tobacco.

Cartodere costulata
Europe, Japan, North America.
In flour, macaroni, drugs, etc.

Cartodere elegans
Europe, North Africa, North America.
Houses.

Cartodere elongata
Europe, North Africa.
Houses.

Cartodere filiformis
Europe, Russia, Japan, North America.
On moldy materials. Development 51 days.

Cartodere filum
Europe, North Africa, North America, South America.
In wheat, corn, rye. Development 36 days at 75°F, 54 days at 65°F.

Cartodere ruficollis
Europe, North Africa, Madeira, Canaries, North America, Central America.
In flour and moldy materials.

Coninomus bifasciatus
Australia.
Tobacco.

Coninomus constrictus
Cosmopolitan.
In cellars and warehouses.

Coninomus nodifer
Cosmopolitan.
Houses, warehouses, probably a mold eater.

Coninomus subfasciatus
Peru, Chile.
Nepal barley.

Corticaria ciliata
Europe, Madeira.
Houses.

Corticaria crenicollis
Europe, Madeira.
Houses.

Corticaria crenulata
Europe, Asia.
Houses.

Corticaria elongata
Cosmopolitan.
In warehouses, in refuse, etc.

Corticaria fenestralis
Europe, Asia, North America.
In flour, etc.

Corticaria fulva
Cosmopolitan,
In cellars and warehouses; a mold eater; development 40 days 65°F.

Corticaria impressa
Europe.
Houses.

Corticaria longicollis
Europe, Asia.
Houses.

Corticaria pubescens
Widespread.
Houses and granaries, tobacco.

Corticaria serrata
Cosmopolitan.
Houses.

Corticaria subtilissima
Australia.
Tobacco.

Enicmus histrio
Britain.
In wheat.

Enicmus minutus
Cosmopolitan,
Houses, cellars, granaries; mold feeder found on many materials. Development 24-30 days.

Enicmus protensicollis
Western North America, Aleutians.
Stored raisins.

Enicmus suspectus
Western North America.
Stored raisins.

Euchionellus albofasciatus
Japan, Java, Seychelles, Germany.
Houses, in drugs, etc.

Eufallia unicostata
Puerto Rico.
On walls of rooms painted with casein wash paint; numerous only in damp weather; actually a fungus feeder.

Eufalloides holmesi
Peru.
Nepal barley.

Holoparamecus caularum
Cosmopolitan.
In various substances, including stored rice.

Holoparamecus depressus
Cosmopolitan.
In various substances, including chocolate bars, flour, rice.

Holoparamecus singularis
Europe, Africa, Canaries, India, North America, South America.
Stored rice.

Lathridius bergrothi
Europe, Greenland.
Houses, warehouses, especially on damp and moldy substances.

Lathridius lardarius
Europe, North America.
Moldy materials.

Lathridius nodifer
Germany, Central America.
Moldy vegetable matter.

Lathridius rugicollis
Europe.
Houses.

Melanophthalma americana
North America, Formosa.
Flour mills.

Melanophthalma picta
North America.
On fresh apples.

Metophthalmus hispidus
Chile.
Tobacco.

Metophthalmus serripennis
New Zealand, Great Britain (introduced).
Straw envelopes of wine bottles.

Migneauxia orientalis
India, China, Japan, South America.
Rice.

Lyctidae - U.S.: powderpost beetle; German: Splintkäfer; Dutch East Indies: drooghoutboeboek.

Lyctoxylon convictor
India.
Timber.

Lyctoxylon japonum
Asia, Europe, United States, Japan, Indo-Malaya.
Timber, bamboo.

Lyctus africanus
Madagascar, Africa, India, Philippines.
Cassava, timber, ginger, derris, tent pins.

Lyctus brunneus - U.S.: Old World powderpost beetle; Brasil: caruncho de madera.
Cosmopolitan.
Attacking copper plates; *Eucalyptus saligna*, cassava, lead, plywood.

Lyctus canaliculatus
Europe.
Lead pipe.

Lyctus carbonarius
Mexico, Florida.
Timber.

Lyctus caribeanus
Central America, West Indies.
Bamboo.

Lyctus cavicollis - U.S.: western powderpost beetle.
Western United States, England (imported).
Timber.

Lyctus linearis - U.S.: European powderpost beetle;
German: Parkettkäfer.
Cosmopolitan.
Oak, ash, willow.

Lyctus malayanus
India, Ceylon, Sumatra.
Timber.

Lyctus opaculus
United States.
Timber.

Lyctus planicollis - U.S.: southern powderpost beetle.
United States, South Africa, northern Europe (imported).
Timber.

Lyctus pubescens
Europe.
Timber.

Lyctus sinensis
E. Asia, Japan, England (imported).
Oak.

Lyctus spp.
United States.
Lead lining of water tanks.

Lyctus spp.
New Zealand.
Timber.

Lyctus tomentosus
Jamaica, Central America.
Furniture.

Lyctus villosus
Hawaii, Mexico.
Wood of Leucaena esculenta.

Minthea obsita
Madagascar, Tropical Africa.
Cassava.

Minthea rugicollis
Tropicopolitan.
In storage places; cassava, rattan, sapwood of at least 93 spp. in Malaya; derris, lead, plywood, timber.
Development about 70 days.

Minthea squamigera
Trinidad, South America.
Mora wood.

Trogoxylon aequale
Puerto Rico, Central America, West Africa, Philippines.
Bamboo.

Trogoxylon auriculatum
Burma, India.
Timber, tent pins.

Trogoxylon impressum
Mediterranean region, Germany.
Timber.

Trogoxylon parallelopipedum
United States, England (imported).
Timber.

Trogoxylon spinifrons
India, Ceylon.
Timber, tent pegs.

Lymexylonidae

Lymexylon navale
Northern Europe.
Wood borer.

Atractocerus brevicornis
Central Africa.
Wood borer.

Atractocerus brasiliensis
Trinidad.
Mora wood.

Melandryidae

Serropalpus barbatus
United States.
Lumber.

Micromalthidae

Micromalthus debilis
North America, South Africa, Hawaii.
Acacia, pine, Eucalyptus, wet or rotted.

Monotomidae

Monotoma quadrifoveolata
Europe.
Waste grain.

Mycetophagidae

Litargus balteatus
New World, Hawaii, New South Wales.
Corn.

Mycetophagus bipustulatus
Eastern North America.
Waste grain and flour.

Mycetophagus quadriguttatus
Europe and Caucasus.
Grain, especially moldy.

Typhoea stercorea - U.S.: hairy fungus beetle.
Cosmopolitan.
Waste grain - probably a secondary invader, a mold feeder; raisins, seeds, tobacco, peanuts, cacao, soybeans.

Mylabridae

Mylabris ademptus
Japan.
Seeds of kudzu.

Mylabris analis - German: Gramerbsenkäfer.
Cyprus, South Africa, Burma, East Indies, Europe.
Cowpeas, lima beans, chick peas. Development 1 month or more.

Mylabris bixae
Holland, South America.
Seeds of Bixa orellana (annato).

Mylabris brachialis
Widespread.
Seeds of vetch.

Mylabris chinensis - U.S.: cowpea weevil; German: Kundekäfer.
Cosmopolitan.
Seeds of *Cajanus*. Field infestation but can continue on dry seeds, dried beans, *Vigna* sp. Development 3-8 weeks killed at 120°-145°, at 122°F in 5 minutes. Optimum temperature 86°F, optimum humidity 90% r.h.

Mylabris dentipes
Germany, Near East, Russia, Central Asia, Afghanistan.
Seeds, lima beans.

Mylabris dolichosi
Afghanistan, East Indies.
Dolichos biflorus.

Mylabris emarginatus
Brasil, Mediterranean region, India.
Peas.

Mylabris ervi
Mediterranean region, Germany.
Lentils.

Mylabris ferrugineipennis
Chile.
Cassia seeds.

Mylabris glaber
China, Italy.
Chickpeas.

Mylabris halodendri
Russia, Afghanistan, Siberia.
Glycyrrhiza echinata.

Mylabris impressithorax
Gold Coast, South Africa.
Stored peas, *Erythrina* seeds.

Mylabris incarnatus - German: agyptische Erbsenkäfer.
Southern Europe, North Africa.
Seeds, horsebeans, peas, lentils, chickpeas.

Mylabris lentis - German: Linsenkäfer.
Russia, Mediterranean region, North America.
Lentils.

Mylabris maculatus - U.S.: southern cowpea weevil; German: vierfleckige Bohnenkäfer.
Widespread.
Attacks seeds of *Vigna* and rarely other legumes; at emergence will perforate paper but not cloth. Generation 20 days - 8 months, upper temperature limit above 112°F.

Mylabris obtectus - U.S.: common bean weevil; Argentine: bruquido del poroto; Italian: tonchio dei fagolo; German: Speisebohnenkäfer.

Cosmopolitan.

Found in cowpeas, lima beans, and common beans, at emergence will perforate paper but not cloth.

In Italy 4-6 generations a year in common beans. Hibernation in larval stage. Generation 25 days-6 months, nee relative humidity of 26% for reproduction, reproduction at 62½°-93°F and relative humidity up to 93%; optimum temperature about 86°F. Largely killed in 7 hours at 5°F.

Mylabris ornatus

Europe, North and Tropical Africa.

Beans, peas.

Mylabris phaseoli

Burma, France, Italy, Brasil, India.

Various legumes in store.

Mylabris pisorum - U.S.: pea weevil; German: Erbsenkäfer.

Cosmopolitan.

Peas, field peas. Does not continue to breed in stored peas.

Mylabris prosopis

S. W. United States, Central America.

Stored mesquite beans.

Mylabris pruininus

Mexico, United States.

Soybeans, *Acacia* seeds.

Mylabris pygmaeus

Italy.

Seed of soola clover.

Mylabris quadrimaculatus - U.S.: four-spotted bean weevil

Widespread.

Stored peas; life cycle about 25 days; in Japan 5 generations per year.

Mylabris rhodesianus

India, Rhodesia.

Cajanus indicus seeds.

Mylabris rufimanus - U.S.: broad-bean weevil; German: Pferdebohnenkäfer.

Widespread.

Vetch seeds, dried pulse. A one generation pest. Oviposits on pods, killed at 131°F in 20 minutes, or in beans in 20 minutes at 158°F.

Mylabris rufipes
Europe, North Africa.
Cowpeas.

Mylabris signaticornis
Mediterranean region.
Lentils, *Vicia monanthus*.

Mylabris theobromae
Formosa, East Indies.
Seeds.

Mylabris trabuti
French Sudan.
Seeds of *Vigna sinensis*.

Mylabris tristis
Central and South Europe.
Lentils, chickpeas.

Mylabris ulicis
Asia Minor, Afghanistan, Southern Europe.
Vetch seeds.

Pachymerus acaciae
Asia, North and West Africa, Southern Europe.
Peanuts, tamarinds. Life cycle 2-3 months at about 90°F.

Pachymerus cassiae
West Africa.
Stored peanuts.

Pachymerus fuscus
West Africa, Mauritius, West Indies.
Tamarind, *Cassia* sp., *Colutea* sp.

Pachymerus gonager
India, Java, Japan, France, Hawaii.
Seeds and pods of tamarind and of *Cassia fistula*, seeds of *Acacia farnesiana*. Development 50 days, minimum temperature about 76°F.

Pachymerus nucleorum
South America.
Stored kernels of licuri nuts.

Pachymerus pallidus - German: Sennasamenkäfer,
Southern Europe, Sudan, Egypt, Asia.
In commercial leguminous seeds, dried senna.

Phelomerus lineola
Brasil, France.
Cassia grandis.

Phelomerus ochropygus
Panama.
Cassia grandis.

Pseudopachymerus brasiliensis
Brasil, Central America, France, Russia.
Mucuna urens seed.

Pseudopachymerus grammicus
Brasil.
Cymbasoma seed.

Pseudopachymerus lallemanti
Mediterranean region.
Acacia pods.

Spermophagus pectoralis - German: Speisebohnenkäfer.
United States, Central America.
Beans, continuous pest.

Spermophagus subfasciatus - U.S.: Brasilian bean beetle; German: Speisebohnenkäfer, Brasilbohnenkäfer.
Serious all over South America, Germany, Africa, Cuba.
Beans, various leguminous seeds, peas, _Voandezia subterranea_, _Vigna sinensis_, _Cajanus indicus_, _Dolichos lablab_, chickpeas, soybeans, _D. sesquipedalis_.
Optimum temperature 81°F, 75% relative humidity, limits 66°-95°F, development 30-33 days at 82½°F.

Spermophagus thomasi
Chile.
Seeds of _Gourliea chilensis_.

Nitidulidae

Carpophilus aterrimus
New Zealand, Australia.
Dried fruit.

Carpophilus bipustulatus
Brasil, Europe, Africa.
Corn.

Carpophilus decipiens
S. W. United States, Germany.
Drugs, dried fruit, cacao, wheat, peanuts.

Carpophilus dimidiatus - U.S.: corn sap beetle; German: Saftkäfer.
Cosmopolitan.
Peanuts, cacao, rice, copra, corn, grain, flour, dates, drugs, dried banana, shelled nuts, nutmegs, ginger; attracted by molds; widespread in foodstuffs.

Carpophilus flavidus
Austria.
Para nuts.

Carpophilus flavipes
India, Malaya, Celebes.
Copra.

Carpophilus hemipterus - U.S.: dried fruit beetle; German: gemeine Saftkäfer.
Cosmopolitan.
Attacks watermelons, apples, grapefruits, prunes, figs, peaches, apricots, oranges, dried fruit, corn, wheat, rice, copra, beans, nuts, bread. Attracted primarily to fermenting fruit.
Development requires from 20 days to several months.

Carpophilus humeralis
Tropical Africa, Madagascar, Seychelles, East Indies.
Grain.

Carpophilus ligneus
Central America, England, Germany, North America.
Dried plums, dried apples, cacao, wheat, peanuts.

Carpophilus mutilatus
Neotropical.
Drugs.

Carpophilus nitens
United States.
Rice.

Carpophilus obsoletus
Formosa, East Asia, Indo-Malaya, East Indies, Madagascar, East Africa.
Grain, rice, wheat, peanuts, corn, sesame.

Carpophilus pallipennis
California, Mexico, Europe, North Africa.
Grain.

Carpophilus unimaculatus
Holland.
Peanuts.

Haptoncus luteolus
Tropical and subtropical regions.
Dried fruit.

Meligethes aeneus - U.S.: rape beetle; German: Rapsglanzkafer.
Palearctic.
Soybeans, normally on growing rape and swedes.

Nitidula bipunctata - German: zweigetupfte Glanzkafer.
Holarctic.
Bacon, sausages, bones.

Stelidota geminata
United States, Brasil.
Rice.

Urophorus humeralis
Africa, South Asia, Europe, Southern United States.
Stored corn.

Oedemeridae

Calopus serraticornis
Palaearctic.
In damp woodwork of houses.

Copidita bicolor
Western North America.
Wet wood.

Ditylus laevis
Europe.
In wood of bridges and dykes.

Ditylus quadricollis
Western North America.
Wet wood.

Nacerda melanura - U.S.: Dutch wharf beetle.
N. E. United States, Europe, Tasmania, New Zealand, Canada, South Africa.
In oak and pine, _Eucalyptus_; normally only in very damp wood.

Ostomatidae

Temnochila caerulea
Southern Europe, Asia, North Africa.
Granaries.

Tenebroides corticalis
North America.
Stored grain.

Tenebroides mauritanicus - German: Getreidenager.
Cosmopolitan.
Larvae burrow into woodwork of bins, will perforate paper and cardboard, cut silk of bolters; in grain, flour, cottonseed meal, cassava, copra, rice, cumin seeds, corn, dried fruit, nuts, insects, currants, raisins, nutmegs, cacao.
Development 70 days or longer. Optimum temperature 82½°F; larvae and adults will stand freezing temperatures for some days.

Tenebroides nanus
S. E. United States.
Stored grain.

Tenebroides oblongus
Central America.
Cacao.

Lophocateres pusillus - U.S.: Siamese grain beetle.
Cosmopolitan.
Stored grain and grain products, rice, fruit, cassava, macaroni, sweet potatoes, butter beans, dried apples, spices.

Platypodidae

Crossotarsus grevilleae
Queensland.
Attacks felled timber, only important in forest. One generation per year.

Platypus alternans
Trinidad, Mexico, Venezuela, British Guiana.
Bores in mora wood.

Platypus lepidus
Malaya, Celebes, Moluccas, Philippines, Java.
Attacks jelutong wood.

Platypus mulsanti
British Guiana, Guadeloupe.
Timber.

Platypus omnivorus - Australian: shothole borer.
Australia, Tasmania.
Several timbers.

Platypus ratzeburgi
Trinidad, Columbia, Guianas, Brasil.
Bores in wood of mora.

Platypus suffodiens
Malaya.
Attacks jelulong wood.

Platystomidae

Araecerus fasciculatus - U.S. Official: coffee bean beetle; German: Kaffeebohnenkäfer; English: mace weevil
Cosmopolitan.
Cacao, coffee beans, corn, mung beans, cottonseed, kapok seed, soybeans, egg plant, Brasil nuts, rubber seed cake, etc., mace, nutmeg, tropical fruits in commerce, cassava, yeast, ginger, dried fruit, yams, sweet potatoes, cassia, strychnine. Development 56 days, requires 60-80% relative humidity; development in tropics about 78 days; killed in 3 days at 122°F.

Brachytarsus alternatus
Eastern North America.
Stored corn, cowpeas, peas.

Brachytarsus sticticus
Eastern North America.
Wheat, velvet beans.

Ptinidae

Eurostus hilleri
Japan, Great Britain, Canada.
Granaries, warehouses.

Gibbium boieldieui
Europe, Persia, Malaya.
Houses, bread, cheese, molds, pastry, cork, dead insects, gut.

Gibbium psylloides - U.S.: hump beetle; German: Kugelkäfer, Buckelkäfer.
Cosmopolitan.
Houses, hotels, warehouses, mills, granaries, bakeries, latrines; cayenne pepper, stored seeds, wheat bran, stale bread, decaying animal and vegetable matter, cereals, opium cakes, paste, hay, rubber bath mat, woolens, towels, leather, tallow, flour; in woodwork; paprika, grain, cottonseed, feedcake, chamomile, poppy seed.

Mezium affine
Europe, North Africa.
Houses, warehouses, granaries; seeds, various kinds of decaying animal and vegetable refuse; dead insects; in woodwork; flour.

Mezium americanum
Cosmopolitan.
Dwellings, warehouses, mills; dried animal products, tobacco seed, cayenne pepper, opium, grain, mouse dung, hair.

Niptus hololeucus - U.S.: golden spider beetle; German: Messingkäfer.
Holarctic.
Houses, bakeries, flour mills, warehouses, granaries, factories; dead insects, mouse and rat dung, feathers, brushes, leather, wool, bath sponges, cotton, linen, greasy clothing, silk, stored books and papers, bran, grain and other stored seeds, bread, cacao, casein, drugs, yarn, cocoa powder, artificial silk; adults especially harmful to fabrics. Two generations a year.

Ptinus bicinctus
Europe, North Africa, North America.
Flour; barns, granaries, warehouses, houses.

Ptinus exulans
Australia, Tasmania, Europe, Asia.
Warehouses; stored products.

Ptinus fur - U.S.: white-marked spider beetle; German: gemeine Diebkäfer, Kräuterdieb.
Cosmopolitan.
Cereals, dried insects, feathers, skins, dried plants, seeds of henbane, etc.; houses, granaries, warehouses, museums; in ginger, cacao, paprika, bread; partitions and ceilings of papered canvos; sacks containing grain and cottonseed; flour, meal, dates, fur, leather, wool, vegetables and roots, castor beans, seeds of cabbage, thyme, hawthorn, lupine; pastry; barley.
Development 3½ months.

Ptinus gandolphei
United States.
Raisins.

Ptinus hirtellus
Cosmopolitan.
Scavenger; rat dung, damaging books, feathers, skins, dried mushrooms, drugs, roots, cacao, dried fruit; warehouses, granaries.

Ptinus japonicus
Japan, China, Sikkim, Eastern Siberia.
Flour of Amorphophallus koniac. Life cycle 3½ months or more.

Ptinus latro
Nearly cosmopolitan.
Houses, warehouses, granaries; stored grain, bran, tobacco seed; probably cacao.

Ptinus pusillus
Europe.
Granaries and houses.

Ptinus raptor - U.S.: eastern spider beetle; German: Rauber-Bohrkäfer.
Europe, Eastern Siberia, Eastern North America.
Cereals in warehouses.

Ptinus rufipes
Europe.
Barns; said to be a pest of stored products.

Ptinus sexpunctatus
Great Britain, France, Corsica.
Houses, damaging a lead roof.

Ptinus subpilosus
Europe.
House pest (rare).

Ptinus tectus
Cosmopolitan.
Fish meal, cereals, cacao, dried insects: eating holes in carpets; also bores into wood of grain elevators; stored hops, dried Hyoscyamus and Datura, nutmegs, almonds, ginger, figs, raisins, dried pears, dried apricots, cayenne pepper, casein, chocolate powder, dried soup, corn, rye, paprika; houses, granaries, warehouses, mills, factories; will perforate wood, cellophane and bolting cloth when ready to pupate; ship biscuits, prepared fish food, malt, meal, dried yeast, dried galls, sago flour, soybean meal.
Development 62 days at 70% relative humidity and 73-77°F and 130 days at 70% relative humidity and 59°F. Minimum temperature 50°F, maximum 82-86°F; optimum about 75°F. At 68°-80°F, 50% relative humidity is needed; this means about 10% moisture in cereals; life cycle 10-25 weeks.

Ptinus villiger - U.S.: hairy spider beetle.
Canada, Europe, Asia.
Cereals, flour, farine, cornmeal, wheat, houses, warehouses, granaries.
Development 3½-4 months. Adults hibernate. Larvae ready to pupate cut their way out of sacks and may bore into wood. Larvae killed at -20°F.

Sphaericus gibboides
Southern Europe, North Africa, California.
Herbaria; red pepper.

Tipnus unicolor
Europe, Transcaucasia, Canada.
Houses, bakeries, flour mills, warehouses, stables; moist skins, grain, old wood, birds nests.

Trigonogenius globulus
Cosmopolitan.
Houses, warehouses, granaries; mills; argol, vegetable ivory, caraway seeds, dried pears, Nepal barley, probably a true grain pest; raisins.

Scolytidae

Coccotrypes dactyliperda
Widespread.
Attacks buttons made of vegetable ivory, date pits, betel nuts, buttons of doum nut, several palm seeds. Life cycle 30-70 days.

Coccotrypes moreirai
Brasil.
Buttons made of palm kernels.

Cryphalomorphus stierliui
Madagascar.
Roots of *Ipomoea turpethum*.

Dryocoetes hirtus
Solomon Islands.
Timber (probably).

Hylocurus langstoni
S. E. United States.
Partly seasoned posts and poles.

Hypothenemus arecae
Germany (imported), East Indies, West Africa, New Caledonia.
Betel nuts.

Hypothenemus eruditus
Malaya, West Africa, Hawaii, New Caledonia, North America.
Derris.

Hypothenemus ritchei
Jamaica.
Dried sweet potatoes.

Hypothenemus sp.
Brasil, England (imported).
Tamarind seeds, butter beans.

Micrasis hirtellus - U.S.: California hardwood bark beetle.
California.
Lead cables.

Neodryocoetes sp.
Surinam.
Sawaric nuts.

Pagiocerus frontalis
Mexico, Chile, Florida.
Corn, seeds of *Persea* and *Anona*.

Pagiocerus zeae - German: kolumbianische Maiskäfer.
Colombia, West Indies.
Corn.

Pityophthorus peregrinus
Brasil.
Tamarind seeds.

Poecilips nuciferus
Surniam.
Sawarie nuts.

Stephanoderes buscki
Trinidad.
Nutmegs - does not survive permanently.

Xyleborus affinis
North and South America, Africa.
Timber.

Xyleborus badius
British Guiana, Madagascar, Japan, Cuba, Tahiti.
Dry wood.

Xyleborus cognatus
India, Malaya, Indo-China.
Several timbers, a coastal species.

Xyleborus confusus
South America, East Africa, Madagascar, Hawaii, Keeling Id., Seychelles.
Timber.

Xyleborus fornicatus - English: shothole borer of tea.
India and Malaya to Java, New Guinea.
A few timbers or logs.

Xyleborus fuscatus
North and South America.
Timber.

Xyleborus interjectus
India to Japan, South to Java and Batoe Is.
Numerous timbers.

Xyleborus intersetosus
British Guiana, Guatemala.
Timber.

Xyleborus kraatzi
Tropicopolitan.
Furniture.

Xyleborus laticollis
India, Ceylon.
Several timbers, prefers sun stored logs.

Xyleborus obraeus
British Guiana.
Timber.

Xyleborus semigranosus
France (imported), Widespread in tropics, Samoa.
Timber, small poles.

Xyleborus tegalensis
Assam, Burma, Java, Sumatra.
Timbers.

Xyleborus torquatus
Madagascar, Mauritius, Tahiti.
Timber.

Xyloterus lineatus - French: bostryche liseré.
Holarctic.
In spruce.

Silphidae

Silpha lapponica
Northern Europe.
Dried fish in houses.

Sulpha rugosa
Northern Europe.
Dried fish in houses.

Silvanidae

Ahasverus advena - English: foreign grain beetle.
Cosmopolitan.
Peach kernels, cacao, cassava, copra, oil palm kernels, dried banana, flour, meal, rice, figs, beans, apples, ginger, nutmegs, algaroba pods, yams, pine nuts.
Optimum temperature 79-82½°F. Killed in 1 hr. at 125½°F.

Cathartus cassiae
Central America to Brasil, Europe.
Corn, cacao.

Cathartus quadricollis - U.S.: square-necked grain beetle.
Cosmopolitan.
Stored corn and in corn fields; tobacco, fruits of Cassia fistula, rice. Development about 3 weeks. Killed in 10 minutes at 117°F.

Cathartus excisus
Germany.
Tobacco.

Monanus concinnulus
Cosmopolitan.
In tobacco.

Nausibius clavicornis
Cosmopolitan.
In store houses; rice, sugar.

Oryzaephilus bicornis
Cosmopolitan.
Wheat, dried figs.

Oryzaephilus gossypii
Cosmopolitan. (This and the preceding may not be different from *O. surinamensis*.)
Cottonseed, peanuts.

Oryzaephilus surinamensis - U.S.: saw-toothed grain beetle; German: Getreideschmahlkäfer, Getreideplattkäfer.
Cosmopolitan.
Peach kernels, rice, cereals, dried fruits, nuts, macaroni dates, confectioners sugar, drugs, dried meats, peanuts cacao, barley, flour, raisins, copra, nutmegs, oil palm kernels, oil seeds, dried litchi nuts, cottonseed, dried grapes, ginger, dried banana, dried pears, mace, almonds, chillies, candy.
Development about 52 days at about 78°F; optimum moisture 18%; killed at 122°F in 2 hours and at 140°F in 45 minutes; at 10-15°F in 3 days. In Malaya breeding is slower at 50-60% relative humidity than at 70% where macaroni was protected by storage at 60% relative humidity. Does not develop at 59°F. Killed at 20-25°F in 7 days and at 0°-5° in one day.

Pediacus depressus
Europe, North America.
Stores.

Silvanus trivialis
British Guiana.
Timber.

Staphylinidae

Atheta coriaria
Cosmopolitan.
Ginger, perhaps predacious.

Theta trinotata
Europe.
Wheat.

Oligota granaria
Europe.
On Japanese cotton goods, actual damage not recorded; cellars.

Philonthus sordidus
Europe.
Ginger, perhaps predacious.

Xylodromus concinnus
Europe.
Ground wheat, corn meal, grain; warehouses.

Tenebrionidae

Alphitobius diaperinus - U.S.: lesser meal worm; German: Stumpfschwarzen Getreideschimmelkäfer.
Cosmopolitan.
Rice, flour, dry bread, dead insects, but does not damage sound dry grain; copra, meal, hides, cacao, linseed, cottonseed, chocolate, peanuts, tobacco. Development one year more or less.

Alphitobius laevigatus
Fiji, Samoa, Marquesas, Madagascar, Malaya.
Rice bran, cassava, derris, copra.

Alphitobius ovatus - German: stumpfschwarzen Getreideschimmelkäfer.
Europe.
Meal, dried bread, dead insects, paper, copra. Development 45 days at 30°C.

Alphitobius piceus - U.S.: grain mold beetle, black fungus beetle.
Cosmopolitan.
In meal; bakeries and stores; soybeans, tobacco.

Alphitophagus bifasciatus - U.S.: two-banded fungus beetle.
Cosmopolitan.
Feeder on molds, in grain, grain products, moist corn-meal.

Aphanotus parallelus
Western United States.
Cereals, nuts, drugs.

Aosena rufipes - U.S.: fig engraver beetle.
California.
Figs, raisins.

Blaps lethifera.
Holarctic.
Stored grain.

Blaps mortisaga
Europe, Asia.
Bakeries.

Blaps mucronata - English: churchyard beetle.
Europe, Eastern North America.
Stored grain, kitchens, bakeries, warehouses.

Blapstinus dilatatus
United States.
Raisins.

Balpstinus rufipes - U.S.: fig darkling beetle.
United States.
Raisins.

Cnameplatia sericea
California.
Raisins.

Cynaeus angustus
Eastern and Western United States.
Stored grain and milled products.

Gnathocerus cornutus - U.S.: broad-horned flour beetle.
Cosmopolitan.
Prefers flour and meal but is found in grain, raisins, rice, cacao, ginger. Development about 8 weeks to 7 months. Optimum 70°F.

Gnathocerus maxillosus - U.S.: slender-horned flour beetle.
Tropicopolitan and Holarctic.
Grain, but prefers animal substances such as dead insects corn, nutmegs, pumpkin seed, tamarind seed.
Two generations per year. Optimum temperature about 70°F

Gonocephalum hoffmannseggi
Dutch East Indies.
Corn, rice.

Hegeter amaroides
England (imported), Madeira, Canaries.
Bananas.

Helops lanipes
Europe.
Fruit.

Homala polita
Senegal.
Peanuts.

Hypophloeus floricola
Japan.
Grain.

Laethetlcus oryzae - U.S.: long-headed flour beetle.
Cosmopolitan.
Grain, rice, cassava, macaroni. Develoonment 25-40 days.

Martianus dermestoides
Siam, Viti Islands.
Puffed rice, dried durian.

Mesomorphus villiger
Old world tropics.
In houses, feed on dead or decaying vegetable matter.

Palorus depressus
United States, Europe, Dahomey.
Grain products, meal, old bread, oil palm kernels; in stores, mills, bakeries.

Palorus ratzeburgi - U.S.: small-eyed flour beetle.
Cosmopolitan.
Ground products and sometimes in grain, rice.

Palorus subdepressus - German: Kleinäugige Reismehlkäfer.
Cosmopolitan.
Copra (usually moldy), grain, flour, chicken feed, cacao, peanuts.

Pimela angulosa
Senegal, Egypt.
Peanuts.

Pimela senegalensis
Senegal, Morocco.
Peanuts.

Platydema ruficorne
United States.
Corn, shorts.

Strongylium erythrocephalum
India, Philippines.
Dry wood.

Sitophagus hololeptoides
Europe, South Africa, Texas, Central America, South America.
Nutmegs, stored cereals.

Tenebrio molitor - U.S.: yellow meal worm; German: gemeine Mehlkäfer.
Cosmopolitan.
Will go through paper and into wood; cottonseed meal, grains, cereals, meat scrap, feathers, tobacco. Optimum 77-80½°, Development 280-630 days, one generation per year. Killed at 10°F in 24 hours and at 125°F.

Tenebrio obscurus - U.S.: dusky meal worm; German: dunkle Mehlkäfer.
Cosmopolitan.
Attacks various substances, incl. dried sweet potato, cottonseed meal, bean cakes, rice. Generation in about 1 year. Killed at 125°F and at 10°F in 24 hrs.

Tenebrio picipes
Japan, Europe, Northern Asia, North America.
Stored cereals.

Tenebrio syriacus
Mediterranean region.
Flour.

Tribolium castaneum - U.S.: rust-red flour beetle.
Cosmopolitan.
Rice, peanuts, cacao, coffee, cassava, ginger, sawarie nuts, raisins, packaged cereals in Mayala protected by storage at 60% relative humidity, copra, oil seeds, corn, pulse powder, biscuits, bran, museum specimens, wool, soybeans, nutmegs, chillies, figs, dried fruit, lac, lentils, beans.
Killed at 122°F in 2 hours and at 140°F in 45 minutes, at 10-15 F in one day.

Tribolium confusum - U.S.: confused flour beetle; German: amerikanische Reismehlkäfer.
Cosmopolitan.
Cottonseed meal, coffee, cassava, chufa, raisins, rice, bruised grain, bran, peanuts, beans, peas, ginger, paprika, cacao, cashew nuts. Development 28 days or longer; respiration affected by CO_2 conc. of 5%; lives between 26½° and 102°F. Reproduces between 84° (and at lower temperatures) and 102°F, relative humidity 65-90%. Killed at 10-15°F in 1 day, at 21°F in 24 hours.

Tribolium destructor - U.S.: false black flour beetle; Germa dunkle Reismehlkäfer.
Holarctic, Argentina.
Lantana seed, corn, seeds.

Tribolium madens - U.S.: black flour beetle.
United States, N. & W.; Europe, Egypt.
Flour and stored grain, seeds.

Uloma culinaris - German: Kuchenkäfer.
Europe.
Meat and grain in houses in rural areas.

Uloma foveicollis
Tropical Africa.
Copra.

Zophosis elineata
Senegal.
Peanut.

Thorictidae

Thorictodes heydeni
France, North Africa, England, Dutch East Indies.
Millet, rice, kapok seed.

Diptera

Borboridae - various species.
Decomposing organic matter.

Calliphora augur
Australia.
Meat, sour milk, rotting grain.

Calliphora erythrocephala - U.S.: blue bottle fly; German: Schmeissfliege; Brummer.
Cosmopolitan.
Fresh and cooked meat.

Calliphora stygia
Australia.
Meat, sour milk, rotting grain.

Calliphora vomitoria - U.S.: blue bottle fly; German: Schmeissfliege.
Cosmopolitan.
Meat.

Drosophila buscki - German: Essigfliege
Widespread.
In milk depots; decaying vegetable and animal substances.

Drosophila fasciata - German: kleine Essigfliege.
Europe.

Drosophila fenestrarum
Europe, North Africa.
Domestic.

Drosophila funebris - German: grosse Essigfliege
Widespread.
Marmalade, preserved fruits, fruit juices, catsup, pickles, rotting potatoes, milk, wine, beer, vinegar.

Drosophila immigrans
Cosmopolitan.
Warehouses.

Drosophila melanogaster
Cosmopolitan.
Houses, grocery stores; bred from various fruits and vegetables.

Drosophila obscura
Europe.
Warehouses.

Drosophila repleta
Widespread.
In milk depots.

Drosophila spp.
United States.
Overripe fruit.

Fannia canicularis - German: kleine Stubenfliege
Europe, North America.
Cheese.

Fannia pusio
Samoa.
Dead fish.

Fannia scalaris - German: Latrinenfliege
Europe.
Prepared mustard in Germany, meat.

Fannia sp.
United States.
Overripe fruit.

Helicobia australis
Australia, Samoa.
Decaying meat.

Hydrotaea dentipes
Europe.
Meat.

Leptocera caenosa
Germany.
In milk depots.

Leptocera sp.
Germany.
Prepared mustard in Germany.

Limosina heteroneura
Europe, Africa, Formosa.
Fermenting ginger.

Lucilia caesar - U.S.: greenbottle fly; German: Goldfliege
Widespread.
Meat.

Lucilia sericata - U.S.: greenbottle fly.
United States, Europe.
Meat.

Meoneura obscurella
Europe, Egypt.
Raisins, snuff.

Musca domestica - U.S.: House fly; German: Hausfliege
Cosmopolitan.
On food.

Musca nebulo
India.
The important bazaar fly and swarms on all foodstuffs.

Musca sorbens
India, Samoa.
House and bazaar fly on human food.

Musca vetustissima - Australian: camp fly, bush fly.
India, Australia.
On food in houses and markets in Australia.

Musca yerburyi
India, especially South India.
The bazaar fly of South India.

Muscina pabulorum
Europe.
Meat.

Muscina stabulans - U.S.: false stable fly; German: Stallfliege.
United States, Europe.
Rotten fruit, meat.

Mydaea sp.
Germany.
Prepared mustard in Germany.

Phormia caerulea
Europe.
Meat.

Phormia regina - U.S.: black blow fly; German: Glanzfliege
United States, Europe.
Meat.

Piophila casei - U.S.: ham or cheese skipper; German: Käsefliege; Australian: bacon fly.
Widespread.
Ham, salt pork, dried beef, cured fish, green hides, bones, cheese; avoids fat parts; oleomargarine; pest in meat factories.

Skipping of larvae is characteristic; very resistant to insecticides and withstand -8° to 131°F; killed at 126½° in 1 hour; optimum relative humidity 60%; reproduces between 56 and 102°; can be kept out by 30-mesh screen.

Sarcophaga albiceps
Widespread in the Old World.
Meat.

Sarcophaga annandalei
India, Ceylon.
Dead animals.

Sarcophaga aurifrons
Australia.
Meat.

Sarcophaga beta
Australia.
Bad meat.

Sarcophaga bullata
Eastern United States.
Meat.

Sarcophaga calicifera
India, Ceylon, Philippines, Formosa.
Meat.

Sarcophaga carnaria
Europe.
Meat.

Sarcophaga cirrhura
Samoa.
Meat.

Sarcophaga cooleyi
North America.
Meat.

Sarcophaga depressa
Australia, Tasmania.
Bad meat.

Sarcophaga dux
Widespread in the Old World.
Meat.

Sarcophaga eta
Australia.
Fish and bad meat.

Sarcophaga falculata
United States, Hawaii, Europe.
Decaying meat.

Sarcophaga froggatti
Australia, Samoa, Tonga.
Bad meat.

Sarcophaga fuscicanda
Tropics from India and Japan to Hawaii.
Meat.

Sarcophaga haemorrhoidalis - German: graue Fleischfliege
Europe, North America.
Meat.

Sarcophaga impar
Southern United States.
Decaying fish, meat refuse.

Sarcophaga impatiens
Australia, Tasmania, N. Hebrides.
Bad meat.

Sarcophaga kappa
Australia.
Bad meat.

Sarcophaga knabi
India, Philippines, Australia, Malaya, Java, China.
Dead animals.

Sarcophaga kohla
Australia.
Bad meat.

Sarcophaga misera
Australia.
Bad meat.

Sarcophaga nemoralis
Europe.
Meat.

Sarcophaga orientaloides
India, Ceylon, Indo-China.
Meat.

Sarcophaga peltata
Samoa, Florida, Puerto Rico, Central America.
Meat.

Sarcophaga peregrina
Australia.
Meat.

Sarcophaga robusta
Southern United States, N. Antilles.
Meat.

Sarcophaga ruficornis
Formosa, India, Philippines, Malaya, N. E. Africa.
Meat.

Sarcophaga spp. - U.S.: gray flesh flies.
United States.
Cheese, oleomargarine, pickled herring, decaying vegetables, limburger cheese.

Sarcophaga texana
Texas.
Meat.

Sarcophagi tryoni
Australia.
Bad meat.

Sarcophagi tuberosa
United States.
Meat, fish, living insects.

Scatopse fuscipes
Widespread.
Fermenting ginger.

Scatopsidae - various species.
Decaying matter.

Sciara annulata
Europe.
Fermenting ginger, raisins.

Syrphid larvae
Germany.
In stored hemp, apparently due to abnormal weather before threshing.

Tephrochlamys canescens
Europe.
Meat.

Hymenoptera

Eriades nigricornis
Europe.
In timber.

Lithurgus albofimbriatus
Hawaii.
Timber.

Sirex areolatus
California.
Redwood lumber.

Sirex gigas
Europe.
Perforated lead linings of sulphuric acid tanks for emergence in France; timber; tin roofs, 1/2" steel plates, cartridges.

Sirex juvencus
Europe.
Bullets. 1 generation in 3 years. A one generation pest.

Sirex noctilio
Northern Europe.
Emerges from coniferous wood.

Stigmus fulvicornis
Mississippi.
Floor boards.

Xylocopa aeneipennis
Hawaii.
Timber.

Xylocopa aestuans
Northern and central Africa to the Sunda Is.
Wood.

Xylocopa auripennis
India to China.
Wood.

Xylocopa californica - U.S.: California carpenter bee.
Western North America.
Timber.

Xylocopa dissimilis
India and China to East Indies and Philippines.
Wood.

Xylocopa iridipennis
India to East Indies.
Wood.

Xylocopa latipes
India, Siam to Amboina.
Lead cable covers, wood borer.

Xylocopa orpifex
Western United States.
Timber.

Xylocopa sp.
Siam.
Boring into lead of aerial cables.

Xylocopa sp.
Eastern United States.
Louisville, Ky. attacking oak and cypress.

Xylocopa tenuiscapa
Southern Asia and the Philippines.
Wood.

Xylocopa varipuncta
Western United States.
Timber.

Xylocopa verticalis
India, East Indies.
Wood.

Xylocopa violacea
Europe and North Africa to central Asia.
In timber.

Xylocopa virginica - U.S.: Carpenter bee.
N. E. United States.
Drills large holes in various woods, scarce.

Formicidae

Attini - the tribe of leaf-cutting ants.
British Guiana: acoushi, coushi ants; Venezuela: huachaca; Peru: coqui; Mexican, Panama: hormiga arriera; Cuba: bibijagua; Trinidad, etc.: parasol ants; Dutch: parasolmieren.

Atta moelleri meinerti var. *globoculis*
British Guiana.
Foodstuffs.

Atta sexdens - Brasilian: sauba; French Guianan: fourmi-manioc.
Central America and northern South America.
Will take farina and other vegetable matter, at least from refuse piles.

Camponotus caryae var. *rasilis*
Southern United States.
Houses, jam, sugar, syrup.

Camponotus compressus - Indian: common black ant.
South India.
Aphids, etc.; house ant.

Camponotus consobrinus - Australian: black sugar ant.
Australia, Tasmania.
Houses.

Camponotus herculeanus - U.S.: carpenter ant; German Rossameise.
Holarctic.
Wood, houses.

Camponotus herculeanus var. modoc - U. S.: Modoc carpenter ant.
British Columbia to South Dakota, southward to New Mexico.
Tunnels into wood.

Camponotus irritans
New Guinea to Guam and Samoa, Malaya.
In Malaya attends coccids, but is a pest in bungalows, especially bathrooms.

Camponotus langi
Belgian Congo.
Nested among piled boxes on a verandah, foraged for sweets.

Camponotus levigatus - U.S.: giant carpenter ant.
British Columbia to Montana and southward to Mexico, usually about 6000 feet.
Tunnels into wood, starting at softened spots.

Camponotus maculatus - Congo: maola; South African: sugar ant.
Tropicopolitan and south Europe, western North America.
Nests variously but usually associated with wood or termite nests. Forages at night in camps; var. vicinus damages buildings in British Columbia.

Camponotus nigriceps var. obniger
South Australia.
Takes sweets; in houses.

Camponotus nigripes - Australian: sugar ant.
Australia.
Houses.

Camponotus punctulatus
Brasil.
Sweets; houses.

Camponotus rufipes
Brasil.
Stakes in ground.

Camponotus senex var. mus
Brasil.
Stakes in ground.

Cardiocondyla britteni
England (imported)
Butterbeans; probably a predator.

Crematogaster lineolata
United States.
In houses; takes sweets.

Dolichoderus bituberculatus - Indian: clack cacao ant: Dutch: zwarte cacao-mier.
Formosa to Java.
In houses.

Dorymyrmex pyramicus - U.S.: pyramid ant
Western United States.
Houses.

Formica cinerea - U.S.: brown field ant.
Western United States.
Houses; sweets.

Iridomyrmex analis
Southern United States.
In houses; takes sweets.

Iridomyrmex anceps var. papuana
New Guinea, Northern Australia.
House pest.

Iridomyrmex detectus - Australian; meat ant. mound ant.
Southern Australia.
Occasionally infests stored food. Nest subterranean, often extensive and mounded, with many entrances. Takes meat and sweets.

Iridomyrmex domestica
Australia.
In houses.

Iridomyrmex glaber
Riukiu.
Houses.

Iridomyrmex humilis - U.S.: Argentine ant; Portuguese; formiga argentina; French: la fourmi d'Argentine; Italian: formica argentina; German: argentinische Ameise.
Tropics and warm temperate regions.
Cornmeal, flour; damages all kinds of food, particularly sweets and cooked meat; most active at high humidity. Most easily transported by man.

Iridomyrmex iniquus var. nigellus
Houses.

Iridomyrmex rufoniger - Australian: little black ant.
Australia.
Takes sweets; in houses.

Lasius brunneus
Europe.
Food stores.

Lasius emarginatus
Europe.
Food stores.

Lasius fuliginosus
Europe.
Panelling and furniture; food stores.

Lasius interjectus
Eastern United States.
Invades houses.

Lasius niger
Europe.
Food stores.

Lasius umbratus
Europe.
Food stores.

Liometopum apiculatum occidentale - U.S.: California velvety tree ant.
Pacific States.
Houses; sweets.

Monomorium destructor - Dutch East Indies: huismier.
Tropicopolitan, United States - Southern States.
Prefers animal to vegetable food but takes sugar readily. Bores into cement; lead 0.8 mm thick. Damages clothes and fabrics. May attack insulation and even lead sheathing of electric cables. Nests in crevices of walls.

Monomorium floricola
Tropicopolitan.
Under bark, clumps of Tillandsia (Spanish moss), in hollow twigs; all kinds of human food, particularly oils; stored food; house pest in Australia, RiuKiu.

Monomorium fraterculum
Queensland, Lord Howe Id., Norfolk Id.
Probably in houses.

Monomorium gracillimum var. mayri
Tropical and warm temperate Old World, Laysan Id.
Attacks electrical insulation.

Monomorium ilia
Western Australia.
Houses and food.

Monomorium latinode
Java, RiuKiu.
Attacks almost all articles made of rubber; in houses.

Monomorium minimum - U.S.: little black ant.
United States.
Houses.

Monomorium minutum
Old World.
Sometimes a house pest.

Monomorium pharaonis - U.S.: Pharaoh's ant; German: Pharaoameise; Australian: little yellow ant.
Cosmopolitan.
Food stores; houses; butter, meats, soap, cold cream; takes sweets. Nest under bark in Java.

Monomorium solomonis - U.S.: Solomon's ant.
Cosmopolitan.
Houses.

Paratrechina bourbonica bengalensis
South and eastern Asia.
In houses.

Paratrechina longicornis - U.S.: crazy ant; British Guinea; black crazy ant.
Tropicopolitan, rarely indoors in temperate regions.
Infests food; general pest; houses. Dead not taken back to nest.

Paratrechina obscura
Australasia and New Caledonia.
Houses.

Paratrechina vaga
Australasia and Pacific Island.
Houses.

Paratrechina vividula
Tropicopolitan.
General pest; houses.

Pheidole javana
Formosa and East Indies to Guam.
In houses.

Pheidole megacephala - U.S.: Madeira ant; South African: brown house ant.
Tropicopolitan.

Stored food; prefers to nest under stone slabs, nests under stones and in crevices of walls; a harvesting ant. Serious pest in Australia.

<u>Pheidole oceanica</u>
Australia and Pacific Is.
Pest, houses.

<u>Plagiolepis custodiens</u> - South African: pugnacious ant.
South Africa.
Carnivorous and insectivorous, takes ermites, but can be a pest. Nest with many small entrances surrounded by very flat craters. In houses.

<u>Plagiolepis longipes</u> - Dutch East Indies: Gramang ant
Tropicopolitan.
Houses. Nests under bark or in sand. Pest in Australia.

<u>Prenolepis fulva</u>
Widespread in tropics.
Houses.

<u>Solenopsis corticalis amazonica</u> - British Guiana: red household ant.
N. E. South America.
Houses.

<u>Solenopsis geminata</u> - U.S.: fire ant; Dutch East Indies: roode tabaksmier; Indian: small red ant.
Tropicopolitan.
Ground nester, probably eats seeds and insects, rather general feeder. Prefers loamy soil along stream banks. Probably perforates rubber covered with cotton with or without paraffin, Prefers meats but will take sweets.

<u>Solenopsis molesta</u> - U.S.: thief ant.
United States.
Feeds on fat and protein; occasional in houses.

<u>Solenopsis saevissima</u> - Portuguese: formiga do fogo.
Neotropical.
The common fire ant from Para to Bolivia, especially the Amazonian region.

<u>Solenopsis xyloni</u> - U.S.: McCook's fire ant.
Southern United States.
Attacks linen, silk, wool, cotton fabrics; soiled clothes being most readily attacked; meat, butter, nuts, greasy food. Nests under stones, at the bases of grass tufts, or in sand near streams. Fouling of working parts of electrical instruments by accumulation of dead ants, damage to insulation.

<u>Solenopsis xyloni</u> var. <u>maniosa</u> - U. S.: Californian fire ant.
New Mexico to California.

Very general feeder, attacks cloth, fruits. Forages chiefly during cooler hours. Stored foods of various kinds. Nests under boards and stones and in cracks of sidewalks.

Tapinoma melanocephalum - British Guiana: small crazy ant.
Widespread.
All kinds of human food. Nests under bark and in termite nests. Pest in houses.

Tapinoma sessile - U.S.: odorous house ant.
North America.
Houses.

Tapinoma simrothi
Morocco.
An aphid tender which invades houses; omnivorous but prefers sweets. Food may be kept in wire safe.

Technomyrmex detorquens - Australian: black house ant.
Tropical and south temperate Old World, Pacific Is.
In houses and stores, serious. Coccid tender.

Tetramorium caespitum - U.S.: pavement ant; English: meadow ant U. S.: European meadow ant.
Eastern and central United States; Europe, Africa.
Houses.

Tetramorium guineense
Florida and Gulf Coast, Tropicopolitan.
In houses; abandoned termite nests.

Tetramorium simillimum
Florida and Gulf Coast, Tropicopolitan.
In houses. Nests under stones and logs.

Triglyphothrix striatidens
Widespread.
House and store pest.

Wasmannia auropunctata - U.S.: small fire ant.
Florida, Tropicopolitan.
Stings; feeds on honey dew; nest on ground and in trees.

Arachnida

Aleuroglyphus ovatus
Europe.
Wheat, flour, etc.; prefers protein or fat in seeds.

Blomia kulagini
Russia.
Wheat.

Blomia thori
Russia.
Flax.

Caloglyphus rodianovi
Europe.
Wheat, rye, oil seeds.

Carpoglyphus anonymus
Europe.
On wine, dried fruits, dried figs, cheese, flour, grain.

Carpoglyphus lactis
Europe.
Dried fruits, jams, wine even in bottles.

Carpoglyphus passularum - U.S.: dried fruit mite.
California.
Dried figs, peaches, raisins, prunes, apples, ham.

Carpoglyphus taiwanensis
Formosa.
Sugar.

Chortoglyphus arcuatus
Europe.
Grain, rice, flour.

Chortoglyphus gracilipes
United States.
Tobacco.

Dermanyssus gallinae
Cosmopolitan.
Has occurred in houses. A parasite of chickens, bites man.

Eberhardia krameri
Widespread.
Tobacco, grain, flour.

Eberhardia rodikorzewi
Bashkiria.
Moldy grain.

Eriophyes domesticus - (This is an enigmatical species.)
Europe.
Smoked meat, may be a predator.

Ferminia fusca
Europe.
Grains; not found in fields.

Glycyphagus cadaverum - English: hairy mite,
Europe.
Grain; not in field; wheat, bran flaxseed.

Glycyphagus domesticus - U.S.: furniture mite; German: Hausmilbe.

Holarctic.

Attacks fiber, hair, various foods, grain, fur, feathers, sugary substances in a new house; green Algerian fibre, yeast, dry fodder, dried fruit, cheese, flour, drugs, spices. Lethal temperature above 104°F.

Glycyphagus fustifer
Europe.
Grain, not in field.

Glycyphagus michaeli
Europe.
Grain, seeds, flour, hay.

Glycyphagus obesus
United States.
Seeds.

Glycyphagus ornatus
Europe.
Grain.

Glycyphagus robustus
United States.
Seeds.

Glycyphagus spinipes
Europe.
Candy factories.

Kuzinia rhizoglyphoides
Russia.
Grain.

Lepidoglyphus destructor
Europe.
Grain.

Lepidoglyphus destructor mixtus - English: hairy mite.
Russia.
Wheat, rye, oats, barley.

Lepidoglyphus michaeli
Europe.
Grain.

Moniezielia entomophaga
Europe.
Grain, flour; not in field.

Pediculoides tritici
Europe.
A predator causing dermatitis.

Phaulocylliba marginatus
Europe.
On wooden shavings in a vinegar factory.

Rhizoglyphus callae - German: Wurzelmilbe.
Malaya, East Indies, introduced elsewhere.
Copra.

Rhizoglyphus echinopus - German: Kartoffelmilbe
Europe, North America.
Stored cereals, 16% moisture or over, grain, potatoes, bulbs. Life cycle 20-30 days; development 32 days.

Tarsonemus hordei
Japan.
In grain.

Tyroglyphus americanus
United States.
Seed, grain.

Tyroglyphus farinae - U.S.: flour mite; German: Mehlmilbe.
Cosmopolitan.
Feeds on fungi growing on damp seeds of kok-saghyz; mustard seed, wheat, rye, oats, barley, cheese, flour, cereal products, oil seeds, tobacco. Store grain at 11% moisture in temperate zone and lower in tropics. Mills, granaries. Requires 14-17% moisture, breeds at 53½-115°F. Dies in 12 hours at 120°F. Dormant below 27°F.

Tyroglyphus lintneri - U.S.: mushroom mite.
United States, Europe.

Tyroglyphus siro - U.S.: cheese mite; German: Käsemilbe.
Cosmopolitan.
Cheese, dried fruit, etc., not in field, grain, flour.

Tyroglyphus terminalis
United States.
Cheese.

Tyrophagus bullari
Crimea.
Wheat, corn.

Tyrophagus dimidiatus
Europe.
Oil seeds.

Tyrophagus infestaus
Europe.
Grain.

Living mushrooms; cheese, etc., grain; flax, mustard, cottonseed, coconut, dead insects.

<u>Tyrophagus mycophagus</u> - German: Mehlwurmmilbe.
Europe.
Oil seeds, cooked potato, meal, meat, fat, cheese, flour, bran, dead insects, gourds, pears. Optimum temperature 89½-90°, maximum 100½°, minimum 57°, 50% relative humidity.

<u>Tyrophagus noxius</u> - English: elongate mite.
Russia.
Feeds on fungi growing on damp seeds of kok-saghyz; wheat, rye, oats, barley, semolina.

<u>Tyrophagus putrescentiae</u> - U.S.: sugar mite, elongate mite.
Cosmopolitan.
Grain, requires 14-17% moisture; dried fruit, cheese, copra, dried meat, flour.