FILTH-INHABITING FLIES OF GUAM

BY

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PREFACE

This study is an outgrowth of the interest expressed by Commodore Thomas M. Rivers, Captain J. J. Sapero, and other naval medical officers in muscoid flies and other Diptera which may be involved in the mechanical transmission of diseases.

Although much research was conducted on mosquitoes during World War II, relatively little attention was paid to other flies. However, serious fly problems made specific control measures necessary, though such measures were often inefficient or unsuccessful owing to the general lack of knowledge concerning species of Pacific flies and their habits. For instance, the campaigns started on several islands to control muscoid flies by elimination of fallen coconuts were probably based on observation of maggots of the coconut fly (*Scholastes*) rather than on muscoid species. Another unsuccessful measure was the burial of garbage, corpses, and excrement under shallow layers of earth. This practice actually relieved the maggots already present of the necessity of burrowing into the earth for pupation, and did nothing to lessen oviposition and subsequent migration of the first instar larvae to the breeding materials.

The establishment on Guam early in 1945 of U. S. Naval Medical Research Unit 2 with its extensive facilities for laboratory and field work offered an excellent opportunity to study the habits of the flies on the island, and this work was continued for much of the year.

Although the fly fauna of Guam is not extensive, it is fairly representative of that on most oceanic islands in the Pacific; and although many fly-borne diseases are not found on the island, the conditions for fly breeding are similar to those of most areas in the Pacific and along the coast of eastern Asia. Thus, it is hoped that this paper will be useful as a handbook on fly problems of Guam and serve as a general guide for studies of fly-breeding problems in other Pacific areas. Persons in areas other than the Marianas should be able, with due caution, to make use of the keys and drawings for identification of the various stages of many genera and some of the widely distributed Pacific species.

The official support and encouragement given to this research project by Captain J. J. Sapero, U.S.N.; Commodore T. M. Rivers, U.S.N.R.; and other medical officers associated at various times with the research Division and Naval Medical Research Unit 2 are gratefully acknowledged. Able as-

sistance in field work was given by former Navy hospital corpsmen C. L. Wyman, J. R. Stuntz, G. R. Norris, and J. Laffoon. Mr. Wyman also made the excellent pencil drawings for the halftone plates. The senior author drew the pen and ink figures, except the map (fig. 1), which was drawn by E. H. Bryan, Jr.

We are also indebted to many members of the Division of Insect Identification in Washington for taxonomic assistance and to Dr. C. F. Muesebeck and Dr. E. A. Chapin for the facilities used in our taxonomic studies. Dr. O. W. Richards, Mr. George Steyskal, Mr. E. T. Cresson, Jr., and Dr. A. H. Sturtevant also assisted by identifying species in their taxonomic specialties and by describing new species when necessary.

Mr. W. L. Brown of Harvard deserves special thanks for generously allowing us to use bibliographic references and field data which he collected in the course of special research on fly problems in China during and after the war.

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INTRODUCTION

Guam is an oceanic island nearly 30 miles long and 4 to 8 miles wide. It lies between 144° 37′ and 144° 57′ east longitude and 13° 15′ to 13° 40′ north latitude and is about 1,200 miles from Luzon, the nearest continental island. Apparently it has been isolated for a long period, as it has a limited and specialized fauna. The total number of insect species on the island is probably about 2,000, or very little over that figure. Because of its relatively recent volcanic origin, it has an even poorer native fauna than have oceanic islands of greater antiquity, such as Hawaii and Samoa. Another clue to the relatively recent origin of the island and its fauna is the low proportion of endemic families or genera, and the similarity of the species to those of the nearer continental islands.

Possibly as many as one-fourth of all the species of insects on Guam were introduced by man, either accidentally or purposely. Of the insects of agricultural and medical significance, it is probable that the majority belong in this category.

Fresh-water insects are poorly represented on Guam, and the two orders Ephemeroptera and Plecoptera are absent, as are many aquatic families. In the Diptera, the large families Culicidae (mosquitoes) and Chironomidae are represented by only nine species each.

Few of the insects of primary medical significance are peculiar to Guam. Some of the Heleidae (biting midges) and Psychodidae, which includes the true sand flies, are endemic; but, with the possible exception of one midge, none of them feed on human blood. Many of the muscoids and other higher flies are widely distributed species, though a number of important widely distributed species have not yet reached Guam. Among the latter are the lesser house fly (*Fannia canicularis*), the common house fly of temperate regions (*Musca domestica*), blow flies of the genera *Calliphora, Phormia, Pollenia,* and many *Lucilia* and bot flies (*Gasterophilidae*). Other less easily transported medical flies absent from Guam are the true sand flies (*Phlebotomus*), black flies (Simuliidae), horse flies (Tabanidae), and eye flies (*Hippelates*).

GEOGRAPHICAL ZONES IN RELATION TO FLY POPULATIONS

Geologically and biologically, Guam is separated into a northern and a southern half. The northern half of the island is an elevated limestone plateau of coral reef origin, which is about 300 feet high, with a few regions as high as 600 feet. At the margin are precipitous, jagged cliffs 200 to 300 feet above sea level. Along the shoreline there are a few forested coves surrounded by cliffs and sea. The plateau is largely covered with dense, scrubby jungle not extensively cleared or inhabited until the advent of American troops. The southern half is composed of low but rather steep and mostly barren hills with coves and stream valleys which are usually cultivated and inhabited. This section was little touched by battles or the establishment of military camps. The middle zone is composed of rolling hills and a broad valley to the west containing the principal town of Agana. This is the most heavily populated part of the island and was the most disturbed by battles and military camps. (See map, fig. 1.)

In the north, fly problems are mostly centered around a few large airfields and some isolated ranch houses and tiny villages. Jungle-inhabiting species of flies, such as *Sarcophaga stricklandi* and *Dichaetomya saperoi,* were more common here than elsewhere. However, most of the species dealt with in this paper occur in the north and could become locally abundant under certain conditions.

In the south, the numerous villages and native farms present, with their livestock, a greater problem. It is also the area which produces the most copra, and the resulting piles of waste coconuts probably breed various species of flies in the proper seasons. In this region *Musca sorbens* is dominant, probably because of the large number of pig pens, the indiscriminate dropping of human feces, and, perhaps, the handling of cattle manure. In the villages, *Chrysomya megacephala* is nearly as common as *Musca sorbens* and breeds primarily in poorly constructed and untreated privies.

In the central part of the island, a variety of conditions has resulted in a rather high population of most kinds of flies, except in certain well-sanitated camps. The numerous unauthorized garbage dumps near military camps during the war, the piling of manure at the Island Farm, and the scattered ranches with their pigs and water buffalo are contributing factors to the densities of *Musca vicina* and *M. sorbens, Chrysomya megacephala,* and several species of *Sarcophaga.* The offal washed in from ships in Apra Harbor and standing off the central coast furnishes ideal breeding grounds for many flies. Also, in this area, the several native towns built by naval construction battalions had privies which were neither kept closed nor treated and seemed to be ideal for the breeding of *Chrysomya megacephala* and *Hermetia illucens.* The dangerous conditions in this area from a disease dissemination standpoint

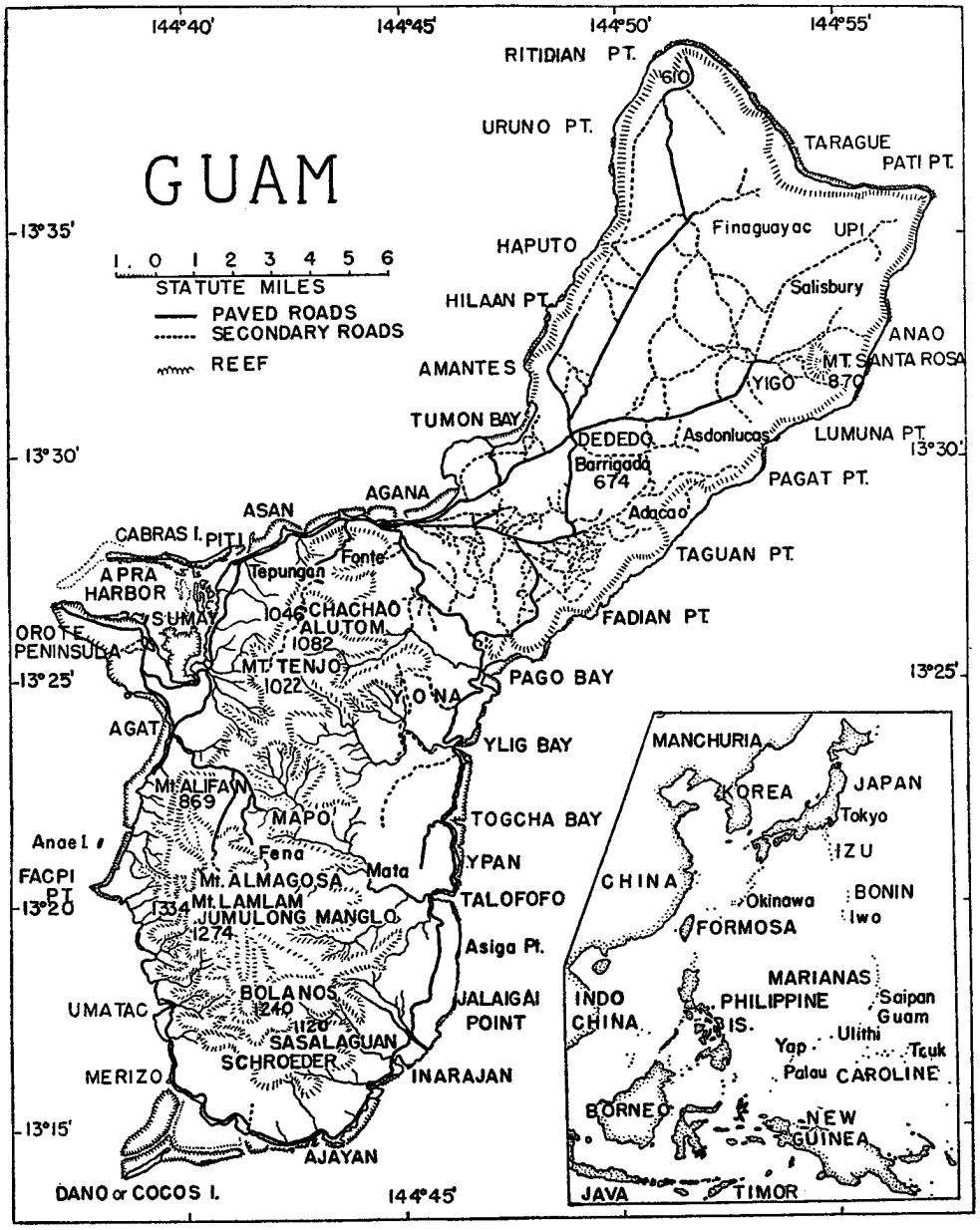

FIGURE 1.—Map of Guam.

were clearly shown by Harris and Down (33)[1] who studied the intestinal fauna, through examination of the feces, of *Chrysomya* taken from traps near the privies, many of which were located only a few hundred feet from military camps. Another circumstance in this area which maintains blow-fly and flesh-fly populations and would make control work difficult is the large number of toads lying dead along the roads. The flies on these toads attract more toads which are in turn run over and breed more flies. It is hard to say what the result of such a condition is on the ultimate population of flies and toads.

In the course of our general collecting on Guam, about 1,000 species of insects were obtained. These collections, including immature stages and adults, are now largely deposited in the United States National Museum. About 230 of them were flies, of which 99 are discussed in this paper. Of the approximately 100 species obtained, we reared 55 from eggs and larvae.

Keys and drawings are included for the separation of species in all stages. The biology and possible medical significance of the various species, as they were found on Guam, are discussed and suggestions for specific control measures are given. The habitats of flies and the materials in which they breed are discussed in regard to their place in the general scheme of fly breeding and disease dissemination on the island. Also included, as a basis for understanding the problems involved, are brief discussions of the morphology and biology of the Diptera and a summary of their role in the spreading of diseases.

SCOPE OF PAPER

Because we feel that any species of fly commonly associated with filth has the potentiality for mechanical transmission of disease, we have decided to include all flies with such habits. The habitats considered under the term "filthy" include all forms of excrement; decaying flesh; and certain decaying plant materials, such as garbage, large masses of rotting vegetation, and fermenting fruits. For genera most species of which were found to be filth-inhabiting, we also include species of unknown habits in the key to adults. Borderline situations, such as decaying vegetation, are included because many of the insects which breed in them also breed in excrement or carrion. An example of this is the stable fly (*Stomoxys*), which we found breeding equally well in piles of decaying vegetation and in cow manure. *Ophyra chalcogaster* and *Chrysomyza aenea* are examples of species which breed in all three media: excrement, carrion, and rotting vegetation. Fermenting fruits are also significant, because the flies which breed in them are commonly found around garbage and are attracted to food in kitchens. Thus, the flies could carry pathogens from garbage to food intended for human consumption or could cause either accidental or false intestinal myiasis by ovipositing in food;

[1] Numbers in parentheses refer to the Bibliography, page 141.

and some groups, such as *Drosophila,* which normally breed in fruit, occasionally visit and breed in human excrement.

Table 1 shows the number of families, genera, and species of flies on Guam presumed to be filth-inhabiting, listed according to their major taxonomic categories. Probably several of these were only accidentally associated with filthy environments at the time of their capture. The table includes only flies collected or reared from filth during the field work on Guam.

TABLE 1

	FAMILIES		GENERA		SPECIES	
Taxonomic Category	Total collected on filth	Definitely associated with filth	Total collected on filth	Definitely associated with filth	Total collected on filth	Definitely associated with filth
Nematocera	6	3	6	3	10	5
Brachycera	2	1	3	2	4	2
Aschiza	2	2	6	6	9	9
Cyclorrhapha Acalypterata	12	9	34	25	46	31
Cyclorrhapha Calypterata (Muscoidea)	4	4	15	14	25	24
Total	26	19	64	50	94	71

METHODS OF STUDY

POPULATION AND HABITAT STUDIES

Bait trapping was the basic method for determining abundance and food preference of flies. The traps were semi-cylindrical in shape and 18 inches long by 10 inches wide by 7 inches high, fitted inside with a roof-shaped piece of screen with an entrance slot along the ridge of the "roof." The trap was supported on short wire legs, which were placed in cups of oil to exclude ants. A pan of bait was set on the ground under the trap. Where dogs were abundant, it was necessary to fasten the trap to the ground with wire and stakes and to suspend or stake down the bait. Unfortunately, such traps limited accurate analyses. Very small flies, such as phorids and drosophilids, had no difficulty in getting out through the screen; and no practical method was found to prevent toads from taking a percentage of the flies before they entered. Furthermore, some substances, such as breadfruit, although highly

attractive in the open to many muscoid flies, were not effective as baits when placed under traps.

For studies on the food and habitat preferences of the flies, each trap was baited with a different substance and set as nearly as possible in the same environment as the others, but at least 150 feet distant. These trap lines were maintained for several days in order to determine the periods of maximum attractiveness during the aging of the baits.

For comparison of habitats, each of a series of traps was set with the same bait, a mixture of several substances, and placed in environments such as jungles, beaches, native villages, farms, and camp kitchens.

By combining data obtained by all the trapping methods, information was procured on the total relative abundance of the species and on the ratio of the sexes coming to baits.

Field Observations and Collecting

Trapping was supplemented with field observation and collecting; and an attempt was made to observe the adult flies found in the immediate neighborhood of the various types of filthy environments and in buildings, particularly kitchens and mess halls. For identification purposes, we collected as many specimens of adults as possible and compiled lists of those frequenting representative filthy environments. We also collected larvae, or maggots, of the various fly species in all types of situations for rearing in the laboratory. In addition, the jungles were searched for flies which did not readily enter village or camp areas.

On the beach at the north end of the island, a human corpse four days old was put under weekly observation for a month, in order to study the succession of fly species attracted to and breeding in it during the process of decomposition.

To determine accurately the various types of media on which the different flies would feed or oviposit, various materials were exposed in bait cans at different localities. These materials included dead mammals, birds, amphibians, fish, crustacea, and echinoderms, excrement from various animals, cooked vegetables, wild fruits, and rotten coconuts. Some of the experiments were to determine what species of flies would be attracted to the various baits, others to capture for laboratory use adult female flies or mating pairs for oviposition. In other experiments, baits were exposed for several hours in open cans with dampened dirt in the bottoms then tightly covered with cloth for three or four weeks. The cans were then opened and the contents examined for puparia and for adult flies which had developed from eggs laid when the baits were exposed.

Rearing

Rearing was undertaken for three major purposes: (1) to determine life cycles and larval habits, (2) to compare various materials as larval foods, and (3) to obtain correlated specimens of the developmental stages of each species.

For most of the controlled laboratory rearing, eggs or young larvae were isolated as to species in small, wide-mouthed jars. They were placed on several thicknesses of paper toweling cut enough larger than the diameter of the jar to form a concave nest. The atmosphere in most of the jars remained moist and the larvae could choose the degree of dampness necessary for pupation by migrating between the layers of paper at various levels. Food was provided in small quantities, moistened frequently, and replenished as needed. The jars were covered with tightly woven cloth held firmly in place by rubber bands.

At various stages of a rearing, specimens were placed in a rubber-stoppered procaine tube containing alcohol. When the rearing was completed, the tube contained eggs, larvae, puparia, and adults.

Shortly before we left Guam, we started a comparison of media as food sources for maggots. Eggs of the more important species of flies were placed on the following series of seven standardized media representing the principal breeding materials available on the island: meat (liver); C-ration stew; human, pig, and cattle excrement; rotting coconut; and decaying breadfruit. Rates of development and survival were measured for the flies on each material. Although the laboratory experiments were not completed, interesting preliminary results were obtained.

Taxonomic Study

Preliminary identifications of adults were made in the field, and representative specimens were sent to the United States National Museum for further identification. When we returned to Washington with the complete collection, groups of flies were distributed among and studied by various specialists as follows: Nemocera, Alan Stone; Aschiza (except Phoridae), C. T. Greene; Phoridae, G. E. Bohart; Cypselidae, O. W. Richards; Drosophilidae, A. H. Sturtevant; Ephydridae, E. T. Cresson, Jr.; Chloropidae, C. W. Sabrosky; other acalypterates, George Steyskal; Sarcophagidae, D. G. Hall, G. E. Bohart; and other muscoids, J. L. Gressitt and G. E. Bohart.

CLASSIFICATION OF DIPTERA

The scheme of Diptera classification followed for the most part in this paper is that used by Comstock in "An introduction to entomology" (11). The major categories containing filth-inhabiting flies on Guam are as follows:

Order Diptera: two-winged flies
- Suborder Orthorrhapha: straight-seamed flies
  - Series Nemocera: long-horned Orthorrhapha
    - Family Psychodidae: owl midges, moth flies
      - Heleidae: biting midges, punkies
      - Itonididae: gall gnats
      - Scatopsidae: scatopsid gnats
      - Fungivoridae: fungous gnats
  - Series Brachycera: short-horned Orthorrhapha
    - Family Stratiomyidae: soldier flies
      - Empididae: dance flies
- Suborder Cyclorrhapha: circular-seamed flies
  - Series Aschiza: Cyclorrhapha without a ptilinum
    - Family Phoridae: hump-backed flies
      - Syrphidae: syrphus flies
  - Series Schizophora: Cyclorrhapha with a ptilinum
    - Section Acalypterata: the acalypterates
      - Family Clusiidae: the clusiids
        - Cypselidae: minute scavenger flies
        - Ephydridae: shore flies
        - Tephritidae: fruit flies
        - Tylidae: stilt-legged flies
        - Drosophilidae: small fruit flies
        - Lonchaeidae: the lonchaeids
      - Family Piophilidae: the piophilids
        - Milichiidae: the milichiids
        - Chloropidae: frit flies
        - Otitidae: the otitids
    - Section Calypterata (Muscoidea): muscoid flies
      - Family Anthomyidae: the anthomyids
        - Muscidae: house flies and allies
        - Calliphoridae: blow flies
        - Sarcophagidae: flesh flies
        - Tachinidae: tachinid flies (not normally filth-inhabiting)

MORPHOLOGY OF DIPTERA

Adults of all Diptera are characterized by modification of the hind pair of wings into small, club-shaped balancing organs (halteres) and by the suctorial or occasionally vestigial mouthparts in which the mandibles are stylet-like or entirely absent. The mouthparts are usually developed into a proboscis which is further developed for piercing, as in mosquitoes, or for lapping, as in house flies. In the latter, the labium is distally expanded into a pair of fleshy lobes. In keeping with the great development of the mesothoracic wings, the prothorax and metathorax are small and fused to the large mesothorax.

In adults, the major trends in the evolution of Diptera are most easily traceable in the specialization of the antennae and the development of a frontal sac above the antennae. The antennae of primitive Diptera, the Nemocera, are composed of many more or less equal segments, whereas in the Brachycera

and Cyclorrhapha, the number is reduced to two basal segments which subtend an enlarged third segment or group of closely united segments. The third segment is annulate in the primitive Brachycera but it bears an elongate terminal style in the other Brachycera. The third segment is non-annulate in the Cyclorrhapha and, except in a few primitive members, bears a dorsal bristle-like arista. The ptilinum, another organ the development of which marks the higher flies, is an inflatable frontal sac with which the newly developed adults of the Schizophora section of the Cyclorrhapha push off the end of the indurated last larval skin in which they are encased as pupae. After serving its function, the ptilinum is withdrawn and its existence is marked externally by a ∩-shaped (frontal) suture around the antennae.

Piercing mouthparts rose independently in various stages of evolutionary development. The piercing organs are developed as stylets or blades ensheathed in the labium. In the higher flies, such as the Muscidae, the mandibles and maxillae are lost and the only remaining stylets are the labrum epipharynx and the hypopharynx.

The structures used in this paper for the differentiation of species in the adult stage are shown in figure 2, *a-d*.

Diptera larvae are eruciform and legless and have small heads, which are frequently reduced in number of parts and retracted. In most of the Nemocera, the head capsule and its principal parts are present and more or less free from the thorax. In the Brachycera, the posterior part of the head is much reduced and imbedded in the prothorax. In the Cyclorrhapha, the head is completely withdrawn into the thorax, the antennae and palps are reduced to minute papillae, and the other mouthparts are represented by only a pair of mouth hooks, developed from basal sclerites of the mandibles.

Respiratory systems of fly larvae vary with environment. Primitive terrestrial forms, such as crane flies, have a pair of spiracles on most of the segments (peripneustic), whereas the primitive aquatic forms, such as mosquitoes, have them only caudally (metapneustic). Most maggots of the higher flies have a small anterior pair and a large caudal pair of spiracles (amphipneustic).

Pupae of the lower flies (Nemocera and many Brachycera) are free of the last larval skin. The pupa of the Brachycera may become quite hard and resistant to dessication. The higher flies (Cyclorrhapha and some Brachycera) remain in the last larval skin as pupae. In the Brachycera, this skin merely hardens; but in most of the Cyclorrhapha, it also shrinks and takes on more or less the shape of a gelatin capsule. In the latter the puparial skin is broken transversely by the emerging adult so that the anterior end becomes loose (hence the term Cyclorrhapha, meaning circular seam).

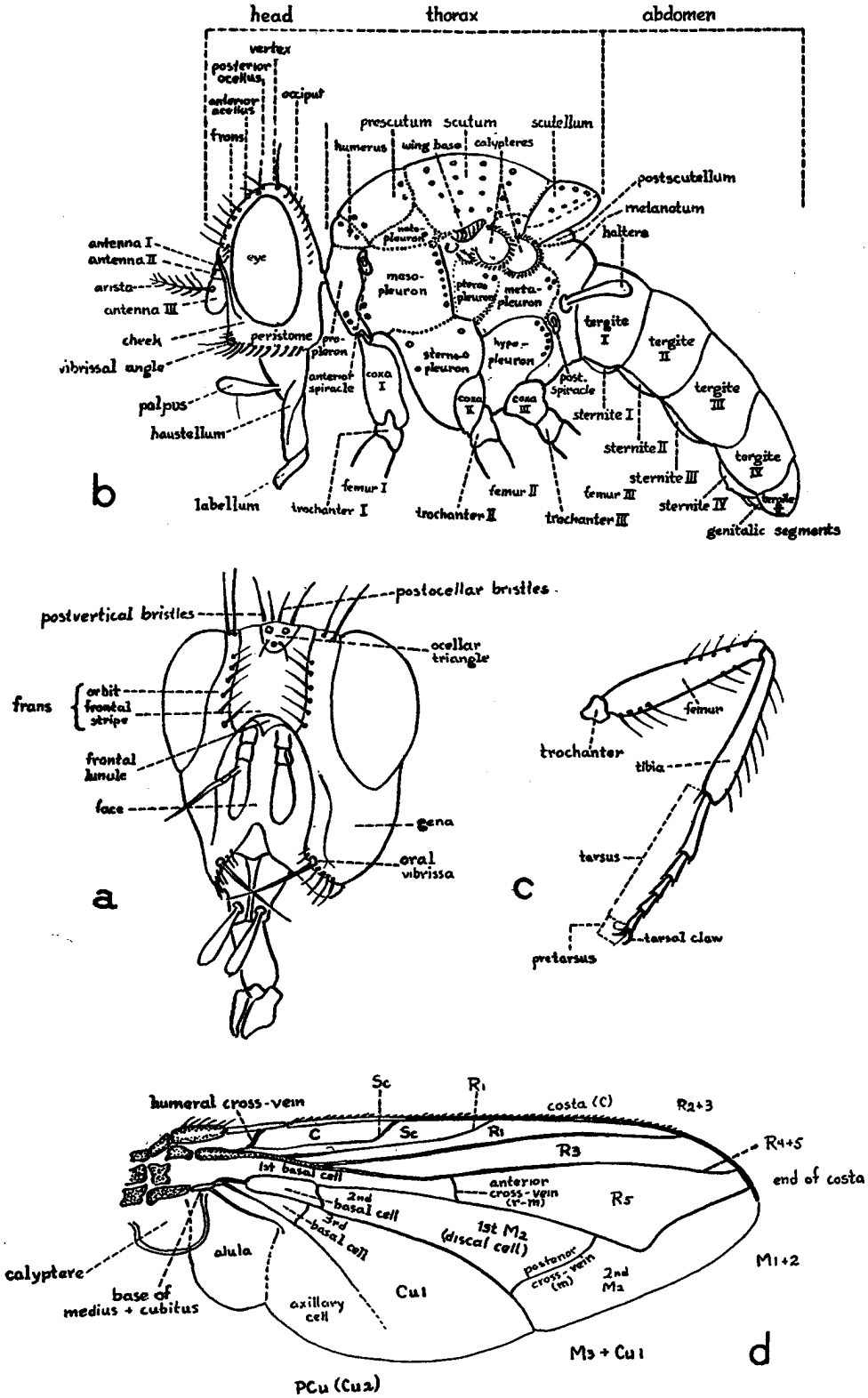

FIGURE 2.—Structure of adult Muscoidea: a, head, oblique view (after Seguy); b, body sclerites, lateral view (after Seguy); c, fore leg; d, wing.

Structures of larvae as used in this paper are shown in figure 3, *a, b*. The same structures are present on the hardened last larval skins (puparia) which enclose the pupae of higher forms.

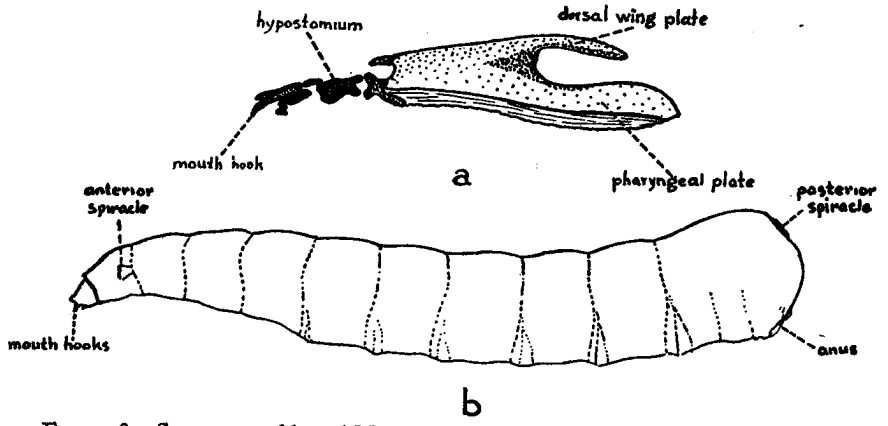

FIGURE 3.—Structures of larval Muscoidea: **a**, buccopharyngeal structures of first-stage larva; **b**, third-stage larva.

BIOLOGY OF DIPTERA

The order Diptera includes species with highly diverse biologies. In general, the adults are free-living and are active flyers and the larvae are aquatic or live inside moist or semiliquid environments such as decaying vegetation, garbage, rotten or living fruit, plant tissues, excrement, carrion, and living animal tissues.

Most flies deposit eggs; but some, such as members of the family Sarcophagidae, are ovoviviparous, depositing newly hatched larvae or eggs which hatch almost instantaneously. Other flies, such as certain ones of the family Calliphoridae, carry this to the point of depositing larvae which require only a few hours of feeding on carrion before they mature; and the tsetse flies deposit their larvae fully nourished and ready for pupation. In general, the eggs of flies are laid in moist situations and hatch in less than 24 hours. Their thin, porous shells do not withstand dessication.

Though sometimes laid singly, it is usual for a number of eggs to be laid at one time in a particular microhabitat, hence the larvae tend to be gregarious. In media such as carrion and certain types of excrement, which attract many ovipositing flies of different species, the larvae may become exceedingly abundant and consume the available food before many are mature. When this happens most species become predaceous and feed on maggots of their own and other species. Some, such as *Chrysomya rufifacies,* are said to be prin-

cipally predaceous, though it is not outstandingly predaceous when suitable food is abundant.

Larvae of primitive flies have exposed heads, and feed with mandibles; but most maggots have buccal mouth hooks with which they tear food and fasten to it. The food, taken in a liquid state, is predigested externally if solid. Larvae of the higher flies, including most of those dealt with in this paper, have rather thin skins and cannot live exposed to sunlight or in dry situations. Thus, small amounts of carrion, feces, or other food exposed to continual sunlight are unfavorable to larval growth, except in rainy seasons. The period of larval growth, or the feeding period of the larva, is usually rather short in tropical climates, lasting two to five days for the higher flies.

After feeding is completed, the mature larva finds a suitable place for pupation. If the larval microhabitat or its immediate surroundings is suitable, it will be used for the pupation site. Otherwise the larva may enter the ground or nearby debris, or simply pupate on any available substrate. The prepupal period, from cessation of feeding until pupation, is generally two or three days in warm, moist situations.

In most flies, the pupal stage is that best protected from enemies, dessication, and other forces, hence pupae may be transported easily from one locality to another in foods, in packing cases, or with animals. This stage lasts a few days to a few weeks, or even longer, depending on the latitude, the season of year, and the species. Flies overwinter or withstand long periods of drought in the pupal stage in some places. As the pupa of most primitive flies is naked and lightly chitinized, it must remain in a moist environment.

Literature on the biology of flies contains many references to the duration of the various stages of their life cycles. However, most of them merely illustrate the strong influence which small changes in temperature, humidity, and food supply have on the duration of the stages. A decrease of 5° F. in the temperature of the rearing room may double the length of the larval period of some species. Table 2, which shows the cycles of most of the flies reared by us, is based on average periods. Unfortunately, the cultures, although held at the rather uniform temperatures which prevail on Guam (about 85° F.), were highly variable as to food and moisture supply. Consequently, the figures should be used cautiously. A careful series of experiments with important species in which the flies are reared under known optimum conditions of temperature, humidity, and type and amount of food supply, would be useful as a basis for further work.

Adult flies have diverse feeding habits, but a large proportion of them, including most of those treated here, feed on the filthy substances previously defined. Most of them have mouthparts of the "lapping" type, and actually imbibe their food in a liquid state. They are able to feed on solid food, however,

by ejecting saliva containing digestive enzymes onto the food and drinking up the resulting predigested material. Various families throughout the order Diptera have developed bloodsucking habits and pierce the skin of man or other animals or insects for their food. So far as is known, the only filth-inhabiting flies on Guam which are also bloodsuckers are three species of the muscid subfamily, Stomoxydinae, that feed on warm-blooded animals and two empids that feed on insect blood.

TABLE 2

SPECIES	EGG STAGE IN HRS.	LARVAL GROWTH IN DAYS	PREPUPAL PERIOD IN DAYS	PUPAL PERIOD IN DAYS	DEVELOPMENTAL PERIOD IN DAYS
Psychoda sp. a	12	3	0	1	5
Hermetia illucens	....	23	?	14	37+
Microchrysa flaviventris	....	21	?	10	31+
Megaselia scalaris	14	3	1	2	7
Megaselia suis	....	2+	1	3	6+
Parafannia molluscovora	?	10	2	4	16+
Puliciphora wymani	....	....	....	3	....
Diploneura cornuta	....	6+	?	9	15+
Discomyza maculipennis	24	4	2	5	12
Allotrichoma sp.	....	1+	1	3	5+
Paralimna aequalis	....	2+	1	4	7+
Dacus cucurbitae	....	5	1	5	11+
Drosophila sp. a	15	3	1	1	6
Drosophila ananassae	15	2.5	0.5	1	5
Chaetodrosophilella 4-lineata	15	4	1	3	8.5
Milichiella lacteipennis	....	5	?	4	9+
Desmometopa sp.	....	4	?	4	8+
Lonchaea filifera	....	5+	1.5	7	13.5+
Chrysomyza aenea	....	5	2	5	12+
Pseudeuxesta prima	....	....	1	4	....
Scholastes aitapensis	22	20	?	8	29
Notogramma stigma	18	3	1	6	11
Atherigona longipalpus	24	5	2	4	13
Atherigona orientalis	12	5	3	3	12
Limnophora plumiseta	8	3	1	6	11
Fannia pusio	....	4+	?	8	12+
Ophyra chalcogaster	18	3	2	8	14
Stomoxys calcitrans	20	5	1	3	10
Siphona carabao	20	3	2	6	12
Haematobia exigua	18	3	1	5	9.5
Musca sorbens	12	3	1	3	8
Musca vicina	15	6	2	5	14
Rhinia testacea	10	3	1	5	9.5
Lucilia cuprina	10	3	1	6	10.5
Chrysomya megacephala	24	3	2	2	8
Chrysomya rufifacies	26	2.5	1.5	3	8
Chrysomya "nigripes"	....	4	2	7	13+
Sarcophaga ruficornis	0	3	4	7	14
Sarcophaga gressitti	0	3	2	8	13
Sarcophaga dux	0	4	3	9	16
Sarcophaga knabi	0	6	2	7	15
Sarcophaga stricklandi	0	4	2	6	12

THE RELATION OF FLIES TO DISEASE

It is probable that most flies which frequent both human feces and human food can mechanically transmit any of the disease organisms which various authors have recorded as "fly-borne." Among the best known diseases likely to be thus carried are amoebic and bacillary dysenteries, typhoid fever, cholera, and helminthic infections.

Flies may also mechanically transmit diseases from sores or other material containing pathogens to lesions or delicate mucous tissue. Outstanding examples of diseases which can be carried thus are yaws, oriental sore, trachoma, pinkeye, impetigo, and boils and various minor skin infections. Flies, particularly house flies, are also suspected of spreading tuberculosis by feeding on infected sputum or other discharges of patients and then on food.

Mackie *et al.* (74, p. 613) claim positive laboratory proof for transmission by the house fly of 30 different diseases. They classify the mechanical vectorship of organisms by flies as follows: (1) by the general body surface, especially the foot and leg hairs; (2) by feces from the fly, sometimes accompanied by bacterial multiplication in the gut; (3) by vomitus of the flies, regurgitation before feeding being a normal habit of many flies; (4) by metamorphosis, organisms taken up by the larval stage being present in the body of the adult fly (the ova of *Ascaris* and the spores of anthrax and tetanus have been transmitted in this fashion).

Those filth-inhabiting flies which are bloodsucking in the adult stage have been suspected of carrying or definitely shown to carry systemic diseases such as infantile paralysis, encephalitis, and surra (in horses). These flies need not be alternate hosts of the parasites, but may merely effect quick mechanical transmission of infected blood.

Dysenteries and helminthic infections are most easily carried by house-frequenting flies attracted to milk and sweet substances and to human excrement, especially by the common temperate and tropical house flies, *Musca domestica* and *M. vicina,* respectively. Some of the other muscoids, such as *Chrysomya megacephala* and some species of *Ophyra,* are equally capable of transmitting enteric pathogens. However, no flies which visit human excrement can be eliminated from consideration. Many phorids are attracted by a great variety of human foods as well as by human excrement and frequently force their way into food containers which are tight enough to exclude most insects; and many of the sarcophagids and calliphorids, although not particularly attracted to sweets, frequent and breed in both human excrement and fresh meat or meat products and are not loathe to enter houses. Primarily "outdoor species" of flies, such as *Musca sorbens,* assume importance where troops are bivouacked in the open, or in warm climates and in conditions of poverty where houses are of open construction and where food is commonly

prepared and eaten out of doors. *M. sorbens,* for example, is known in India as the "bazaar fly" and has been reported to swarm on all sorts of produce displayed and sold in open-air markets. The circumstances are similar in South China. Actually, there appear to be few flies that limit their choice of food to human excreta. Some of the small forms, such as cypselids, that normally breed in decaying vegetation but occasionally choose human excrement seem least attracted by table foods.

Considerably fewer species have habits which suit them for transmitting dermal infections. Those which feed persistently on body secretions and exudates are the most suspect. *Musca sorbens,* besides feeding on running or pustulent sores, visits many filthy substances which might contain sore-producing organisms. Some of the common eye gnats, such as *Hippelates* and some drosophilids, are especially likely to carry opthalmic infections. Bloodsucking flies, particularly some of the biting *Musca,* which prefer scarified tissue, are transmitters of dermal infections.

As few of the bloodsucking Diptera which transmit systemic blood infections breed in or feed on filth, they are not discussed in this paper. Some of the mosquitoes, such as *Culex quinquefasciatus,* which seem to breed by preference in polluted water are best studied with other mosquitoes. In the family Muscidae, including stomoxydines and several *Musca* and close allies, are bloodsucking forms which generally breed in filthy situations. The best known of these, *Stomoxys calcitrans,* has been suspected of the transmission of such systemic viruses as poliomyelitis and encephalitis, though this has not been proved. Several types of encephalitis harbored by horses or other animals might be mechanically carried to nearby persons by these flies, or from animal to animal.

MYIASIS

Myiasis is the invasion of the living human or other vertebrate body by the maggots of flies. Some species have developed this as an obligatory habit. In many others it is occasional, or even accidental. Myiasis is generally produced by the deposition of eggs or larvae by the female flies on the bodies of persons or animals, usually in body openings or in sores or wounds. However, larvae may be ingested with food and cause accidental intestinal myiasis. In cases where larvae feed and grow for a while, or pupate, before leaving the intestines, the phenomenon is called transitory myiasis. When they merely pass along the digestive tract and die or fail to feed or cause damage to tissues, their invasion is called false myiasis.

Bishopp (5) makes the following classification of types of myiasis, on the basis of the parts affected by the flies: (1) tissue-destroying forms, including wound myiasis and "strike" of sheep; (2) subdermal migratory forms;

(3) larvae infesting the intestinal and urogenital tracts; (4) forms infesting the head passages; and (5) bloodsucking forms.

Lucilia cuprina, which is responsible for most of the damage to the wool and the hides of sheep in Australia, is the only well-known myiasis producer on Guam. However, its attacks on man are rare. Most of the other flesh flies and blow flies on Guam are probably capable of producing myiasis in wounds, sores, or body openings; and occasional reports of invasions of man and other animals by some of them have been made. *Chrysomya bezziana,* an oriental species which does not occur on Guam, is apparently an obligatory myiasis producer and a frequent invader of man.

DISEASE-TRANSMITTING POTENTIALITIES OF FLIES ON GUAM

A high percentage of Guam Diptera visit human feces for food. We found 45 species which do so, of which 25 should be suspect in disease dissemination because they are also attracted to human beings or their foods. Among the many organisms likely to be carried by these flies are bacteria causing typhoid, paratyphoid, the dysenteries, and cholera; protozoans causing amoebic, giardial, and balantidial dysentery; and helminths causing taeniasis, ascariasis, ancylostomyiasis, enterobiasis, and trichuriasis.

The flies of Guam which—by reason of their abundance, domestic habits, size, hairiness, and food preferences—are probably of the greatest importance in the transmission of fecal-borne diseases are as follows, in the presumed order of importance:

1. Chrysomya megacephala
2. Musca sorbens
3. Musca vicina
4. Atherigona orientalis
5. Sarcophaga ruficornis
6. Lucilia cuprina
7. Ophyra chalcogaster
8. Sarcophaga dux and knabi
9. Sarcophaga gressitti
10. Chrysomyza aenea

A. H. Harris and Harold Down of Naval Medical Research Unit 2 write (33) of finding the following living forms of protozoans and helminths in the feces of *Chrysomya megacephala* collected in native villages on Guam:

Trichuris trichiura, ova
Chilomastix mesnili, cysts
Giardia lamblia, cysts
Endamoeba histolytica, cysts
Endamoeba coli, cysts
Trichomonas sp.
Ascaris lumbricoides
Enterobius vermicularis
Ancylostoma, ova and rhabditiform larvae

In the laboratory, Harris and Down successfully infected reared adults of *C. megacephala* with the following species:

Endamoeba histolytica, cysts
Endamoeba coli, cysts
Endolimax nana, cysts
Giardia lamblia, cysts
Ancylostoma, ova and rhabditiform larvae

Chow's recent work in China (10) demonstrates that *C. megacephala* is a good carrier of bacillary dysenteries and typhoid. Similarly Chang (9) has found this fly to be the principal agent for the spread of intestinal protozoans and helminths in West China.

Further investigations of the intestinal flora and fauna of the various species of flies on Guam in different locations and situations will have to ascertain the true role of each in the transmission of diseases. For a general discussion of diseases carried or presumably carried by flies, the reader is referred to Herms' "Medical entomology" (36) and Graham-Smith's "Flies in relation to disease" (27).

FLY HABITATS

An understanding of the abundance and relative importance of the different types of microhabitats as sources of fly populations and fly-borne pathogens is necessary for the proper application of sanitary measures. Some materials, such as rotting vegetable matter, are important as sources of fly breeding but not important as sources of pathogens, whereas others, such as human feces, may be equally important from the standpoints of breeding and disease-germ dissemination. Still others, sores for instance, may be important sources of pathogens, but not of fly populations. These circumstances vary considerably with the species of fly in question. For example, *Musca vicina* develops principally in manure heaps, but carries pathogens in the adult stage when it travels from human feces to human food.

The relative importance and abundance of the different materials forming microhabitats may vary with seasonal or other conditions. For example, during the invasion of Guam by American forces in 1944, when a large outbreak of *Chrysomya megacephala* took place, maggots bred in unburied corpses on the battlefields. After the corpses were buried, the high population was maintained by breeding in poorly constructed and inadequate privies; but with improved and better controlled latrines, the population rapidly decreased. At the same time, the larvae were developing in such scattered media as dead toads, meat in garbage dumps, and native privies which were not, or were insufficiently, treated. A similar outbreak of flies along the coast of Guadal-

canal occurred after a heavy storm, when materials such as seaweed, sea animals, carcasses, and garbage and other wreckage from ships were washed up on the beaches and assumed importance as breeding sources for many species of flies.

COMMON SUBSTANCES WHICH BREED AND ATTRACT GUAM FLIES

Human Excrement

The most dangerous material exposed to filth-visiting flies is human excrement. It not only attracts adults of most species, but is one of the most potent sources of breeding. It is the natural place for flies to contaminate themselves externally and internally with fecal-borne pathogens. Isolated deposits of excrement in the shade or partially concealed under leaves or stones are ideal for visitations and ovipositions by flies. Feces in the direct sun often dessicate too rapidly for protracted attractiveness to flies or for survival of maggots. This applies particularly to periods of hot, dry weather. Feces in large masses in deep pits do not seem to attract oviposition by many species of flies. The darkness of the pit probably discourages light-loving forms, and the type of decomposition may be unfavorable to the development of many larvae. According to Herms (36), areas of excrement in privy pits which receive light often receive oviposition by house flies, whereas areas in the dark do not.

Table 3*

Species	Abundance	Notes
Lycoria sp.	once	very old excrement
Hermetia illucens	common	in privy pits
Megaselia scalaris	common	in buildings
Tubifera arvora	once	in septic tank
Drosophila ananassae	once	isolated stools
Chrysomyza aenea	once	in laboratory
Atherigona orientalis	once	in a tent
Ophyra chalcogaster	twice	isolated stools
Musca sorbens	several times	isolated stools
Chrysomya megacephala	common	in privy pits
Sarcophaga ruficornis	common	isolated stools
Sarcophaga gressitti	common	stools on beach
Sarcophaga knabi	common	isolated stools
Sarcophaga dux	occasional	stools in jungle

* Buxton (8) also reared *Synthesiomyia nudiseta* from human excrement in Samoa.

In our studies on Guam, *Chrysomya megacephala* was found to be the principal breeder in human excrement, in or out of privy pits. Another fly commonly breeding in the pits was *Hermetia illucens*. In the open, several species of *Sarcophaga* bred as freely as *Chrysomya megacephala* did in feces, but were usually crowded out when in competition with the latter. Apparently

maggots of *Musca domestica* commonly infest privy pits and other accumulations of feces in temperate climates, but we did not observe its close relative, *M. vicina,* breeding in any form of human excrement. *M. sorbens,* which is supposed to be a common breeder in human excrement in the tropics, was found only occasionally in isolated deposits and never in pits. However, as our survey of fecal material from privies or isolated deposits in the open was not extensive, it is probable that more thorough investigation would considerably alter these remarks.

TABLE 4

SPECIES	ABUNDANCE	NOTES
Psychoda sp. a	several times	on lab. table
Diploneura cornuta	once	on lab. table
Leptocera spp.	common	marshy places
Actocetor solitarius	common	in privies
Chlorichaeta tuberculosa	once	septic tank
Octhera canescens	once	near road puddle
Sobarocephala sp.	several times	in jungle
Drosophila spp.	several times	in lab. and jungle
Rhodesiella boharti	twice	traps
Cadrema bilineata	common	traps
Lasiopleura virilis	several times	traps
Desmometopa tarsalis	common	near manure, marshes
Lonchaea filifera	unusual	observation
Lonchaea sp.	fairly common	traps and observation
Mimegralla galbula	very common	in jungle
Acrosticta apicalis	unusual	traps
Notogramma stigma	unusual	traps
Scholastes aitapensis	fairly common	jungle, coconut groves
Scholastes hirtiventris	common	jungle, coconut groves
Pogonortalis fulvofemoralis	fairly common	restricted jungle sites
Pseudeuxesta prima	uncommon	traps
Neoeuxesta sp.	occasional	restricted jungle sites
Dichaetomyia saperoi	occasional	jungle
Dichaetomyia nigroscuta	twice	jungle
Fannia pusio	common	traps
Pygophora lobata	once	observation
Atherigona longipalpus	uncommon	traps
Limnophora plumiseta	once	traps
Musca vicina	common	traps, observation
Lucilia cuprina	common	traps, observation
Chrysomya rufifacies	uncommon	traps
Sarcophaga "peregrina"	common	traps
Sarcophaga stricklandi	fairly common	in jungle

Howard, in his extensive treatise on the insect fauna of human excrement (41), gives a good discussion of the problem in the area around Washington, D. C.

Table 3 lists the species of flies which were bred on Guam from natural ovipositions on human excrement; table 4, those which were merely attracted to it. Further study should considerably increase the number found breeding.

Liquid Sewage and Other Liquid Wastes

Careful investigations of liquid environments were not conducted on Guam, partly because stagnant bodies of water are not common in the porous soil of Guam, though some search was made of slowly moving ditch water in Agana wherein the rat-tailed maggots of *Tubifera arvora* were seen, as were moth-fly larvae (probably *Psychoda alternata*). However, in the Solomons, a stagnant ditch containing waste washing water was covered with a thick scum in which wriggled huge numbers of rat-tailed maggots and the leathery larvae of *Hermetia illucens*. Larvae of the house mosquito, *Culex quinquefasciatus,* teemed around the edges of the scum. It is, of course, well known that *C. quinquefasciatus* has a liking for polluted water. On Okinawa, rat-tailed maggots and larvae of soldier flies (mostly of the genus *Ptecticus*) and *Culex quinquefasciatus* are the most conspicuous inhabitants of village ditches, but various species of moth-fly larvae are even more abundant.

Herms (36) has shown that drying sludge from sewage is a good medium for the development of house flies and stable flies.

Pig Excrement and Pens

As might be expected from the omnivorous feeding habits of pigs, the fly fauna in their excrement is similar to that in the excrement of man. However, it is usually somewhat more limited because pig manure dries out more quickly and the pigs themselves feed on larvae and puparia of flies. From our observations, it appears that the largest share of the *Musca sorbens* population on Guam is bred from the excrement in pig pens. Especially is this true in muddy pens where the feces fall into deep hoof tracks, where they remain moist and where the pigs cannot get at them. This is also true in dry weather, when the deep tracks are "frozen" in the hard mud. The most common flesh fly on the island, *Sarcophaga knabi,* is apparently supported largely by pig feces, although it breeds in human and horse excrement. *Chrysomya megacephala* rarely breeds in pig feces, and apparently *Musca vicina* never does. Adjacent to the government pig pen was a field with heaps of cow manure which bred countless *M. vicina,* but none of these laid eggs in the pen so far as could be observed.

The use of garbage for pig feed is another factor which makes pig pens good places for maggots of many species of flies to develop, especially when the garbage is allowed to accumulate out of reach of the pigs.

On Okinawa, where pigs were fed in concrete tanks which received human feces through a slit between slabs of concrete in the roof, as well as straw and other materials, the pigs ate royally on maggots and puparia but could not keep up with the oviposition rate of the adult flies which continually

swarmed about. The resulting combination of human feces, pig feces, straw and other pig feed, and maggots were used to fertilize the rice fields.

The flies which we found attracted to and breeding in pig feces on Guam are listed in table 5, and their relative abundance is indicated.

TABLE 5

BRED FROM FECES		MERELY ATTRACTED TO FECES	
SPECIES	ABUNDANCE	SPECIES	ABUNDANCE
Psychoda sp. a	very common	Lycoria sp.	unusual
Megaselia suis	moderately common	Chonocephalus hirsutus	unusual
Leptocera femorina	moderately common	Drapetis sp.	unusual
Allotrichoma sp.	very common	Tubifera arvora	unusual
Paralimna aequalis	very common	Desmometopa sp.	common
Lonchaea filifera	moderately common	Atherigona orientalis	very common
Ophyra chalcogaster	common	Lucilia cuprina	common
Stomoxys calcitrans	unusual	Musca vicina	unusual
Musca sorbens	very common		
Chrysomya mega-cephala	once		
Sarcophaga knabi	very common		

CATTLE DROPPINGS AND MANURE HEAPS

Experience on Guam showed that cattle droppings and manure heaps must be studied separately. Manure heaps, usually mixed with hay and well-aerated in feeding or milking barns, have a fauna closely resembling that of vegetable compost or other accumulations of decaying vegetation. They remain moist for a considerable period and support several generations of flies. Isolated droppings in the field breed cattle flies of two species, *Haematobia exigua* and *Siphona carabao,* and the stable fly, *Stomoxys calcitrans,* which also breeds in manure heaps. On the other hand, *Musca vicina,* which breeds well in manure heaps, was not found in cattle droppings. *M. sorbens* was found once in cattle droppings and once in a pile of manure, but neither seems to be its normal breeding medium. *Hermetia illucens,* which requires a long time for development, breeds in manure heaps but not in isolated droppings. This parallels its breeding in latrines and not in isolated deposits of human feces. *Ophyra chalcogaster,* one of the most common inhabitants of cattle droppings, is rare in manure heaps, whereas the reverse is true of *Chrysomyza aenea.* Neither seems to support blow flies or flesh flies on Guam, although adults of these flies are somewhat attracted to fresh droppings.

From the standpoint of breeding flies which are active in the dissemination of human diseases, manure heaps are the more suitable since they breed house flies. Cattle droppings are much more suitable for the breeding of cattle pests.

Hammer, in his "Biological and ecological investigations of flies associated with pasturing cattle and their excrement" (31), gives a detailed and excellent account of the ecology of cattle droppings in Denmark.

Table 6 lists the flies bred from cattle droppings and from heaps of cow manure, with the relative abundance of each species.

TABLE 6*

FROM CATTLE DROPPINGS		FROM HEAPS OF COW MANURE	
SPECIES	ABUNDANCE	SPECIES	ABUNDANCE
Lycoria sp.	unusual	Lycoria sp.	fairly common
Leptocera spp.	very common	Hermetia illucens	fairly common
Desmometopa tarsalis	common	Microchrysa flaviventris	common
Milichiella lacteipennis	common	Tubifera arvora	unusual
Chrysomyza aenea	fairly common	Leptocera spp.	very common
Ophyra chalcogaster	very common	Desmometopa tarsalis	very common
Stomoxys calcitrans	very common	Milichiella lacteipennis	very common
Siphona carabao	very common	Chrysomyza aenea	very common
Haematobia exigua	very common	Ophyra chalcogaster	unusual
Musca sorbens	once	Stomoxys calcitrans	very common
		Musca sorbens	unusual
		Musca vicina	very common

* In addition to the species listed in this table, flies found commonly around dairy barns were *Lonchaea* sp., *Cadrema bilineata, Atherigona orientalis, Sarcophaga knabi* and *ruficornis, Chrysomya megacephala.*

HORSE DROPPINGS

Large accumulations of horse manure were not available for study, but isolated groups of droppings in a fairly moist environment were found to have a richer fauna of potential disease spreaders than has cow manure. Flesh-fly larvae of two species, *Sarcophaga knabi* and *S. ruficornis,* were quite common, as were larvae of *Musca sorbens.* Larvae of *M. vicina* were not seen, although they probably do breed in such material since horse excrement is known to be the favorite breeding medium for *M. domestica* (Hewitt, 37). Larvae of *Chrysomyza aenea* were also abundant in the horse droppings on Guam.

DECAYING VEGETATION

A large and constantly accumulating pile of aquatic vegetation which had been dragged from the Agana Spring reservoir was excellent for the study of fly breeding in such material. It remained very moist, in places having almost a fecal odor. The accumulated heat of decomposition was too great for fly breeding in some parts of it, but generally it was an excellent medium. Its fauna closely resembled that of cattle manure heaps, except that *Musca vicina* larvae were not found. Both species of *Musca* were abundant visitors to the pile, but they apparently did not oviposit. *Chrysomyza aenea* was the most prolific breeder in the drier material, but in the very moist, slimy portion, *Stomoxys calcitrans* was dominant. Of the two soldier flies, *Microchrysa flaviventris* was much more abundant than *Hermetia illucens.* The same relationship for all four of the above species was present in the manure heaps. Similarity between decaying vegetation and heaps of manure was also demon-

strated by small acalypterate flies such as *Leptocera, Milichiella,* and *Desmometopa,* all of which bred in exceeding abundance in both materials.

Decaying Fruit

It is difficult to conceive of the amount of mashed and fermenting breadfruit on the ground in the neighborhood of native villages during certain seasons. At such times swarms of flies are attracted and cover all exuding portions of the fruit.

Although not usually considered a filthy substance, decaying fruit on Guam has several important connections with filth-inhabiting flies. In the first place some types, such as breadfruit and species of *Anona,* are powerful attrahents for such flies as *Chrysomya megacephala,* both species of *Musca,* and *Atherigona orientalis.* Some of this fruit is eaten raw from the ground by the natives, and the flies which come to feed on it also visit human feces and table food.

Flies such as *Atherigona orientalis* and several species of *Drosophila,* which probably breed chiefly in fruit, also breed in human excrement on occasion.

Table 7 lists the species of flies bred from decaying breadfruit and the flies attracted to but not found breeding in it. The relative abundance of each species is indicated.

Table 7

Breeding		Attracted but not breeding	
Species	Abundance	Species	Abundance
Psychoda sp. a	very common	Diploneura cornuta	unusual
Psychoda alternata	unusual	Megaselia scalaris	unusual
Cecidomyidae gen. sp.	common	Drapetis spp.	fairly common
Megaselia sp.	unusual	Actocetor solitarius	common
Chonocephalus subglaber	very common	Chrysomyza aenea	common
Chaetodrosophilella quadrilineata	very common	Scholastes aitapensis	rather common
Drosophila ananassae	very common	Acrosticta apicalis	unusual
Drosophila melanogaster	common	Cadrema bilineata	rather common
Drosophila, 2 spp. undetermined	both common	Lasiopleura virilis	unusual
Notogramma stigma	unusual	Atherigona longipalpus	unusual
Atherigona orientalis	very common	Fannia pusio	common
Limnophora plumiseta	common	Musca sorbens	very common
		Musca vicina	common
		Chrysomya megacephala	very common
		Sarcophaga ruficornis	fairly common

Decaying Coconuts

It is unfortunate that the possibilities of decaying coconuts for fly breeding on Guam were not more thoroughly investigated. Most decaying nuts seemed to harbor only larvae of *Scholastes* and *Atherigona orientalis* and to have an

odor rather like that of cheese, which it probably is in a sense. However, some coconuts rotted in a different manner and developed an odor like that of diarrhetic stools. These seemed to support a rich fauna. From the two such nuts investigated, *Sarcophaga "peregrina," Chrysomya megacephala, Cadrema bilineata,* and *Megaselia scalaris* were reared, in addition to the usual *Scholastes* and *Atherigona.* We suspected on several occasions that *Musca sorbens* might breed in the coconuts under certain conditions, though we found none of their larvae. However, D. G. Hall informs us that while on an island in the Marshalls, he reared *M. sorbens* from some rotten coconuts he had picked up in the field and placed in tightly covered cans.

Carrion

Carrion of all sorts is the principal adult and larval food for most of the species of filth-inhabiting flies on Guam. Nearly all of the human excrement-inhabiting species can breed in carrion and many species are apparently entirely carnivorous. All, except possibly two, of the flesh flies and blow flies breed well in carrion, and all but two of the anthomyids whose habits were studied also breed in it commonly. The same can be said for the tiny phorid flies. Even *Stomoxys calcitrans* breeds in it occasionally, according to the literature (Seguy, 114). The principal flies which were not found in carrion in the larval stage are cattle flies (which are confined to cattle droppings), both species of *Musca,* and some of the otitids. However, all of these, except the cattle flies, are attracted to carrion as adults.

For the most part, samples of carrion from different sorts of animals were about equally attractive to flies for feeding and oviposition. In the Solomons it had been found that crushed crabs were particularly attractive, but these were not available in sufficient numbers for tests on Guam. Animals with fur were oviposited on more readily than bare pieces of meat but showed no special feeding attraction to adults. Echinoderms were slow to rot, but when semi-liquefied, furnished excellent bait. Dead sea snails were very attractive, especially to phorids and several acalypterates, for visitations and oviposition. Most flies oviposited in dead snails without showing a preference for early or late stages of decay. *Parafannia* and *Puliciphora,* however, showed a distinct preference for old material.

Under normal conditions, there is a distinct succession of insect faunae breeding in a large piece of carrion and a less distinct one in the adult insects visiting it for food. Fuller, in "The insect inhabitants of carrion" (26) describes in detail the succession in animal carcasses of temperate Australia. Mégnin (79) gives an exhaustive account of the fauna of human corpses in France. Studying buried corpses in a cool climate, he was able to determine their ages quite accurately from a study of the insect inhabitants. This sort

of knowledge has been used to some extent in medico-legal work and criminal detection.

Our best opportunity to study the succession of insects in carrion was the aforementioned human corpse on a remote beach at the north end of Guam. At the time of our first visit, when the corpse was four days old, great numbers of mature *Chrysomya megacephala* larvae were already migrating from the abdomen of the corpse to pupate in the sand. At this time, *C. rufifacies* were the most abundant adult flies, and they deposited several egg masses while we watched. A small proportion of mature *C. rufifacies* larvae was also present. A week later the corpse had lost its bloated appearance and the flesh was easily pulled from the bones. About 15 feet from the body, several flowering trees of the genus *Tournefortia* were swarming with adults of all three species of *Chrysomya* and smaller numbers of *Sarcophaga dux* and *Musca sorbens*. Many of the striking "hairy maggots" of *C. rufifacies* were seen leaving the carcass in company with some maggots of *C. megacephala* and *C. "nigripes."* Examination of the abdominal cavity of the corpse revealed many full-grown maggots of *C. rufifacies* and even greater numbers of *C. "nigripes"* in various stages of development. A species of *Sarcophaga* larva, probably *dux,* was also present in small numbers. Two weeks later, when the corpse was about a month old, it was considerably dessicated and had the musty smell of old carrion, although the deeper muscle tissues were still moist and highly putrid. Probably the extended preservation of some of the tissues was due to a high tide that had washed over the body and left a deposit of salt and to the fact that it had been sprayed with oil, presumably by a sanitation detail. The most abundant inhabitants in the corpse and in the sand about it were now adults and larvae of larder beetles (Dermestidae, *Dermestes*), ham beetles (Corynetidae, *Necrobia*), and steel beetles (Histeridae, *Saprinus*). Adults of the muscoids *Atherigona orientalis, Ophyra chalcogaster, Musca sorbens,* and *Rhinia testacea* were rather common on the corpse, as were the acalypterates *Pseudeuxesta prima, Scholastes hirtiventris,* and *Hecamede persimilis*. Numerous larvae of the *Pseudeuxesta* were found in the muscle tissue close to the bones. Directly under the body in the moist sand we found many larvae of the little gray beach ephydrid, *Hecamede persimilis*. Still viable puparia of *Chrysomya "nigripes"* were in the same situation. Pieces of old tissue which were brought back to the laboratory for rearing of the *Pseudeuxesta* became infested with *Fannia pusio* and *Ophyra chalcogaster* larvae.

Table 8 presents a list of the more important species which were found breeding in carrion on Guam. The asterisks indicate the frequency and degree of infestation in carrion from scarce (*) to very abundant (****). The parenthetical remarks refer to the stage which they usually occupy in the succession of faunae. Preference for mollusks, if present, is indicated.

TABLE 8

SPECIES	ABUNDANCE	TIME OF INVASION	MEAT PREFERENCE, IF ANY
Hermetia illucens	*	tertiary	
Megaselia scalaris	***	primary to tertiary	
Megaselia stuntzi	*	secondary	on mollusks
Parafannia molluscovora	**	secondary to tertiary	on mollusks
Puliciphora wymani	**	secondary	mollusks and fish
Puliciphora nigrosterna	*	secondary	on mollusks
Diploneura cornuta	**	secondary	especially mollusks
Discomyza maculipennis	**	tertiary	especially mollusks
Hecamede persimilis	*	tertiary	
Chrysomyza aenea	*	secondary	
Pseudeuxesta prima	*	tertiary	
Atherigona orientalis	**	secondary and tertiary	
Fannia pusio	***	tertiary	
Ophyra chalcogaster	***	tertiary	
Rhinia testacea	*	late secondary	
Lucilia cuprina	**	primary	
Chrysomya megacephala	****	primary to secondary	
Chrysomya rufifacies	****	early secondary	
Chrysomya "nigripes"	***	secondary to tertiary	
Sarcophaga ruficornis	***	primary to secondary	
Sarcophaga gressitti	***	secondary	
Sarcophaga knabi	**	secondary	
Sarcophaga "peregrina"	***	primary to secondary	
Sarcophaga dux	****	primary to secondary	

Table 9 lists the flies which showed a distinct attraction to carrion but were not found breeding in it. Abundance, as indicated with asterisks, is based on total counts in our traps.

TABLE 9

SPECIES	ABUNDANCE	SPECIES	ABUNDANCE
Drapetis spp.	*	Scholastes hirtiventris	*
Chlorichaeta tuberculosa	*	Notogramma stigma	**
Actocetor solitarius	*	Dichaetomyia saperoi	*
Sobarocephala sp.	*	Dichaetomyia nigroscuta	*
Rhodesiella boharti	*	Atherigona longipalpus	**
Cadrema bilineata	****	Limnophora plumiseta	**
Lasiopleura virilis	*	Musca sorbens	****
Lonchaea filifera	*	Musca vicina	**
Lonchaea sp.	***	Synthesiomyia nudiseta	*
Acrosticta apicalis	*	Stomorhina quadrinotata	*
Neoeuxesta sp.	*	Sarcophaga stricklandi	*

GARBAGE DUMPS

The contrast between controlled and uncontrolled dumping of garbage in relation to fly breeding was clearly brought out by a study of the flies at two

Guam dumps which we visited frequently. The one near the Government Farm serviced kitchens for at least 50,000 persons and covered several acres. At the start, garbage was buried under only a few inches of soil but was piled as pure garbage to such a depth that the heat of decomposition prevented fly breeding, except where small amounts were mixed with soil or had slopped over the edges of the burial trenches. The odors attracted vast numbers of flies which were mostly *Chrysomya megacephala* and *Musca vicina.* Most of them must have come from considerable distances. Other species seen in numbers were: *Lucilia cuprina, Atherigona orientalis, Musca sorbens,* and *Chrysomyza aenea.* After a few weeks, the burial trenches were made deeper and the garbage was covered daily with several feet of soil, greatly reducing the odor and, consequently, the adult flies in the area.

The other dump, in the Pago River Canyon, was probably supplied by only one small camp, since the material, although piled above ground, never totaled more than about 20 tons. As cans, packing boxes, jungle slashings, and waste paper, and other refuse were piled with the garbage, the mass was well-ventilated and not too warm for maggots. Hence this dump was breeding immense numbers of flies of several species and attracting many others. The following species were abundant:

Musca vicina: breeding in ears of corn and a meat-soaked rag.
Musca sorbens: not found breeding.
Fannia pusio: larvae on bones of old turkey carcasses.
Limnophora plumiseta: eggs in breadfruit squashed on road.
Atherigona orientalis: larvae common in corn and cans with adherent vegetables.
Ophyra chalcogaster: larvae in turkey carcass, meat-soaked rag, C-ration stew.
Stomoxys calcitrans: larvae in ears of corn, vegetation cuttings.
Sarcophaga gressitti: larvae not seen.
Lucilia cuprina: larvae in C-ration stew, green cowhide.
Chrysomya megacephala: larvae in turkey carcass, dead toads, green cowhide.
Chrysomya rufifacies: larvae in green cowhide.
Notogramma stigma: breeding not seen.
Chrysomyza aenea: larvae in ears of corn, rotting potatoes.
Mimegralla albimana galbula: probably not breeding in dump.
Lonchaea species: larvae not seen (perhaps stem borers).
Cadrema pallida bilineata: larvae not seen.
Desmometopa sp.: larvae in vegetation cuttings and corn ear sheaths.
Milichiella lacteipennis: larvae not seen.
Drosophila ananassae: eggs, larvae in breadfruit squashed on road.
Drosophila melanogaster: eggs, larvae in breadfruit squashed on road.
Chaetodrosophilella quadrilineata: eggs, larvae in breadfruit squashed on road.
Discomyza maculipennis: larvae in C-ration stew.
Leptocera (5 species): larvae not seen.
Megaselia scalaris: larvae in turkey carcass, C-ration stew.
Psychoda sp. a: larvae in rotting corn.
Lycoria (4 species): larvae in sheaths of corn ears.
Heleid: adults extremely common but larvae were overlooked.

TABLE 10.—FOOD HABITS OF LARVAE AND ADULTS OF COMMON FILTH-INHABITING FLIES*

† = Larvae ‡ = Adults

SPECIES	CLASSES OF FOOD													
			EXCREMENT						DECAYING VEG. MATERIAL					
	CARRION**	BODY SECRETIONS OR BLOOD	HUMAN	PIG	COW	HORSE	MANURE PILES	LIQUID SEWAGE	VEGETATION	FRUIT	STARCHY VEGETABLES	COCONUTS	SWEETS	FLOWERS
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Psychoda sp. a	.....	.....	.....	†	.....	.....	.....	.....	.....	† ‡	.....	.....	‡	.....
Hermetia illucens	.....	.....	† ‡	.....	.....	.....	† ‡	† ‡	†	.....	†	.....	.....	‡
Microchrysa flaviventris	.....	.....	.....	.....	.....	.....	†	.....	†	.....	†	.....	.....	‡
Megaselia scalaris	† ‡	‡	† ‡	.....	.....	.....	.....	.....	.....	.....	†	† ‡	.....	.....
Megaselia suis	.....	.....	.....	† ‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Parafannia molluscovora	† ‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Puliciphora wymani	† ‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Chonocephalus subglaber	.....	.....	.....	.....	.....	.....	.....	.....	†	† ‡	.....	.....	.....	.....
Diploneura cornuta	† ‡	.....	† ‡	.....	.....	.....	.....	.....	.....	.....	†	.....	.....	.....
Tubifera arvora	.....	.....	‡	.....	‡	.....	† ‡	† ‡	.....	.....	.....	.....	.....	‡
Leptocera femorina	.....	.....	‡	‡	† ‡	† ‡	† ‡	.....	† ‡	.....	‡	.....	.....	.....
Discomyza maculipennis	† ‡	.....	‡	.....	.....	.....	.....	.....	.....	.....	.....	†	.....	.....
Hecamede persimilis	† ‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	‡
Paralimna aequalis	.....	.....	.....	† ‡	.....	.....	† ‡	‡	‡	.....	.....	.....	.....	.....
Allotrichoma species	.....	.....	.....	† ‡	.....	.....	‡	‡	‡	.....	.....	.....	.....	.....
Chlorichaeta tuberculosa	.....	‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Actocetor solitarius	‡	.....	‡	.....	.....	.....	.....	.....	.....	‡	.....	.....	‡	.....
Drosophilidae	.....	.....	† ‡	.....	.....	.....	.....	.....	.....	† ‡	† ‡	.....	.....	.....
Cadrema bilineata	‡	.....	‡	.....	.....	.....	.....	.....	.....	.....	†	† ‡	‡	.....
Milichiella lacteipennis	.....	.....	.....	.....	† ‡	† ‡	† ‡	.....	† ‡	.....	.....	.....	.....	.....

Pseudeuxesta prima	† ‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Acrosticta apicalis	‡	.....	‡	.....	.....	.....	.....	.....	.....	‡	.....	.....	.....	.....
Scholastes aitapensis	.....	.....	‡	.....	.....	.....	.....	.....	.....	‡	‡	† ‡	.....	.....
Scholastes hirtiventris	.....	.....	‡	.....	.....	.....	.....	.....	.....	.....	.....	† ‡	.....	.....
Notogramma stigma	‡	.....	‡	.....	‡	.....	.....	.....	.....	† ‡	† ‡	‡	.....	‡
Dichaetomyia saperoi	‡	.....	‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Atherigona longipalpus	‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	‡	.....	.....	.....
Atherigona orientalis	† ‡	.....	† ‡	‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Limnophora plumiseta	‡	.....	‡	.....	.....	.....	.....	‡	.....	† ‡	.....	.....	‡	.....
Fannia pusio	† ‡	.....	‡	.....	.....	.....	.....	.....	.....	‡	.....	.....	.....	.....
Ophyra chalcogaster	† ‡	.....	† ‡	† ‡	† ‡	.....	†	.....	.....	.....	.....	† ‡	‡	.....
Stomoxys calcitrans	‡	‡	.....	†	†	†	†	.....	†	.....	.....	.....	.....	.....
Siphona carabao	.....	‡	.....	.....	†	.....	.....	.....	.....	.....	.....	.....	.....	.....
Haematobia exigua	.....	‡	.....	.....	†	.....	.....	.....	.....	.....	.....	.....	.....	.....
Musca sorbens	‡	‡	† ‡	† ‡	† ‡	† ‡	† ‡	‡	‡	‡	‡	‡	‡	‡
Musca vicina	‡	‡	‡	‡	‡	† ‡	† ‡	‡	‡	‡	† ‡	.....	‡	‡
Synthesiomyia nudiseta	‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Rhinia testacea	†(?)‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	‡
Lucilia cuprina	† ‡	.....	† ‡	‡	.....	.....	.....	‡	.....	‡	‡	.....	‡	‡
Chrysomya megacephala	† ‡	‡***	† ‡	‡	‡	.....	.....	.....	.....	‡	‡	† ‡	‡	‡
Chrysomya rufifacies	† ‡	.....	‡	.....	.....	.....	.....	.....	.....	‡	.....	.....	.....	‡
Chrysomya "nigripes"	† ‡	.....	‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	‡
Sarcophaga ruficornis	† ‡	.....	† ‡	.....	‡	† ‡	.....	.....	.....	‡	‡	.....	.....	‡
Sarcophaga gressitti	† ‡	‡***	† ‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	‡
Sarcophaga knabi	† ‡	.....	† ‡	† ‡	‡	†	.....	.....	.....	.....	‡	.....	.....	.....
Sarcophaga dux	† ‡	.....	† ‡	.....	.....	.....	.....	.....	.....	‡	‡	.....	‡	‡
Sarcophaga "peregrina"	† ‡	.....	‡	‡	.....	.....	.....	.....	.....	.....	.....	† ‡	.....	.....
Sarcophaga stricklandi	‡	.....	‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	‡

* According to observations on Guam and based upon habits found in nature.
** Including fish and shellfish.
*** Seen on sores of natives.

SUMMARY OF FOOD HABITS

Table 10 shows the foods for adults and larvae of most of the filth-inhabiting flies on Guam. Further research will undoubtedly fill in many of the blanks. From a disease transmission standpoint, the species whose adults fall in the second, third, eleventh, and thirteenth columns are the most important. However, other materials, such as cattle manure and carrion, which are not directly connected with the spread of human diseases, often maintain high populations of flies which visit more significant substances, such as human excrement and table sweets.

In order to supplement the data on breeding media obtained by rearing flies from naturally infested materials, we started a series of experimental laboratory rearings in which eggs were placed on standardized media and the development of the flies was measured in terms of survival and rapidity of growth. The media used were representative of important sources of breeding in the field, but the choice of C-ration stew was unfortunate, as its meat content made it quite similar to liver. A canned vegetable such as corn or peas would have been better for experimental purposes. And the data on coconuts may not be particularly significant because we were unable to produce anything but a "cheesey" type of spoilage in the laboratory. Furthermore, the resultant table 11 is incomplete because we had to leave the island

TABLE 11

Species	Feces			Carrion	Garbage	Decaying Vegetable Material	
	Human	Cow	Pig	Liver	C-ration stew	Coconut	Breadfruit
Chrysomya megacephala	****	*	**	****	***	*	0
Lucilia cuprina	****	***	***	****	****	?	**
Sarcophaga ruficornis	****	*	**	****	***	?	0
Sarcophaga knabi	?	?	****	****	?	0	?
Musca vicina	***	****	?	***	***	**	0
Musca sorbens	***	***	****	?	**	?	?
Stomoxys calcitrans	***	****	*	*	?	?	?
Atherigona orientalis	***	?	?	****	?	****	****
Scholastes aitapensis	?	?	0	?	**	****	**
Megaselia scalaris	****	*	**	****	****	***	***

0 No growth or only a trace.
* Several larvae attaining at least half of their growth.
** Delayed but with a small percentage reaching pupal stage.
*** Delayed but with a large percentage reaching pupal stage.
**** Large percentage reaching pupal stage in minimum time.
? Not tried.

soon after the experiment was launched. In any case, interpretations would have to be made with caution, because materials on which a species of maggot develops may not be those chosen by the adult for oviposition. However, in general, it may be assumed from the figures presented that material which rates two asterisks or fewer for a species of fly is of no consequence as a breeding source for that species.

TABLE 12.—NUMBER OF FLIES ATTRACTED TO VARIOUS BAITS IN A NATIVE VILLAGE

SPECIES	COW DUNG	DEAD RATS	TOMATOES	PIG DUNG	PAPAYA	COCONUT	BREADFRUIT
Atherigona orientalis	27	2,133	7	28	31	35	91
Ophyra chalcogaster	2	147	1	0	25	5	14
Fannia pusio	0	2	0	0	1	0	0
Musca sorbens	293	2,216	1	6	79	13	36
Chrysomya megacephala	47	7,588	0	3	718	17	28
Chrysomya rufifacies	0	98	1	0	4	0	0
Lucilia cuprina	2	215	0	0	67	1	2
Sarcophaga dux, knabi, and "peregrina"	6	147	1	0	18	0	5
Sarcophaga ruficornis	0	8	0	0	12	0	0
Synthesiomyia nudiseta	0	0	0	0	4	0	0
Chrysomyza aenea	2	1,541	1	10	7	2	7
Notogramma stigma	1	467	1	11	0	3	6
Scholastes aitapensis	1	37	0	0	0	7	2
Cadrema bilineata	46	1,608	3	0	20	123	15
Lonchaea species	2	8	0	0	0	6	0
Totals	429	16,215	16	58	986	212	206

Several trapping experiments were undertaken in order to compare the attractiveness to flies of various baits under different environmental conditions, but the comparisons were not experimentally sound because dessication and decay were more rapid in some materials than in others. Too late to conduct conclusive tests it was found that baits should be left semi-immersed in water when exposed in the traps. However, table 12, which represents one of our tests, clearly shows the superiority of carrion to the other materials exposed. The latter, however, would have compared more favorably with the carrion if their surfaces had been kept moist. Table 13, which compares the attractiveness of two types of carrion and human excrement, indicated that human excrement is inferior to carrion for the trapping of nearly all flies. Later work with larger amounts of fresh, moist excrement showed that the reverse may be true for many species.

TABLE 13.—COMPARISON BETWEEN FLIES IN TYPICAL VILLAGE AND MILITARY CAMPS

SPECIES	EDGE OF JUNGLE BY CAMP*			EDGE OF VILLAGE***
	DEAD RATS	STAR FISH	HUMAN** EXCREMENT	DEAD RATS
Discomyza maculipennis	9	36	0	2
Lonchaea species	142	187	64	374
Cadrema bilineata	1,046	1,462	182	1,540
Lasiopleura virilis	21	6	18	14
Notogramma stigma	86	74	94	42
Chrysomyza aenea	1,840	1,920	421	1,420
Acrosticta apicalis	11	8	0	1
Neoeuxesta species	9	4	0	0
Pseudeuxesta prima	4	4	0	2
Scholastes aitapensis	8	14	19	360
Atherigona orientalis	2,340	2,541	450	11,241
Atherigona longipalpus	15	18	12	24
Ophyra chalcogaster	320	341	34	946
Fannia pusio	140	429	14	87
Limnophora plumiseta	3	1	0	6
Musca sorbens	160	87	42	4,204
Musca vicina	15	4	11	124
Synthesiomyia nudiseta	4	3	0	2
Chrysomya megacephala	3,240	3,167	370	9,430
Chrysomya rufifacies	348	382	10	452
Chrysomya "nigripes"	3	6	0	20
Lucilia cuprina	9	7	5	52
Sarcophaga stricklandi	6	4	2	10
Sarcophaga gressitti	94	116	27	102
Sarcophaga dux, knabi and "peregrina"	524	743	240	631
Sarcophaga ruficornis	163	184	57	356
Totals	10,560	11,748	2,072	31,442

* Naval Medical Research Unit 2.
** Not kept sufficiently moist in this experiment to retain its attractiveness. For best results baits should be partially immersed in water.
*** Mung Mung.

In order to determine the effect of age and consequent dessication on the attractiveness of baits, carrion and excrement were exposed for a week without the addition of moisture except for some brief rain showers. The results (tables 14 and 15) show that human excrement loses its attractiveness much more quickly and completely than does carrion.

SEX RATIOS OF FLIES

Various statements have been made in the literature concerning the relative attraction of the sexes of flies to different baits. Some discrepancies in the figures obtained by different workers may be caused by variations in trap design, but most records indicate that on carrion, at least, the females outnumber the males 10 to one (Graham-Smith, 28). As Graham-Smith points

TABLE 14.—HUMAN EXCREMENT AS BAIT

SPECIES	1-2 DAYS	3-4 DAYS	6-7 DAYS
Chrysomyza aenea	48	27	2
Notogramma stigma	18	0	0
Lonchaea species	13	3	0
Cadrema pallida bilineata	21	37	15
Atherigona orientalis	30	39	5
Musca sorbens	11	2	0
Chrysomya megacephala	72	2	1
Chrysomya rufifacies	6	0	1
Sarcophaga gressitti	3	1	0
Sarcophaga dux group	63	45	2
Sarcophaga ruficornis	6	0	0
Totals	291	156	26

TABLE 15.—CARRION AS BAIT

SPECIES	1-2 DAYS	3-4 DAYS	6-7 DAYS
Chrysomyza aenea	31	61	25
Notogramma stigma	39	42	25
Lonchaea species	22	3	7
Cadrema pallida bilineata	110	256	118
Atherigona orientalis	521	774	216
Ophyra chalcogaster	29	33	8
Fannia pusio	26	103	2
Musca sorbens*	11	2	0
Chrysomya megacephala male	346	76	27
Chrysomya megacephala female	422	32	41
Chrysomya rufifacies*	84	12	1
Sarcophaga stricklandi*	8	4	1
Sarcophaga gressitti*	22	22	15
Sarcophaga dux group male	39	43	24
Sarcophaga dux group female	131	69	33
Sarcophaga ruficornis male	6	12	1
Sarcophaga ruficornis female	27	4	4
Totals	1,874	1,548	548

* Sexes were counted but showed the same trends.

out, males are more averse than females to entering darkened traps. This may explain why, with our completely unshaded traps, the ratio of females to males of most species was only about five to three on carrion and two to one on human feces (table 16).

Apparently, different species vary greatly in the ratio of sexes attracted to various substances. To arrive at significant values for these differences, a long series of carefully controlled experiments would be necessary. From the results in screen traps it would appear that males may be nearly as dangerous to public health as females. However, as females enter houses and toilets more readily than males, they are probably far more dangerous under ordinary conditions.

The aversion of males to darkened rooms was particularly noticeable on Okinawa, where *Musca sorbens* was very troublesome in native villages. It was noticed that head sores of children in the sunlight attracted as many male as female flies, but that the unwashed bodies of old people lying in the typical open-style houses were covered by flies which were nearly all females.

TABLE 16

SPECIES	CARRION*		EXCREMENT	
	MALE	FEMALE	MALE	FEMALE
Musca sorbens	2,725	4,435	15	60
Synthesiomyia nudiseta	5	40	0	0
Chrysomya megacephala	24,540	38,140	450	611
Chrysomya rufifacies	1,120	1,774	5	45
Chrysomya "nigripes"	115	185	0	0
Lucilia cuprina	92	133	6	15
Sarcophaga gressitti	354	670	10	32
Sarcophaga dux group	1,243	3,260	91	432
Sarcophaga ruficornis	272	1,001	16	24
Sarcophaga stricklandi	5	96	0	8
Totals	30,471	49,734	593	1,227

* Figures for carrion represent many more trappings than do those for excrement.

NATURAL ENEMIES OF GUAM FLIES

Perhaps one reason for the abundance of flies on Guam is the small number of their natural enemies compared to the number found in continental areas.

Of vertebrate enemies, birds are few and insectivorous mammals are absent. Rats, however, compete with flies for carrion and garbage and eat some of their maggots. The most abundant vertebrate insectivores are lizards (geckos, skinks, and monitors) and giant toads, but the toads may increase the populations of flesh-breeding flies by furnishing them with numerous squashed carcasses along the roads.

Competition among maggots is the prime factor in holding down the populations, both between and within species, particularly in the case of flies that breed in such concentrated media as meat and human excrement. Apparently such materials attract so many gravid females of highly fecund species that they may become infested with more larvae than they can support. This happens sometimes even in large carcasses or privy pits full of excrement. The weaker or slower species are crowded out, and if too many of the dominant ones are left, there is a high mortality and the adults which do emerge have reduced fecundity and life expectancy. Holdaway (40) records that in a carcass infested with *Lucilia sericata* maggots, competition was so keen that

only 231 adults emerged from about 50,000 larvae. Fuller (26) gives a good account of maggot competition in carrion in Australia.

Predaceous maggots are also important in holding down populations of other species although they may themselves be objectionable in the adult stage. *Chrysomya rufifacies* is a well-known predator on other maggots, especially when the maggots are many and the food is scarce. The same is true of *Ophyra chalcogaster,* which operates in many kinds of filthy media. Some of the most efficient predaceous maggots in excrement, such as *Scatophaga,* are not found on Guam. In the dung of herbivores, decaying vegetation, and decaying fruit competition among maggots, except for a certain degree of predatism, is unimportant. Hammer (31) shows that in cattle droppings, coprophagous beetles offer serious competition for food and cause an even more serious early dessication of the droppings. Except for one or two species of *Aphodius,* coprophagous beetles seem to be scarce on Guam.

Predaceous beetles probably take a large toll of maggots, especially in the excrement of herbivores, in decaying fruit and vegetation, and in old carrion. They are not so active in rapidly decomposing human excrement or carrion. Staphylinids are abundant on Guam in species and individuals, but histerids and dytiscids are not; and several other notable beetle predators are absent. It is possible that the introduction of coprophagous and predaceous filth-inhabiting beetles would reduce populations of such flies as *Haematobia exigua, Musca vicina,* and perhaps many others.

Of insect parasites, we reared chalcid wasps from fly puparia of several species but not in large numbers. The chalcids reared were: *Brachymeria fonscolombei* Du Four in *Sarcophaga dux,* and *Spalangia muscidarum* in *Stomoxys calcitrans.* From our observations, it may be said that the parasites on Guam have little total effect on the population of any of the flies.

Of parasitic fungi, several species of *Empusa,* in particular, have been seen to suddenly overwhelm large populations of adult flies in various parts of the world. This phenomenon was not observed on Guam; but since such epidemics are generally seasonal or even less frequent such fungi may be present.

POSSIBLE METHODS FOR FLY CONTROL ON GUAM AND OTHER PACIFIC ISLANDS

It is beyond the scope of this paper to give an exhaustive account of methods for fly control. Several textbooks of medical entomology and bulletins of the United States Department of Agriculture describe in detail most of the standard measures. Herms (36) gives a rather complete résumé of house fly control in the United States, and Bishopp (3) does likewise for stable flies. Hammer (31) discusses recent methods in the control of cattle flies, and

various authors in Australia (24, 25, 54, 73, 128) have discussed control of blow flies with particular reference to species invading the cutaneous tissue of sheep. Although literature on the specific control of saprophagous blow flies and flesh flies is scanty, many of the general methods of sanitation used for the control of house flies apply to most other filth-inhabiting species.

The basic method for fly control, in spite of the recent development of DDT and other chlorinated hydrocarbons, is still the disposal of breeding materials, which may be handled in one or more of the following ways: (1) storage in fly-tight containers; (2) storage in complete darkness; (3) incineration; (4) deep burial; (5) removal by offshore tidal currents; (6) dessication, usually by thin spreading in the sun; (7) increase of natural heat of decomposition by deep piling and sealing off from ventilation; (8) treatment with toxic materials, usually with borax, paradichlorobenzene, hellebore, sodium arsenite, calcium cyanamid, or one of the chlorinated hydrocarbons such as DDT.

The same methods, except for the use of fly-tight containers and dark storage, may destroy eggs and larvae already present in the wastes. Another method frequently used to destroy larvae of muscoids in manure is to pile the manure on a slatted platform over water and then wet the top of it regularly so that the mature larvae, in seeking a dry place for pupation, crawl downward and fall into the water. If manure or stock feed containing fly larvae is stored in an enclosed space, the adults may be trapped in window or ventilator traps when they emerge.

In general, the usual types of wastes are best handled as follows: (1) spread manure thinly over the fields each day as it accumulates; (2) keep stock feed from becoming wet and rotting; (3) incinerate garbage or bury deeply; (4) for human feces, install and use flush toilets draining into proper septic tanks or sewage disposal plants or privies which are either fly-tight or adequately treated with chemicals.

The following methods are often used for the control of adult flies; (1) trapping, (2) setting out of poisoned baits, (3) use of sticky fly paper indoors, (4) spraying large or small areas with insecticides, (5) charging screen doors of barns and stables with electricity, (6) applying persistent types of insecticides for residual action on barns, walls of mess halls, screens, and the like, and (7) using screens to keep adult flies out of buildings.

Chemical control of adult flies, which has been the subject of much recent investigation and of numerous reports holds much promise as an emergency measure. However, any attempt at this time to prescribe in detail the most effective chemicals and methods of application or to assess their ultimate value would be premature. Recent literature on this subject includes

reports by Hering (35), Jettmar (51), and numerous contributors to the Journal of Economic Entomology (39, 58, 67, 71, 72, 90, 92, 125, 131).

Properly used, the chlorinated hydrocarbons have a definite place in fly control programs, but their limitations and dangers should be recognized. They are highly toxic to flies and, as a deposit on animals or other landing places for flies, retain their killing power for a few days to several months, depending upon the amount deposited and the conditions of weathering. Such residual deposits are often effective in reducing already low or static fly populations but are of less value when populations are high or increasing.

Most of the chlorinated hydrocarbons, including DDT, are toxic to mammals and accumulative in their action. DDT secreted in the butterfat of milk from dairy animals is particularly hazardous to small children. It has been shown that dangerous amounts may occur in the milk of even unsprayed cows kept in DDT-sprayed barns. Methoxychlor, a close relative of DDT, is much less toxic to mammals and reasonably effective against flies. It is the only material approved by the United States Department of Agriculture for residual application to dairy animals and dairy structures.

Populations of house flies have developed resistance to DDT in many areas and it may be only a question of time until many kinds of flies will tolerate much larger doses than they do now. DDT-resistance carries over to some extent to methoxychlor, and a few cases of specific resistance to other materials such as chlordane have also been observed. But perhaps the most serious limitation is that, as ordinarily applied from spray or aerosol equipment, chemicals have little or no effect on maggots in fly-breeding materials. In fact, reliance on the destruction of adults tends to result in lax general sanitation.

The recently developed synthetic pyrethrins, which are non-toxic to mammals, may largely supplant the chlorinated hydrocarbons in sprays and aerosols where no residual deposit is required, though DDT or methoxychlor will continue to be valuable where long lasting deposits are needed.

In any case, chemical controls of adult flies should be considered primarily as stop-gaps until more basic sanitary measures can take effect.

CONTROL PROBLEMS PECULIAR TO PACIFIC AREA

Certain conditions in the Pacific islands create special problems. The importance of the large blow fly, *Chrysomya megacephala,* makes significant fly control a more difficult problem than in the United States, where blow flies are generally of minor importance. *Chrysomya,* in addition to breeding well in all types of meat and large masses of human excrement, is more resistant to chemical treatment both as a larva and as an adult than is the house fly. To kill it in the open, dosage of sprays must be increased several fold over

the dosage for house flies. Privy pits, too, need greater dosages of sodium arsenite, paradichlorobenzene, DDT, or other chemicals to eliminate *Chrysomya* larvae. Under certain conditions adults of this species, which tend to cluster during hot days on vegetation near water, may be destroyed by applying heavy DDT residual sprays to the favorite clustering places.

The swampy areas on many islands contain decomposing land crabs and provide a reserve of natural fly-breeding materials despite rigid sanitary measures. The large land snails on islands like Saipan and Rota and the giant toads on Guam present a similar situation.

Coconuts bear a certain relationship to fly breeding which may prove significant, and destruction of coconuts over large areas is a difficult problem. Breadfruit offers a similar problem, breeding some flies and attracting many others.

Native populations, usually highly infested with intestinal parasites, make fly populations more dangerous than they are in most temperate regions. In addition, the habits of native populations are usually unsanitary and difficult to change, even when facilities are provided. In some regions, human excrement is extensively used for fertilizer and substitutes are either not available or are too expensive for the inhabitants. Excrement in storage basins should be treated with suitable chemicals, provided by military personnel if necessary. Calcium cyanamid mixed with animal manure at the rate of one-half pound per bushel of manure controls maggots and increases the nitrogen and phosphate value of the manure. A similar treatment might be found sufficient for night soil though even treated night soil is a menace because of its availability to adult flies. (See Lumsden *et al.*, 70.)

In the Pacific, flies breed in all seasons and have short life cycles, hence figures on life cycles of flies in the United States cannot be used for the timing of fly control in tropical areas. Many species can develop from egg to adult in less than 10 days on Guam, whereas the same or related species may take twice that time in temperate regions. Furthermore, some control methods are not as satisfactory in the Pacific as they are elsewhere. This is true of DDT sprayed from airplanes. For several standard spray jobs which were evaluated entomologically on Guam and Okinawa, some control of *Musca* for several days was observed but no practical control of *Chrysomya* was obtained even for a few hours. Since it is obvious that the maggots cannot be killed by this method, applications would have to be made at least once a week over a considerable period of time to effect a general decrease in breeding, even if sprays were made heavy enough to achieve high mortality of adults.

Suggestions for specific control of the various species of flies on Guam are given with the discussion of each species.

Problem Areas

NATIVE VILLAGES

Under normal, peacetime conditions, most species of filth-inhabiting flies are more abundant and find more breeding media in and around native villages than elsewhere. It is probable that many of the species could not persist on the smaller islands without the media provided by man's activities. Owing to the lack of permanent sanitation facilities or the lack of civic responsibility, villages on most islands—whether the inhabitants be of Polynesian, Melanesian, Malayan, or Japanese stock—present numerous year-around fly-breeding problems. Even in more northern islands such as Okinawa, which is inhabited by people of Japanese stock and where general sanitation is somewhat better than elsewhere in the Pacific, use of human excrement in agriculture provides fly visiting and breeding places which are particularly menacing in relation to the dissemination of fecal pathogens. In the Philippines, although human fecal material is not always used agriculturally, little attention is paid to its proper disposal. In rural villages on Samar, trails from house to house were splattered at nearly every step with diarrhetic human stools. In a large town on the same island, there was a constant fecal odor emanating from large fields on the windward side of town where townspeople could always be seen defecating. Guam natives generally use latrines but seldom treat them chemically or keep them fly-tight. In the Solomons, village compounds are kept quite clean but refuse of all sorts, including human feces, are generally dumped just beyond the jungle fringe. In all villages of the central and south Pacific decaying fruit within the compounds breeds several species of flies and attracts swarms of others.

The forms of sanitation most obviously needed in typical villages include the proper screening of dwellings, the permanent construction and regular treatment of latrines, the systematic gathering and burning of fallen fruit and household refuse, and the removal of livestock from village compounds. In coastal villages, latrine pits should be provided with oil drums which, when filled, could be carried to sea and emptied into offshore currents.

There is a fundamental need for the development of a fly and disease consciousness among the natives, who bear the torments of hordes of flies as stoically as cattle and accept dysentery and yaws as inevitable. However, it is encouraging that many native areas have been awakened to the relationship between mosquitoes and disease and to the need for mosquito control.

NATIVE LIVESTOCK AREAS

Small-scale raising of livestock is bound to create fly-breeding problems in Pacific islands. However, proper use of cattle and horse manure should

prevent serious outbreaks of *Musca vicina,* and slaughterhouse sanitation should assist in the control of sarcophagids and calliphorids. If, as we found on Guam, pig pens comprise the principal breeding places for *M. sorbens,* it is probable that its control could be obtained only through the use of concrete flooring for the pens so that the pigs would be able to find and eat the developing maggots in the garbage and pig excreta. Such a program, of course, would be impossible without governmental assistance.

The common native policy of sharing the household with pigs and poultry brings flies into the houses, where accumulated animal feces in corners or under floors provide fly-breeding places. Although the animals in and around houses help with garbage disposal, it would be better sanitary practice for the natives to collect refuse and carry it to well-kept animal pens away from the village compounds.

Control of adult cattle flies on beef animals not being prepared for slaughter and beasts of burden, can probably best be obtained with residual aqueous suspensions of DDT applied directly to the animals. Methoxychlor should be substituted for DDT on dairy animals and animals being prepared for slaughter.

MILITARY CAMPS

During the war, many unsanitary camping areas were left by troops which were on the move during combat or practice maneuvers. A Navy hospital area on Guadalcanal was plagued by flies until it was discovered that they were breeding in the nearby jungle in camps left by marines on maneuvers. It was apparent that burial of feces and garbage had been seldom, if ever, practiced in these camps. Except where headquarters are established for several days or longer, it is generally unnecessary to build latrines and establish garbage dumps; but rules regarding burial of feces and refuse by individuals should be strictly enforced.

Wartime sanitary facilities in temporary military establishments in the Pacific were generally too small, too few, and too temporary in construction. Usually, camps scheduled for a life of one month were occupied for several months, toward the end of which latrines and garbage pits overflowed, sewage and drainage lines caved in, screens deteriorated, and orders for sanitary chemicals were not renewed. Garbage from one camp was dumped in proximity to others or to native villages; and camps were seen where drains led to open sumps at the edge of the camp clearing.

Where temporary camps are close to fly-infested native quarters, it may be necessary to institute large-scale chemical control of adult flies until conditions in the village can be improved. The same sort of control would probably be warranted during combat where rear-area headquarters or construction

camps are established in areas swarming with flies developing in unburied corpses. However, fly populations in temporary camps can be effectively controlled by the installation of adequate sanitary facilities, chemical treatment of latrines and other fly-breeding areas, and enforcement of a few simple rules of sanitary conduct.

Usually permanent military installations are well enough constructed and policed to prevent extensive fly-breeding. However, control should be extended to include native villages, livestock farms, and other breeding areas within the flight range of the flies. Close watch should also be kept for fly breeding in sewage treatment plants, garbage dumps, and slaughterhouses, even those several miles from camp.

JUNGLE, BEACH, AND ROADSIDE BREEDING

In swampy areas, dead land crabs may furnish a food "reservoir" for many species of flies, as do dead toads and other animals along roadsides, and dead land snails, where the latter are very large and numerous, as they are on Rota. Control of flies in such situations, except in the immediate surroundings of the area needing protection, is probably impractical. Natives and their livestock, having no inhibitions about defecating during their travels, contribute further to fly breeding along roadsides. Here again, control, away from inhabited areas, is probably impractical.

Beaches may receive large deposits of plant and animal drift which rot and provide extensive beds of breeding media. The cleaning of beaches is a relatively simple matter and should be maintained for at least a mile on either side of towns and camps. Particular attention should be paid to beaches after storms and exceptionally high tides.

TAXONOMY

KEYS TO FILTH-INHABITING FLIES OF GUAM

ADULTS

1. Wingless (Phoridae, part) 2
   Winged 5
2. Head strongly flattened dorsoventrally and with front produced beyond antennae; dorsum of thorax without strong bristles; eye smaller than antenna (*Chonocephalus*) 3
   Head neither flattened nor conspicuously produced; dorsum of thorax with several pairs of strong bristles; eye larger than third antennal segment (*Puliciphora*) 4
3. Abdomen, viewed from the side, with tergites uniformly haired and without distinct apical fringes; venter of abdomen light brown, almost as dark as dorsum ..... **Chonocephalus hirsutus**

Abdomen with very fine sparse hairs except for apical fringes of tergites; blackish dorsum of abdomen contrasting strongly with creamy white venter..... **Chonocephalus subglaber**

4. Frons, mesonotum and first 5 abdominal tergites uniformly blackish; thoracic pleuron strongly marked with dark gray along most sutures; hind tibia without noticeable fringe of bristles or stiff hairs; fifth abdominal segment not uniformly ringed with several rows of hairs or short bristles..... **Puliciphora nigriventris**

Most of frons and much of mesonotum and abdominal tergites testaceous to brown, not strongly different from thoracic pleural color; fifth and sixth abdominal segments uniformly ringed with short bristles or hairs; hind tibia with distinct posterior fringe of strong hairs or bristles..... **Puliciphora wymani**

5. Antenna composed of more than 5 distinct segments; antennal bristle (arista) absent 6

Antenna composed of not more than 3 segments; the third usually aristate..... 13

6. Wing acute apically, symmetrical, rather densely clothed with long hairs or scales; body, legs and antenna very hairy (Psychodidae)..... 7

Wing not acute apically, not heavily clothed with long hairs or scales; body, legs and antenna not clothed with long hairs..... 10

7. Body pale; hairs largely white..... 8

Body dark; hairs and scales on wing largely brown or blackish..... 9

8. Wing entirely white, densely clothed with hairs..... **Psychoda** sp. **a**

Hairs on wing sparse; distal ends of veins blackish, more conspicuous on alternate veins of posterior wing margin..... **Psychoda alternata**

9. Wing densely covered with black scales; body hairs largely dark..... **Brunettia** sp.

Wing veins with long suberect brownish hairs, mixed with a few scattered tufts of white hairs; body hairs largely pale brown to white..... **Telmatoscopus albipunctatus**

10. Antenna with loosely jointed segments, generally longer than head and thorax combined, or at least as long as thorax..... 11

Antenna with segments transverse and closely jointed, somewhat clavate and shorter than thorax; strong wing veins concentrated near anterior margin; no cross veins behind radius..... **Psectrosciara brevicornis**

11. Hind leg distinctly longer than body; dorsum of thorax and abdomen not conspicuously marked with black; ocelli present..... 12

Hind leg shorter than body; dorsum of abdomen largely black and dorsum of thorax conspicuously striped with black; ocelli absent..... **Dasyhelea** sp.

12. Antenna with 23 segments; wing finely clothed with minute hairs; 2 conspicuous longitudinal veins in anterior portion of wing..... ITONIDIDAE, gen. sp.

Antenna with 15 segments; wing not clothed with distinct hairs except on margin; 3 equally conspicuous longitudinal veins in anterior basal portion of wing..... **Lycoria** spp.

13. Wing with first M_2 (discal cell) less than twice as long as wide and with the branches of the medius ending before the wing margin (Stratiomyidae)..... 14

First M_2, if present, over twice as long as wide, or with branches of medius reaching wing margin..... 15

14. Small species, less than 6 mm. long; metallic green in female and green with testaceous abdomen in male..... **Microchrysa flaviventris**

Large species, over 12 mm. long; black, with a pair of large clear spots on second abdominal tergite..... **Hermetia illucens**

15. Eyes contiguous or nearly so below the antennae (Empididae)..... 16

Eyes widely separated below antennae..... 17

16. Body and antenna black, legs testaceous..... **Drapetis** sp. (near **setigera**)

Thoracic pleuron, antenna, pronotum, prescutum, legs, and base and apex of abdomen testaceous..... **Drapetis** sp.

17. Wing venation concentrated near anterior margin of wing except for 4 long, weak, unbranched veins; antenna apparently composed of one subspherical segment and a long arista (Phoridae) 18
Wing with at least one cross-vein in posterior two-thirds; anterior veins not strikingly stronger than ones of middle region; antenna generally with 3 distinct segments 28
18. Frons covered with long, strong bristles and not produced forward between antennal bases 20
Frons with at most 2 or 3 pairs of strong bristles and produced forward between antennal bases (*Chonocephalus*) 19
19. Frons broadly impressed medially, from above appearing like a pair of ridges between antennal bases, and with anterior border near eyes having a series of 3 or 4 moderate bristles; mesopleuron with several setae....**Chonocephalus subglaber**
Frons narrowly impressed along midline and with bristles along anterior border scattered and weak; mesopleuron with a single seta.....**Chonocephalus hirsutus**
20. Radius unbranched 21
Radius branched near apex 23
21. Clypeus strongly produced forward at oral margin; hind tibia with a spine on outer surface toward the base; midtibia with a pair of bristles toward base ..... **Parafannia molluscovora**
Clypeus not produced at oral margin; tibiae without basal or subbasal bristles (*Puliciphora*) 22
22. Propleuron with about 5 small setae in addition to the dorsal bristle; genitalia with long anteroventral extension.....**Puliciphora wymani**
Propleuron with dorsal bristle only; genitalia without conspicuous anteroventral extension .....**Puliciphora nigriventris**
23. Preantennal bristles (on anteromedian margin of frons) directed backward; midtibia with a pair of subbasal bristles.....**Diploneura cornuta**
Preantennal bristles directed forward; midtibia without bristles before middle (*Megaselia*) 24
24. Abdomen with extensive yellow areas anteromedially on most tergites..... 25
Abdomen black or dark brown above..... 26
25. Fourth and fifth abdominal tergites entirely pale; frons with inner preapical bristles much shorter than outer ones.....**Megaselia suis**
Fourth and fifth abdominal tergites partially dark; frons with inner preapical bristles nearly as long as outer ones.....**Megaselia scalaris**
26. Posterodorsal corner of mesopleuron with a patch of small setae..... 27
Posterodorsal corner of mesopleuron without setae; basal half of ventral margin of hind femur with 4 or 5 long hairs.....**Megaselia setifemur**
27. Posteroventral corner of mesopleuron with a small bristle in addition to setae; costal margin of wing with about 11 bristles, which are longer than distance between costa and radius.....**Megaselia parabasiseta**
Posteroventral corner of mesopleuron with uniform setae only; costal margin with about 15 short bristles.....**Megaselia stuntzi**
28. Wing vein R_{4+5} (third longitudinal) deeply arcuate before apex; large orange fly with 4 longitudinal black stripes on dorsum of thorax and with dark bands on abdomen; face without strong bristles.....**Tubifera arvora**
Wing vein R_{4+5} nearly straight; if large and conspicuously banded or striped, face with strong bristles..... 29
29. Mesonotum with a complete transverse suture across anterior third; with 2 subcircular membranous lobes (squamae, calypteres) arising from wing base, the lower lobe about one-third the area of one compound eye; second antennal segment with a longitudinal seam or groove dorsolaterally (Muscoidea)..... 75

Mesonotum with transverse suture absent or incomplete; squamae small or vestigial, lower lobe much less than one-third the area of one compound eye, not at all circular; second antennal segment without a longitudinal dorsolateral seam or groove (Acalypterata) 30

30. Hind leg with first tarsal segment much shorter and broader than second; arista more than 5 times as long as third antennal segment; minute, bristly fly (Cypselidae) (**Leptocera**[2]) 31

Hind leg with first tarsal segment similar to, and sometimes longer than, second; arista generally less than 5 times as long as third antennal segment 34

31. Wing vein R_{4+5} strongly curved, long overpassed by costa 32
Wing vein R_{4+5} straight, not overpassed by costa 33

32. Second sector of costa thickened, costa somewhat bristly; head without a row of bristles between orbitals and interfrontals, large species with obviously bristly midtibia ..... **Leptocera collinella**

Second sector of costa not thickened, costa not bristly; head with a row of small bristles between orbitals and interfrontals; small species with midtibial bristles inconspicuous ..... **Leptocera atoma**

33. Wings clear; third antennal segment rounded; hind femur of male with a row of 6 to 8 short bristles posteroventrally ..... **Leptocera femorina**

Wings with pattern; third antennal segment conical; hind femur of male without this row of bristles ..... **Leptocera conica**

34. Vertex of head with a large, shining, clearly defined triangular area, its apex extending nearly to antennal insertions; cubital vein with a slight bend, jog, or offset thickening about midway from its base to the posterior cross-vein; antenna nearly circular (Chloropidae) 34

Vertex nearly always without a large clearly defined triangular extension of the ocellar area; cubital vein straight or gently curved throughout 37

35. Body shiny black, triangle of vertex blue-black; tarsi largely white ..... **Rhodesiella boharti**

Body testaceous or brownish; triangle of vertex and tarsi not contrastingly colored 36

36. Hind tibia with apical spur over one-half as long as first tarsal segment; dorsum of thorax with a pair of sublateral black or dark brown stripes ..... **Cadrema pallida bilineata**

Hind tibia with apical spur not more than one-third as long as first tarsal segment; dorsum with poorly defined median, as well as sublateral, dark areas ..... **Lasiopleura virilis**

37. Arista strongly pectinate, or the clypeus with a callosity at the middle 38
Arista bare or pubescent; clypeus without callosities near the middle 57

38. Thorax black, sometimes closely covered with gray or dark greenish pruinosity; postocellar bristles divergent (Ephydridae) 39

Thorax testaceous, sometimes with longitudinal brown stripes on notum; postocellar bristles convergent or absent (Drosophilidae) 48

39. Arista bare or feebly pubescent 46
Arista pectinate 42

40. Body shiny black, without pruinosity; face below antennae strongly rugose; wing milky white ..... **Chlorichaeta tuberculosa**

Body covered with gray pruinosity; wing not milky white; face below antennae not rugose 41

[2] The key separating the species of this genus is based upon correspondence from O. W. Richards, who described the Guam species in 1946 (106).

41. Face below antennae with a broad median non-pruinose ridge or callosity; antennae fitted closely into facial grooves ..... **Placopsidella cyanocephala**
Face below antennae without bare ridge or callosity; antennae not fitting into facial grooves ..... **Parydra** sp.

42. Wing with pattern 43
Wing without pattern 44

43. Face below antennae shiny metallic green and rugose; thorax strongly mottled with silvery gray and black ..... **Discomyza maculipennis**
Face below antennae smooth, pruinose; thorax without mottling; wing mostly dark, with milky spots arranged in transverse bands ..... **Actocetor solitarius**

44. Face below antennae with a round bare callosity at the middle; body uniformly pale gray pruinose ..... **Hecamede persimilis**
Face below antennae without a round, bare callosity at the middle 45

45. Arista with about 5 pectinae 46
Arista with at least 9 pectinae 47

46. Fore femur strongly swollen; fore tibia arcuate, with a long ventral extension at apex; large species, at least 4 mm. long ..... **Octhera canescens**
Fore legs normal; small species, not more than 2 mm. long ..... **Allotrichoma** sp.

47. Coxae and femora largely pale testaceous; face below antennae with a strong median ridge ..... **Brachydeutera longipes**
Coxae and femora black; face below antennae without a median ridge ..... **Paralimna aequalis**

48. Dorsum of thorax with 4 longitudinal dark stripes; mesonotum with 4 pairs of strong bristles ..... **Chaetodrosophilella quadrilineata**
Dorsum of thorax without longitudinal stripes 49

49. Wing entirely clear; body pale testaceous except for broad grayish median area on scutum and dark gray occiput and ocellar area; mesoscutum with one pair of long bristles ..... **Mycodrosophila** sp.
Wing pale yellowish or faintly smoky; veins dark testaceous or brown; body testaceous to reddish; mesoscutum with 2 pairs of long bristles; anterior pair one-third to one-half as long as posterior pair 50

50. Abdomen jet black; scutellum and posteromedian portion of mesonotum dark gray; occiput black with pale outer rim; anterior mesonotal bristle not more than one-third as long as posterior ..... **Leucophenga nigriventris?**
Abdomen pale, at least basally on first 4 segments; scutellum not darker than scutum; anterior mesonotal bristles one-half as long as posterior 51

51. Antennal arista with about 5 dorsal and 3 ventral branches (*Drosophila*) 52
Antennal arista with about 7 dorsal and 4 ventral branches; mesonotum with 2 pairs of strong, equal bristles ..... **Microdrosophila congesta**

52. Mesonotum with 2 pairs of strong bristles 53
Mesonotum with 3 pairs of strong bristles; anterior and posterior scutellar bristles approximately equal ..... **Drosophila polychaeta**

53. Anterior pair of scutellar bristles only one-half as long as posterior pair; abdomen mostly or entirely black 54
Anterior pair of scutellar bristles at least two-thirds as long as posterior pair 55

54. Mesothorax pale testaceous, no darker at sides ..... **Drosophila** sp. **a**
Mesothorax reddish ochraceous, darker at sides ..... **Drosophila** sp. **b**

55. Anterior pair of scutellar bristles subequal to posterior pair 56
Anterior pair of scutellar bristles two-thirds as long as posterior pair; anterior mesonotal bristles about three-fourths as long as posterior ones; micro-bristles of mesonotum rather strong ..... **Drosophila takahashii**

56. Abdomen narrowly and distinctly banded with dark; anterior sternopleural bristle one-half as long as posterior one ..... **Drosophila melanogaster**

Abdomen broadly or indistinctly banded with dark; anterior sternopleural bristle three-fourths as long as posterior one ..... **Drosophila ananassae**

57. Body long, slender; legs long, stilt-like; head globular; wing nearly 4 times as long as broad ..... **Mimegralla galbula**
Body, legs and wing of ordinary length 58

58. Wing with at least one dark cloud, or head with sides of vertex metallic blue green .. 59
Wing uniformly colorless, gray, or yellowish; head without metallic colors 68

59. Head, viewed from side, as long as deep; second and third antennal segments together forming a circular disk (Clusiidae) ..... **Sobarocephala** sp.
Head, viewed from side, much deeper than long; third antennal segment distinctly longer than wide 60

60. Third antennal segment over three times as long as broad, reaching or nearly reaching oral margin ..... **Dacus cucurbitae**
Third antennal segment not over twice as long as broad, not reaching nearly to oral margin (Otitidae) 61

61. Arista pubescent or with short pectinae above and below 62
Arista bare 64

62. Face with oral margin twice as wide as frons; arista pubescent ..... **Pogonortalis fulvofemoralis**
Face with oral margin only a little wider than frons; arista with about 10 pectinae above and 15 below (*Scholastes*) 63

63. Scutum and scutellum, except for sharply defined creamy borders, black ..... **Scholastes hirtiventris**
Scutum and scutellum testaceous to dark brown; scutellum without sharply defined creamy border ..... **Scholastes aitapensis**

64. Wing entirely clear; body brilliant blue green to coppery ..... **Chrysomyza aenea**
Wing with some pattern; body not brilliantly metallic 65

65. Wing with numerous small dark spots in the cells; mesonotum with black spots on a silver background medially and with black stripes on a silver background laterally ..... **Notogramma stigma**
Wing with a few large markings, each occupying parts of 2 or more cells; thorax without distinctive pattern 66

66. Fore femur yellow; frons transversely rugose ..... **Acrosticta apicalis**
Fore femur black; frons not rugose 67

67. Costal portion of wing with dark area at the middle extending posteriorly to near the center of the wing ..... **Pseudeuxesta prima**
Costal portion of wing with dark area at the middle confined to the costal area ..... **Neoeuxesta** sp.

68. Wing with cell R_5 (apical cell) narrowed at apex where it is less than two-thirds as broad as at broadest point; female without long ovipositor; costa broken just basad to union with subcosta (Milichiidae) 69
Wing with cell R_5 only slightly narrower at apex than at broadest point; female with long ovipositor; costa without distinct break near union with subcosta 73

69. Body covered with light gray pruinosity ..... **Milichia orientalis**
Body slate-colored or black 70

70. Face perpendicular, receding below antennae; antennal insertion about midway from vertex to epistoma; arista bare 71
Face oblique, projecting below antennae; antennal insertion much closer to epistoma than to vertex; arista pubescent 72

71. Tarsi and halteres reddish; both sexes shiny black ..... **Milichiella lacteipennis**
Tarsi black, halteres pale; abdomen of male silvery white ..... **Milichiella lacteiventris**

72. Proboscis and palpi brown, the latter distinctly broader than antennae ..... **Desmometopa palpalis**

Proboscis and palpi black, the latter about as broad as antennae..... **Desmometopa tarsalis**

73. Arista pubescent; body jet black..... **Lonchaea filifera**
Arista bare; body with bluish reflections, or thoracic pleuron and anterior portion of frons brownish..... 74

74. Fore femur and frons black or dark blue..... **Lonchaea** sp.
Fore femur testaceous; frons brown anteriorly..... **Piophila casei**

75. Apical wing cell R_5 scarcely narrower at apex than at widest point (Anthomyidae) 76
Apical wing cell not more than one-half as broad apically as at widest point, sometimes closed or nearly so basad to wing margin..... 84

76. Arista broadly plumose..... 77
Arista bare or with very short hairs..... 80

77. Wing yellowish basally and anteriorly; either thorax or abdomen and scutellum entirely reddish; rather large, robust species, over 5 mm. long (*Dichaetomyia*) 78
Wing clear or slightly yellowish along veins; thorax and abdomen largely gray or black; rather slender flies, less than 5 mm. long..... 79

78. Mesonotum dark pitchy brown; abdomen reddish orange; femora pitchy black ..... **Dichaetomyia nigroscuta**
Thorax entirely reddish orange; abdomen pitchy except basally and apically; femora orange..... **Dichaetomyia saperoi**

79. Arista plumose on basal three-fifths only; frons with pruinose gray triangle extending only slightly beyond anterior ocellus..... **Pygophora lobata**
Arista plumose to apex; frons with pruinose gray triangle extending anteriorly to frontal lunule..... ANTHOMYIDAE, **gen. sp.**

80. Legs largely yellowish; abdomen or thorax mostly yellowish or reddish or pale gray pruinose..... **(Atherigona)** 81
Legs and body black, sometimes with restricted areas of silvery pruinosity..... 82

81. Thorax reddish brown, without distinct grayish pruinosity; antenna and palpus reddish testaceous..... **Atherigona longipalpus**
Thorax pale gray pruinose; antennae and palpi dark brown to nearly black ..... **Atherigona orientalis**

82. Anterior third of mesonotum conspicuously marked with silvery gray pruinosity; arista with distinct short hairs nearly to apex..... **Limnophora plumiseta**
Mesonotum without grayish pruinosity, except sometimes on anterolateral corners; arista appearing bare except under high magnification..... 83

83. Thorax with pleuron and anterolateral corners of mesonotum grayish pruinose; male with grayish pruinosity basally on abdominal segments; small flies, not more than 5 mm. long..... **Fannia pusio**
Entire body in both sexes shiny jet black; moderately large flies, at least 6 mm. long..... **Ophyra chalcogaster**

84. Wing with vein M_{1+2} (fourth longitudinal) only gently curved upward toward apex; cell R_5 (apical cell) at least one-third as broad at apex as at broadest point and meeting margin at or slightly posterior to wing tip (Stomoxidinae).. 85
M_{1+2} strongly upcurved apically; cell R_5 less than one-fourth as broad at apex as at broadest point and meeting margin distinctly anterior to wing tip..... 87

85. Palpus parallel-sided and less than one-half as long as proboscis..... **Stomoxys calcitrans**
Palpus dilated apically and at least three-fourths as long as proboscis..... 86

86. Arista haired on upper side only; slender species..... **Haematobia exigua**
Arista haired above and below; robust species..... **Siphona carabao**

87. Wing cell R_5 (apical cell) with posterior margin straight or convex beyond its posterior angle 88
Wing cell R_5 concave beyond its posterior angle..... 90

88. Arista with short hairs above and below; mesonotum gray with 4 black stripes; abdomen gray and black pruinose, with orange apex.....**Synthesiomyia nudiseta**
Arista with long hairs on upper side; mesonotum without stripes; abdomen pale, at least basally (Rhiniinae)..... 89

89. Wing entirely clear; abdomen orange; cell R_5 closed before apex.....**Rhinia testacea**
Wing with a smoky spot before apex; abdomen black, with first or first to third segments largely testaceous; cell R_5 not closed before apex.....**Stomorhina quadrinotata**

90. Body metallic green, blue, or bronze..... 91
Body largely gray and black..... 94

91. Wing with radial vein (first longitudinal) bare basally; head, seen in profile, strongly convex above antennal insertions.....**Lucilia (Phaenicia) cuprina**
Upper surface of wing with radial vein setose basally on posterior side..... 92

92. Antenna and cheek testaceous to reddish brown; gray pruinosity of cheek not obscuring ground color when viewed from any angle.....**Chrysomya megacephala**
Antenna dark brown to black; cheek black or nearly black ventrally and silvery pruinose dorsally from certain angles..... 93

93. Cheek and antennal groove reddish brown when viewed from in front; first 2 antennal segments reddish brown.....**Chrysomya rufifacies**
Antennal groove and most of cheek black when viewed from in front; first 2 antennal segments black.....**Chrysomya "nigripes"**

94. Metanotum large and convex in profile; posterior portion of abdomen with many long stout bristles; arista bare (not filth-inhabiting).....3 species of TACHINIDAE
Metanotum small and concave in profile; abdomen less strongly bristled; arista plumose..... 95

95. Hypopleuron without long bristles, sometimes with hairs; hind tibia with the longest bristles in central portion scarcely longer than tibial diameter; base of R_{4+5} (third longitudinal vein) bare (*Musca*)..... 96
Hypopleuron with 2 to 4 long bristles; posterior tibia with the longest bristles in central portion at least twice as long as tibial diameter; base of R_{4+5} setose (*Sarcophaga*)..... 97

96. Mesonotum with the 2 black stripes on each side fused (except anteriorly in female); abdomen of female with black ground color.....**Musca sorbens**
Mesonotum with two separate black stripes on each side in both sexes; abdomen with sides partly orange in both sexes.....**Musca vicina**

97. Base of radial vein (first longitudinal) bare..... 98
Base of radial vein setose.....**Sarcophaga gressitti**

98. Palpus, antenna, and genital segments black or brown..... 99
Palpus, antenna, and genital segments reddish orange.....**Sarcophaga ruficornis**

99. Squamae white or slightly yellowish.....100
Squamae bright yellow to orange.....**Sarcophaga stricklandi**

100. Propleuron pilose in center.....101
Propleuron bare.....102

101. Male with posterior claspers of genitalia bilobed apically (Guam).....**Sarcophaga "peregrina"**
Male with posterior claspers of genitalia truncate apically (Saipan).....**Sarcophaga "peregrina"**

102. Second abdominal tergite of male with a strong lateral pair, and a weak inner median pair, of bristles; female with first hypopygial tergite not cleft medially and with marginal bristles only at sides.....**Sarcophaga knabi**
Second abdominal tergite of male with 2 pairs of lateral bristles, without a distinct median pair; female with first hypopygial tergite cleft medially, the marginal bristles extending almost to midline.....**Sarcophaga dux**

Eggs

1. Surface apparently without reticulation, processes, protuberances, ridges, punctures or grooves; less than three times as long as broad ..... **Psychoda** sp. a
   Surface distinctly reticulate, grooved, ridged, knobbed, or flagellate; if smooth, more than three times as long as broad 2
2. Dorsal surface of egg with a groove or long flattened strip broadened anteriorly and bounded by a low ridge or prominent flange 23
   Dorsal surface of egg without a long groove bounded by a ridge, sometimes with a flattened surface bounded by scale-like protuberances 3
3. Anterior end of egg with 2 to 6 long filaments 4
   Egg without filaments, or with only one 7
4. Six filaments present ..... **Drosophila** sp. a
   Two or 4 filaments present 5
5. Two filaments present ..... **Drosophila ananassae**
   Four filaments present 6
6. Distal filaments less than one-half, proximal pair less than, length of egg ..... **Chaetodrosophilella quadrilineata**
   Distal filaments more than one-half, proximal filaments longer than, length of egg ..... **Drosophila takahashii**
7. Short, oval egg with surface appearing minutely granular and with a single recurved filament at one end; length less than 0.3 mm ..... **Chonocephalus subglaber**
   Filament lacking; surface smooth, punctured, reticulate, or with protuberances, but not appearing granular 8
8. Surface with sculpturing of slightly raised stellate bodies ..... **Tubifera arvora**
   Surface without sculpturing of stellate pattern 9
9. Surface of at least one side covered with knobs, short ridges, or scale-like projections 10
   Surface smooth, reticulate, or punctured but not with numerous projections or ridges 13
10. One side slightly flattened, covered with scale-like projections, and bordered with a row of scales; remainder of egg reticulate; length 0.8 mm ..... **Megaselia scalaris**
    Surface without a margin of scale-like structures 11
11. Surface covered with knobs or short ridges 12
    Surface covered with small punctures ..... **Diploneura cornuta**
12. Surface covered with small round or short oval knobs; length 0.4 mm ..... **Parafannia molluscovora**
    Surface covered with parallel longitudinal ridges, broken at intervals; length 0.35 mm ..... **Puliciphora nigriventris**
13. Egg less than four times as long as broad 14
    Egg more than four times as long as broad, generally more than five times 17
14. Ovate, gradually tapering from broad end ..... **Hermetia illucens**
    Oval in general outline, sometimes more pointed at one end; broadest near middle 15
15. Upper and lateral surfaces coarsely reticulate; lower surface pocked with white, oval depressions; length 0.7 mm ..... **Discomyza maculipennis**
    Upper surface rather finely reticulate; lower surface without white depressed areas 16
16. Egg ovate, bluntly rounded posteriorly, lacking an anterior groove ..... **Leucophenga nigriventris**
    Egg subarcuate-elliptical, acute at each end, grooved in anterior fifth ..... **Lonchaea** spp.[3]
17. Surface distinctly reticulate, the reticulae mostly elongated longitudinally and appearing more 4- than 6-sided; length 0.7 mm ..... **Mimegralla galbula**
    Surface smooth, the reticulae visible only on the strongest highlight 18

[3] Eggs of Guam species not studied.

18. Egg with a darkened translucent line at one end appearing like a slit in the chorion.. 19
Egg without such a slit 20
19. Egg about four times as long as broad and about equal in size at both ends but one end with a small nipple; length 0.7 mm. ..... **Notogramma stigma**
Egg five or more times as long as broad; one end more strongly tapered than the other, with a broad nipple; length 0.9 mm. ..... **Chrysomyza aenea**
20. Not curved like a banana, at most flattened on one side; not more than five times as long as broad 21
Gently curved like a banana; at least six times as long as broad 22
21. Nearly cylindrical, with a distinct nipple at one tip which is translucent ..... **Pseudeuxesta prima**
Slightly flattened on one side, distinctly tapered from the middle, with indistinct nipple ..... **Dacus cucurbitae**
22. Nipple not clearly differentiated; length 0.87 mm. ..... **Scholastes aitapensis**
Nipple more clearly differentiated ..... **Scholastes hirtiventris**
23. Dorsal surface broadly flattened, bordered along both sides, but not at ends, by strong flanges 24
Dorsal side without strong flanges although dorsal groove may be more or less completely encircled by a ridge 27
24. Flanges equally developed at both ends; dorsal surface with not more than 8 hexagons in a transverse line ..... **Fannia pusio**
Flanges developed much more strongly at anterior end; dorsal surface not so coarsely reticulate as above 25
25. Flanges developed into tail-like processes at anterior end which latter is produced as a flat lobe between the "tails" ..... **Limnophora plumiseta**
Flanges and anterior end of egg not produced into tail-like processes 26
26. Ventral surface appearing granular, not definitely reticulate; egg not strongly flattened at anterior end; length 0.9 mm. ..... **Atherigona longipalpus**
Ventral surface coarsely reticulate; egg with anterior end more depressed; length 0.8 mm. ..... **Atherigona orientalis**
27. Surface with several long longitudinal wrinkles; length 1.3 mm. ..... **Rhinia testacea**
Surface without definite wrinkles 28
28. Eggs brown or tawny 29
Eggs white or pale creamy 30
29. Dorsal groove narrower than one-fifth diameter of egg, its anterior end about three times as wide as remainder; color dull chocolate brown; length 0.9 mm. ..... **Siphona carabao**
Dorsal groove wider than one-fourth diameter of egg, its anterior end not more than twice as wide as remainder; color testaceous to dull ochraceous; length 0.8 mm. ..... **Haematobia exigua**
30. Egg flat dorsally, with narrow median groove and smooth flat pieces on either side developed into weak flanges at anterior end, which is strongly flattened; length 2.0 mm. ..... **Dichaetomyia saperoi**
Median groove, if narrow, not flanked by broad smooth flat areas; egg not strongly depressed at anterior end 31
31. Width of dorsal groove plus flanking ridge one-third or more as great as width of egg 32
Dorsal groove and ridge much less than one-third as wide as egg 34
32. Dorsal groove and its surrounding ridge emarginate at its broad end; length 0.95 mm. ..... **Chrysomya "nigripes"**
Dorsal groove not emarginate at either end 33
33. Surface of egg, except for dorsal groove, with almost indefinable reticulation; surface of groove not concave; length 1.3 mm. ..... **Musca vicina**
Surface of egg as distinctly reticulate as the dorsal groove; groove concave; length 1 mm. ..... **Stomoxys calcitrans**

34. Narrow end of dorsal groove extending to posterior end of egg; reticulation fine, but distinct; length 1.4 mm.....**Musca sorbens**
Narrow end of dorsal groove terminating before posterior end of egg; surface either with reticulation coarse (not more than 10 visible in a transverse row) or almost imperceptible..... 35
35. Dorsal groove gradually tapered throughout its length, not more than twice as broad at anterior end as at middle; reticulation rather coarse and distinct; length 1.1 mm.....**Lucilia cuprina**
Dorsal groove extremely narrow and not tapered except at anterior end; reticulation almost imperceptible..... 36
36. Dorsal groove emarginate at anterior end; emargination scarcely visible in ventral view 37
Dorsal groove rounded at anterior end, its bordering ridge at extreme end of egg and prominent in dorsal view; length 1.3 mm.....**Ophyra chalcogaster**
37. Anterior enlargement of dorsal groove somewhat triangular, not suddenly broadened; length 1.4 mm.....**Chrysomya megacephala**
Anterior enlargement of dorsal groove crescentic, suddenly broadened; length 1 mm.....**Chrysomya rufifacies**

LARVAE

1. Head capsule external; mandibles or other mouthparts visible..... 2
Head retracted and degenerate; buccal area provided with a pair of hooks which may be protruding; anterior end small..... 9
2. Head capsule minute, pale, translucent; body pink in life; caudal end provided with a pair of small downward curving thornlike processes, and without other appendages; larvae spring several inches when disturbed.....CECIDOMYIDAE, gen. sp.
Head capsule distinct, well sclerotized; caudal end without small downward curving thornlike processes..... 3
3. Body almost unpigmented behind head; caudal segments completely unpigmented, lacking appendages.....**Lycoria** spp.
Body distinctly pigmented behind head; caudal segments pigmented..... 4
4. Body with a conspicuous row of bristles across each segment..... 5
Body without a conspicuous row of bristles across each segment..... 6
5. Larva more than 20 mm. long; several bristles on each side of each body segment .....**Hermetia illucens**
Larva less than 12 mm. long; a single clubshaped bristle on each side of each segment .....**Microchrysa flaviventris**
6. Caudal end of body with a pair of cylindrical air tubes.....**Psectrosciara brevicornis**
Caudal end of body with a single large median air tube..... 7
7. Lateral margins of anterior 5 abdominal segments with not more than one conspicuous hair posteriorly and one minute hair anteriorly (*Psychoda*)..... 8
Lateral margins of anterior 5 abdominal segments with 2 or 3 hairs posteriorly and one anteriorly, all sub-equal in size.....**Telmatoscopus albipunctatus**
8. Thoracic and abdominal tergites all with conspicuous median plates.....**Psychoda** sp. **a**
Thoracic and anterior abdominal tergites lacking median plates.....**Psychoda alternata**
9. At least 4 posterior body segments with prominent, branching lateral processes, at least one-fourth as long as body width (the branches may be closely appressed, giving the processes the appearance of thick horns)..... 10
Larvae smooth or with transverse rows of simple tubercles not particularly longer laterally than elsewhere and generally inconspicuous..... 13
10. Posterior spiracles on a pair of widely separate stalks which are distally trilobed .....**Fannia pusio**
Posterior spiracles situated on a common but bilobed protuberance..... 11

11. Lateral projections usually with a single sub-basal branch and beset with rings of black, thornlike spines; posterior spiracles on a long dorsally directed process ..... **Discomyza maculipennis**

Lateral projections without single basal branch, generally with numerous branches, at least posteriorly; posterior spiracles on a prominence as broad as long 12

12. All abdominal segments with long, widely branched lateral processes; anterior body segment not heavily sclerotized ..... **Parafannia molluscovora**

Lateral processes short, prominent posteriorly but not conspicuously divided, the divisions closely appressed and short; anteriormost body tergite with a conspicuous dark plate ..... **Diploneura cornuta**

13. Posterior spiracles situated on a common protuberance or on a pair of stalks which are fused or in contact 14

Posterior spiracles not situated on a common protuberance nor on a pair of fused or touching stalks, sometimes on short conical processes which touch basally but diverge widely 18

14. Caudal protuberance, when extended, fully as long as body; length more than 10 mm. excluding protuberance ..... **Tubifera arvora**

Caudal protuberance when fully extended much shorter than body 15

15. Spiracles situated on a cylindrical sclerotic tube which is more than twice as long as broad; length less than 3 mm ..... **Chonocephalus subglaber**

Spiracles situated on a pair of stalks which are fused or in contact 16

16. Terminal process including spiracular stalks, nearly one-third as long as body; spiracular stalks completely fused ..... **Drosophila** sp. **a**

Terminal processes about one-tenth as long as body 17

17. Caudal end of body with 3 tubercles on each side near base of spiracular process, the upper 2 subequal and situated on a common base ..... **Drosophila ananassae**

Caudal end of body with uppermost tubercle remote from, and much smaller than, middle one ..... **Chaetodrosophilella quadrilineata**

18. Caudal end of body with one or two pairs of upcurved projections, otherwise atuberculate 19

Caudal end of body without upcurved projections, sometimes encircled by tubercles.. 21

19. Caudal end of body with 2 pairs of upcurved projections, the more dorsal pair minute and not closely associated with the spiracles ..... **Piophila casei**

Caudal end of body with a single pair of upcurved thornlike projections 20

20. Basal plate of caudal process much larger than acute apical portion ..... **Mimegralla galbula**

Basal plate of caudal process shorter than acute apical portion, and forming a basal tooth of it ..... **Sobarocephala** sp.

21. Posterior spiracular plate with fingerlike processes or acute projections 22

Posterior spiracular plate lacking fingerlike processes or acute projections, generally flat 25

22. Posterior spiracles on basally approximate and distally divergent stalks which are more than twice as long as broad; anterior spiracles fringed with fingerlike processes which are more than three times as long as broad ..... **Desmometopa tarsalis**

Posterior spiracles not on stalks which are basally approximate and distally divergent; anterior spiracles with short processes 23

23. Posterior spiracular plate with a fringe of slender fingerlike processes; a pair of long tapering processes at anterior end of body, at least in mature specimens ..... **Leptocera femorina**

Posterior spiracular plate with one or more toothlike dorsal or external processes 24

24. Posterior spiracular plate with a single acute process on dorsal margin ..... **Mimegralla galbula**

Posterior spiracular plate with several toothlike projections on upper and outer sides; caudal segment vertically truncate with ventral callosity at lower angle of truncation ..... **Milichiella lacteipennis**

25. Ventral surface of body with a pair of transverse pigmented plates just before caudal end, which bears 4 pairs of stout fleshy tubercles arranged around spiracles, which are situated on pigmented, outwardly curved, prominent processes with rounded apices ..... **Allotrichoma** sp.

Ventral surface of body lacking a pair of precaudal plates; caudal end not with 6 stout fleshy tubercles and curved, round-tipped spiracular stalks 26

26. Mouth hooks bearing a row of fine teeth on lower edge; dorsal and ventral cephalopharyngeal processes forming a broad U; spiracles projecting, as long as broad, and with 2 U-shaped slits 27

Mouth hooks simple or with a basal projection, lacking a row of fine teeth; dorsal and ventral cephalopharyngeal processes separated narrowly; spiracular plate of mature larvae with 3 slits 29

27. Most tergites with a transverse row of acute tubercles; posterior declivity with a row of 4 small thornlike tubercles below the spiracles 28

Tergites without rows of distinct tubercles; posterior declivity with 2 broad tubercles below spiracles ..... **Megaselia suis**

28. Posterior spiracles separated by less than a spiracular diameter and situated on protuberances joined from their bases to their middles ..... **Puliciphora wymani**

Posterior spiracles separated by more than one spiracular diameter and situated on protuberances which are not joined but may touch basally ..... **Megaselia scalaris**

29. Spiracles placed in a deep cavity or in a transversely depressed area which in lateral view forms an angle of less than 135° 47

Spiracles not placed in a deep cavity, sometimes in a weak transverse depression which in lateral view forms an angle of more than 150°; larva never covered with rows of strong dorsal tubercles 30

30. Spiracular slits straight or with a single gentle arc, sometimes situated on a black prominence with laterally projecting summit 31

Spiracular slits convoluted, wormlike; spiracles flush with caudal surface or only slightly raised (Muscidae) 43

31. Caudal end of body surrounded by 10 prominent tubercles 32

Caudal end of body surrounded by fewer than 10 tubercles 33

32. Spiracles separated by a space equal to three times the diameter of a spiracular plate; spiracular slits arranged in a clover-leaf pattern ..... **Rhinia testacea**

Spiracles separated by a space about equal to the diameter of a spiracular plate; spiracular slits almost parallel ..... **Lucilia (Phaenicia) cuprina**

33. Spiracular plate raised to nearly its diameter or farther from the caudal surface, at least laterally 34

Spiracular plate flush or raised less than half its diameter from the caudal surface 38

34. Spiracles higher on all sides than wide, with a laterally projecting summit 35

Spiracles without projecting summit, sometimes much higher laterally than medially 36

35. Larva about 10 mm. long; in profile, spiracle with a slight swelling dorsally before projecting apical disk ..... **Atherigona longipalpus**

Larva about 7 mm. long; in profile, spiracle with a broad swelling dorsally and ventrally midway between apical disk and base ..... **Atherigona orientalis**

36. Spiracle evenly raised on all sides, the summit circular; slits less than twice as long as wide, the lateral ones at nearly an angle of 180° to each other ..... **Notogramma stigma**

Spiracle high laterally but sloping sharply downward medially, its summit a rounded crest 37

37. Spiracular protuberances separated at their bases by more than the diameter of one of them.....**Limnophora plumiseta**
Spiracular protuberances separated at their bases by less than diameter of one of them.....**Hecamede persimilis**
38. Spiracular slits with outer ones oriented at less than a right angle to each other..... 39
Outer spiracular slits oriented at greater than a right angle to each other (clover-leaf pattern); spiracular slits less than twice as long as broad.....**Lonchaea filifera**
39. Anterior spiracle with about 6 diverticula.....**Ophyra chalcogaster**
Anterior spiracle with 12 or more diverticula..... 40
40. Spiracular plate unpigmented around slits; slits widely spaced, the middle slit of one spiracle in line with middle slit of the other.....**Dacus cucurbitae**
Spiracular plate distinctly pigmented around slits; middle slit of one spiracle not nearly in line with middle slit of the other..... 41
41. Spiracular slits obliquely placed, not parallel; spiracle lacking a distinct button within the disk and without a large circular pale area on the inner side..... 42
Spiracular slits nearly parallel; spiracle with a distinct button surrounded by a large broadly oval pale area.....**Scholastes aitapensis**
42. Spiracle with a darkly sclerotized marginal strip on each side external to lateral slits, and with a narrow unpigmented gap at the inner ventral corner.....**Chrysomyza aenea**
Spiracle without conspicuously darkened lateral strips, and with a broadly truncate but complete inner ventral margin.....**Pseudeuxesta prima**
43. Spiracular plate with a single kidney-shaped central pale area comprising most of the spiracle..... 44
Spiracular plate with pale area broken into 3 parts each surrounding a slit..... 45
44. Spiracles separated by nearly one-half their diameters; caudal end of larva without distinct series of tubercles.....**Musca vicina**
Spiracles separated by less than one-third their diameters; caudal end of larva with a series of low tubercles.....**Musca sorbens**
45. Spiracles separated by a distance no greater than the diameter of a single spiracular plate..... 46
Spiracles separated by a distance equal to at least one and one-half times the diameter of a spiracular plate.....**Stomoxys calcitrans**
46. No tubercles above spiracles; numerous low rounded tubercles on ventral surface of caudal segment; total length less than 10 mm..... 47
A pair of tubercles above spiracles; 3 multidentate tubercles forming a triangle below the spiracles; spiracles trapeziform in vertical section; total length more than 14 mm.....**Synthesiomyia nudiseta**
47. Spiracle with a small clear spot near center; vertical section of spiracle rectangular, more than six times as wide as deep.....**Siphona carabao**
Spiracle lacking a small clear spot near center; vertical section of spiracle about three times as wide as deep, distinctly emarginate at sides.....**Haematobia exigua**
48. Spiracles placed in a transverse depression which is open laterally..... 49
Spiracles placed in a deep pocket which is precipitous on all sides (*Sarcophaga*)..... 51
49. All body segments but first with a dorsal row of long tapering tubercles, giving larva a very spinous appearance; body heavily sclerotized.....**Chrysomya rufifacies**
Precaudal segments lacking rows of long tapering tubercles..... 50
50. Six tubercles on or near ventral margin of spiracular depression and 6 on dorsal margin .....**Chrysomya megacephala**
Only 2 tubercles on ventral margin of spiracular depression and 4 on dorsal margin .....**Chrysomya "nigripes"**
51. Spiracles separated by at least one-half the diameter of one of them; abdominal tergites in most species with extensive smooth areas..... 52
Spiracles separated by less than one-third the diameter of one of them; abdominal tergites nearly or entirely covered with microtuberculae..... 55

52. Spiracle with ventral sclerotized margin extending as far or nearly as far medially as the inner spiracular margin 53
Spiracle with ventral sclerotized margin extending only slightly farther medially than the ventral end of the lateral slit 54
53. Abdominal tergites with smooth areas more extensive than microtuberculate ones ..... **Sarcophaga dux**
Abdominal tergites with microtuberculate areas much more extensive than smooth ones ..... **Sarcophaga ruficornis**
54. Anterior spiracle with a single row of about 11 branches along the margin, the branches laterally appearing as subequal egg-shaped structures in a uniform row ..... **Sarcophaga gressitti**
Anterior spiracle with 2 or more irregular rows comprising over 20 branches, some of them small and hard to discern ..... **Sarcophaga stricklandi**
55. Dorsal surface completely and closely covered with microtuberculae; a smooth protuberant area present on anterior margin of anus; a pair of small tubercles generally present at bases of the usual ventral pair at caudal end of larva; anterior spiracle with about 14 short branches ..... **Sarcophaga knabi**
Dorsal surface with narrow transverse smooth areas; anterior margin of anus without conspicuous smooth area; only one pair of posteroventral tubercles; anterior spiracle with about 18 short branches ..... **Sarcophaga "peregrina"**

Pupae

1. Pupa naked, last larval skin not present; caudal spiracles not present 2
Pupa enclosed in last larval skin (puparium); caudal spiracles of puparium clearly visible 6
2. Posterior margins of body segments with strong bristles or toothlike spines 3
Posterior margins of body segments without bristles or spines 5
3. Breathing trumpets not more than five times as long as broad; fourth to seventh sternites lacking 4 thornlike spines at middle of each ..... **Telmatoscopus albipunctatus**
Breathing trumpets about ten times as long as broad; fourth to seventh sternites each bearing a row of 2 to 4 thornlike spines at middle (*Psychoda*) 4
4. Posterior margins of abdominal segments each with a prominent row of 6 or more thornlike spines ..... **Psychoda alternata**
Posterior margin of abdominal segments each with a row of minute setae ..... **Psychoda** sp. **a**
5. Breathing trumpets absent, a pair of setalike structures visible near anterior margin of head ..... **Lycoria** spp.
Breathing trumpets arising from back of head, in addition to setalike structures near anterior margin of head ..... Cecidomyidae, gen. sp.
6. "Puparium" merely a transparent, membranous skin conforming entirely to form of pupa; breathing trumpet long, bifurcate; caudal spiracles on long stalks ..... **Psectrosciara brevicornis**
Puparium not conforming to shape of pupa; larviform or capsulelike 7
7. Head exserted, mouthparts external; breathing trumpets not visible; body larviform 8
Mouthparts internal (a pair of "mouth hooks" may be exserted) head usually not differentiated; body usually capsulelike; breathing trumpet present or absent 9
8. Body tergites with transverse rows of cilia and with several cilia visible on lateral margins of each segment ..... **Hermetia illucens**
Body tergites without transverse rows of cilia, second to eleventh each with a pair of lateral clubbed cilia ..... **Microchrysa flaviventris**

9. Metathoracic breathing trumpets slender, without terminal processes, arising dorsally on fourth body segment; body dorsoventrally compressed, distinctly margined laterally.....(Phoridae) 10
Metathoracic breathing trumpets absent or arising near front margin of puparium, or lateral and short, thick, and curved; puparium roughly cylindrical when breathing trumpets are dorsal and remote from anterior margin..... 17
10. Breathing trumpet long and bifurcate from near its base.....**Chonocephalus** sp.
Breathing trumpet not forked..... 11
11. Puparium greatly flattened, all segments with long "*Fannia*-like" lateral processes bearing pinnae; breathing trumpet fringed with cilia on anterior margin.....
.....**Parafannia molluscovora**
Puparium with at most long processes on posterior 2 segments..... 12
12. Breathing trumpet densely fringed with cilia on both margins; posterior 2 body segments with long processes bearing appressed pinnae.....**Diploneura cornuta**
Breathing trumpet not distinctly fringed, posterior segments with tubercles only..... 13
13. Puparium nearly smooth, tubercles not projecting laterally except at posterior end; anterior 3 segments without distinct tubercles..... 14
Puparium (mature, darkened specimens) with well-formed tubercles projecting laterally and forming rows on all segments; over 2 mm. long....**Megaselia scalaris**
14. At least 1.7 mm. long; posterior spiracles separated and extending beyond end of puparium in dorsal view..... 15
Not more than 1.5 mm. long; posterior spiracles joined for one-half of their length and not projecting beyond end of puparium..... 16
15. Puparium with minute tubercles laterally.....**Megaselia stuntzi**
Puparium entirely smooth, lacking tubercles.....**Megaselia suis**
16. Breathing trumpet projecting beyond side of puparium as viewed dorsally.....
.....**Puliciphora wymani**
Breathing trumpet not projecting beyond side of puparium as viewed dorsally
.....**Puliciphora nigriventris**
17. Posterior spiracles on end of long "rat tail" recurved over back; over 10 mm. long
.....**Tubifera arvora**
Posterior spiracles not as above..... 18
18. Anterior spiracle on a distinct stalk arising from, or from near, anterior margin of puparium 19
Anterior spiracle small and "earlike," not stalked..... 25
19. Main stalk of anterior spiracle more than twice as long as broad..... 20
Main stalk of anterior spiracle less than twice as long as broad, sometimes with a bifurcate process 21
20. Stalk of anterior spiracle cylindrical, bearing a brushlike tuft apically.....
.....**Chaetodrosophilella quadrilineata**
Stalk of anterior spiracle slender, tapering and bent inward distally, lacking a tuft
..... **Leptocera femorina**
21. Posterior spiracle on the prominent, dorsally directed tip of abdomen; abdominal segments with prominent leglike processes, each with a ventral branch near base .....**Discomyza maculipennis**
Abdomen without conspicuous lateral and erect terminal processes..... 22
22. Anterior spiracle with a thick basal stalk bearing a slender bifurcate process distally .....**Paralimna aequalis**
Anterior spiracle with numerous fingerlike processes arising directly from the main basal stalk..... 23
23. Posterior spiracles on long parallel stalks which are apparently united medially
.....**Drosophila** species a
Posterior spiracles on widely diverging stalks..... 24

24. Posterior spiracles with apical third narrow and nearly transparent; puparium dark chestnut brown, five times as long as broad.....**Desmometopa tarsalis**
Posterior spiracle not narrowed or pale distally; puparium pale testaceous, about three times as long as wide.....**Drosophila ananassae**

25. All segments provided with long tapering processes laterodorsally and latero-ventrally, most of them compound; spiracular stalk branched.....**Fannia pusio**
Not with all segments bearing tapering processes..... 26

26. Caudal end of puparium with a pair of upcurved denticles..... 27
Caudal end of puparium without a pair of upcurved denticles, sometimes with a ring of tubercles around spiracles..... 28

27. Caudal end of puparium with a pair of minute tubercles above spiracles in addition to the upcurved denticles, which are infraspiracular.....**Piophila casei**
Caudal end of puparium with a single pair of denticles, on the bases of which the spiracles are located..... 28

28. Caudal end of puparium densely covered with minute oval swellings.....**Sobarocephala** sp.
Caudal end of puparium smooth except for a few concentric ridges.....**Mimegralla galbula**

29. Posterior spiracle strongly protuberant, usually convex apically, sometimes with outer side more strongly raised than inner..... 30
Posterior spiracular plate flush, or evenly raised to a height not more than one-third its diameter..... 40

30. Anterior spiracle with numerous minute fingerlike processes, each three times as long as broad; posterior spiracle terminating with recurved horns.....**Milichiella lacteipennis**
Anterior spiracle lacking fingerlike processes, sometimes bordered with short rounded lobes; posterior spiracle without recurved horns..... 31

31. Posterior end of body with one or more rings of distinct tubercles..... 32
Posterior end of body lacking rings of distinct tubercles..... 33

32. Puparium less than 2 mm. long.....**Allotrichoma** sp.
Puparium more than 5 mm. long.....**Rhinia testacea**

33. Penultimate segment of puparium with prominent flangelike transverse carinae; second segment of puparium with coarse, irregular carinae; anterior end of puparium notched medially; anterior spiracle with an extremely short stalk and a ring of lobes each about as long as broad.....**Cadrema pallida bilineata**
Carinae lacking on second and penultimate segments of puparium; anterior spiracle without a short stalk or ring of lobes..... 34

34. Puparium coarsely corrugated transversely; fourth segment much higher than third, with steep anterior declivity.....**Hecamede persimilis**
Puparium not transversely corrugated..... 35

35. Anterior end of puparium distinctly truncate; first 2 segments and anterior half of third completely perpendicular; posterior end of puparium truncate; posterior spiracle nearly twice as high as wide..... 36
Anterior and posterior ends of puparium not conspicuously truncate; posterior spiracle much less than twice as high as wide..... 37

36. Viewed ventrally, posterior spiracles no longer than horizontal part of third segment at midventral line; puparium no longer than 4 mm.....**Atherigona orientalis**
Viewed ventrally, posterior spiracles distinctly longer than horizontal part of third segment at midventral line; puparium no shorter than 5 mm.....**Atherigona longipalpis**

37. A curved breathing trumpet on each side of dorsum between fourth and fifth segments..... 38
Breathing trumpet lacking between fourth and fifth segments..... 39

38. Breathing trumpet strongly curved near base; puparium shaped like a "gelatin capsule," more than 5 mm. long ..... **Ophyra chalcogaster**
Breathing trumpet curved near apex; puparium tapered posteriorly, less than 4 mm. long ..... **Limnophora plumiseta**

39. Penultimate tergite with numerous subtransverse ridges and a depressed median line; posterior spiracle irregularly convex, with a dorsally projecting lip ..... **Lonchaea** sp.
Penultimate tergite with a few strong sublongitudinal ridges and without a distinct median groove; posterior spiracle subcylindrical ..... **Notogramma stigma**

40. Slits of spiracular plate convoluted 41
Slits of spiracular plate straight or slightly arched 46

41. Posterior spiracle raised about one-third its diameter from surrounding area; the plate margined with an outwardly projecting flange ..... **Haematobia exigua**
Posterior spiracle flush or very slightly raised, its margins not projecting 42

42. Posterior spiracles separated by more than the diameter of a spiracular plate 43
Posterior spiracles separated by less than the diameter of a plate 44

43. Button of spiracular plate remote from margin of plate; spiracles separated by twice the diameter of a plate ..... **Stomoxys calcitrans**
Button of spiracular plate touching margin of plate; spiracles separated by not more than one and one-half the diameter of a plate ..... **Synthesiomyia nudiseta**

44. Posterior spiracle practically flush with surrounding area; outline of spiracular plate subtriangular ..... **Siphona carabao**
Posterior spiracle slightly raised; outline of spiracular plate truncate on inner side, evenly rounded on outer 39

45. Spiracular plates separated by more than one-half the diameter of a plate; posterior end of puparium lacking minute tubercles ..... **Musca vicina**
Spiracular plates separated by less than one-third the diameter of a plate; posterior end of puparium with rows or pairs of minute tubercles ..... **Musca sorbens**

46. Caudal portion of puparium rather evenly rounded, sometimes with fine ridges or minute tubercles 47
Caudal portion of puparium not evenly rounded, generally with spiracular area apparently sunken into a depression, or surrounded by long tubercles or other gross irregularities 51

47. Puparium reddish brown, not pale testaceous 48
Puparium pale testaceous; all segments posterior to third smooth, polished; caudal end rounded; spiracular plate feebly raised externally, largely pale ..... **Dacus cucurbitae**

48. Spiracular plates slightly raised above surrounding area, generally sloping inward; caudal end of puparium with transverse, oblique or arcuate ridges 49
Spiracular plates flush with surrounding area, separated by the diameter of a plate or more; caudal end of puparium lacking ridges, smooth except for a ring of widely spaced small tubercles around apicular area; puparium over 5.5 mm. long ..... **Lucilia (Phaenicia) cuprina**

49. Puparium three times, or more, as long as broad; ridges above spiracles extending in diverse directions, if numerous; length of puparium about 4.5 mm 50
Puparium only slightly more than twice as long as broad; ridges above spiracles very numerous and parallel or concentric; spiracles separated by about one-half diameter of a plate; length of puparium about 5 mm ..... **Scholastes aitapensis**

50. Caudal end of puparium with only a few ridges or wrinkles; slits of spiracular plate subparallel, diverging slightly from a common point of origin; spiracular plates separated by nearly the diameter of one ..... **Pseudeuxesta prima**
Caudal end of puparium with conspicuous ridges extending in various directions; slits of spiracular plate placed obliquely, not having a common point of origin; spiracular plates separated by one-half a diameter, or less ..... **Chrysomyza aenea**

51. Caudal segment of puparium tapered, not broadened distally or emarginate apically in lateral outline 52

Caudal segment of puparium narrower at base than at apex, when viewed from above or below, emarginate apically in lateral outline, bearing a few smooth, acute tubercles on distal margin; caudal tergite with several strong irregular rugae, some of them sublongitudinal ..... **Chrysomya "nigripes"**

52. Puparium with a ring of flaplike tubercles on each segment, those on posterior segment fairly long, subtriangular in outline, somewhat enclosing spiracular area ..... **Chrysomya rufifacies**

Puparium lacking numerous conspicuous tubercles 53

53. Caudal end of puparium produced around spiracular area, which is thus often apparently deeply sunken 54

Caudal end of puparium very feebly produced around spiracular area, or with only a few low tubercles on border of apical truncation; spiracular plates slightly raised, separated by about one-half a diameter ..... **Chrysomya megacephala**

54. Surface of puparium almost entirely covered with minute transverse asperities or subasperate punctures; posterior cavity with opening deeply emarginate in lateral outline, bordered with asperities but not distinct tubercles; faces of spiracular plates nearly in line with long axis of puparium; fingerlike projections on anterior spiracle 17, in an irregular row ..... **Sarcophaga knabi**

Surface of puparium with alternate bands of asperate punctures and minute ridges, the latter areas often restricted or with scattered weak asperities; opening of posterior cavity not often deeply emarginate in lateral outline 55

55. Depth of posterior cavity of puparium generally greater than diameter of opening; spiracular plates generally almost in same plane with longitudinal axis of puparium 56

Depth of posterior cavity of puparium generally much less than diameter of opening; spiracular plates often placed almost horizontally in relation to transverse axis of puparium; 11 to 14 fingerlike projections on anterior spiracle; puparium generally presenting smooth appearance, its striate areas extensive and rather satiny ..... **Sarcophaga gressitti**

56. Fingerlike projections on anterior spiracle 11 to 14 in number; opening of caudal cavity with feeble or moderate tubercles; ventral subcaudal pairs of tubercles sometimes large, but generally not erect; asperities of surface of puparium rarely in form of reclining, triangular teeth in contiguous oblique series 57

Twenty-one fingerlike projections on anterior spiracle; opening of caudal cavity bordered with a number of conspicuous, subvermiculate tubercles; ventral subcaudal pair of tubercles prominent and erect; asperities of surface of puparium to a large extent in form of reclining, triangular teeth, almost contiguous in oblique series ..... **Sarcophaga stricklandi**

57. Dorsolateral portions of third, fourth, and fifth segments with posterior half completely ridged, without asperities; puparium with strong ridges and large, closely spaced asperities which have bases broadly oval, almost touching in many areas ..... **Sarcophaga dux**

Dorsolateral portions of third, fourth, and fifth segments with posterior halves asperate; asperities generally small and not almost touching 58

58. Posterior two-thirds of tergites in middle portion of puparium with strong ridges bearing narrow, anteriorly directed scalelike teeth; third tergite in large part coarsely ridged and without tubercles ..... **Sarcophaga "peregrina"**

Posterior two-thirds of tergites in middle portion of puparium largely with narrowly elliptical transverse tubercles, sometimes bearing feeble, transparent teeth; third tergite, except for a very narrow band, covered with elliptical or prostrate triangular tubercles ..... **Sarcophaga ruficornis**

SYSTEMATIC SURVEY

Specific information concerning the species and higher categories of filth-inhabiting flies on Guam is summarized in the following pages. Unless otherwise indicated, statements concerning species are based upon specimens and data accumulated on Guam by the authors and other members of Naval Medical Research Unit 2. Statements concerning higher groups are based upon personal experience of the authors and upon information in various textbooks and cited references.

Much of the distributional data and synonymy was taken from card catalogs and specimens at the United States National Museum. Synonymy listed under each genus and species is neither complete nor in all cases according to the most recent revisions. The names were originally synonymous with the oldest name or have been used synonymously by later authors. Complete synonymy must await taxonomic revisions or special synonymic lists and catalogs. Most of the species are recorded from Guam for the first time, since the larger share of the flies collected by Swezey and Usinger in 1936 has not yet been reported upon (Swezey *et al.*, 124).

Suborder ORTHORRHAPHA, Straight-seamed Flies

Adult: Many-segmented antennae, or if it has only three segments, the third is without a bristle or has a terminal one. *Pupa:* Naked, or if enclosed in the last larval skin, the latter is unmodified and splits along a longitudinal seam.

The habits of this family are varied, and aquatic groups are well-represented. The larvae are predaceous, phytophagous, or saprophagous. However, they rarely infest concentrated media such as carrion and human excrement, though some stratiomyids are exceptions to this rule.

Series NEMOCERA, Long-horned Orthorrhapha

Adult: Antennae with five or more segments, the last ones not united in a group. *Pupa:* Naked and usually active.

Most families of this series are aquatic as larvae; but three large families are terrestrial, Tipulidae, Itonididae, and Fungivoridae. Many groups are predaceous, but many are also phytophagous or saprophagous. Only a few live in concentrated media.

Family PSYCHODIDAE, Owl Midges, Moth Flies

Adult: Small to minute, hump-backed, with wings strongly bent near base and with entire body and wings densely covered with hairs. *Egg:* Lenticular, laid in masses. *Larva:* Head fully differentiated, unretractable, and with toothed mandibles; at least some body segments with chitinous dorsal plates; posterior end with a short breathing tube. *Pupa:* Head, wings, and legs closely applied to the body; prothorax with long,

slender respiratory organs and body segments with transverse rows of various types of spines.

The adult is usually found in moist places or coming to lights at night. One genus, *Flebotomus*, is haematophagous in the adult stage and terrestrial in the larval stage. The larva is usually aquatic or semi-aquatic and is found in dilute sewage, waste-water drains, stagnant ditches, tree holes, and other collections of highly organic liquids.

Genus **Psychoda** Latreille

Adult: Small with wing hairs on veins only and with 12 to 16 antennal segments. *Larva:* Resembles *Telmatoscopus,* but has shorter, thicker body bristles.

This is the largest genus of psychodids and the one most frequently seen indoors, where individuals have come to lights or emerged from their breeding places in sink and bathtub drains. Two species have been reported as causing human myiasis, *P. alternata* and *P. albipennis* (James, 50). The latter is recorded by Patton (97) as occurring in the urinary tract.

Psychoda alternata Say (fig. 4, *a*).

Trichoptera phalaenoides Meigen.
Psychoda sexpunctata Curtis.
Psychoda marginepunctata Roser.
Psychoda schizura Kincaid.
Psychoda floridica Haseman.
Psychoda nocturnala Haseman.
Psychoda bengalensis Brunetti.
Psychoda albimaculata Welch.
Psychoda dakotensis Dyar.

Adult: Differs from other species in having dark hairs at ends of the wing veins, particularly the alternate ones; length 2.2 mm. (fig. 4, *a*). *Larva:* With head brown; body yellowish white; only posterior half of body with tergal plates; respiratory tube about four times as long as broad; length 3.8 mm. *Pupa:* With anterior breathing tubes straight; posterior borders of sternites with thornlike spines.

Distribution: Almost cosmopolitan.

The adult is found in bathtubs, sink drains, and the walls of septic tanks, and is attracted to lights at night. The larva breeds in liquid sewage and other water high in organic content. It is also said to breed in filter beds of sewage disposal plants (Headlee, 34). On Guam, we reared it from liquefying breadfruit in cloth-covered pans.

This species, which is common in most parts of the world, was not observed in great numbers on Guam. It is medically significant in that it stops up pipes and disrupts sewage disposal beds, but James (50) gives a record

of a girl who vomited living larvae. The application of DDT to liquid sewage and stopped drains would probably free such places, although there is evidence with some insects that foul water inhibits the toxicity of DDT.

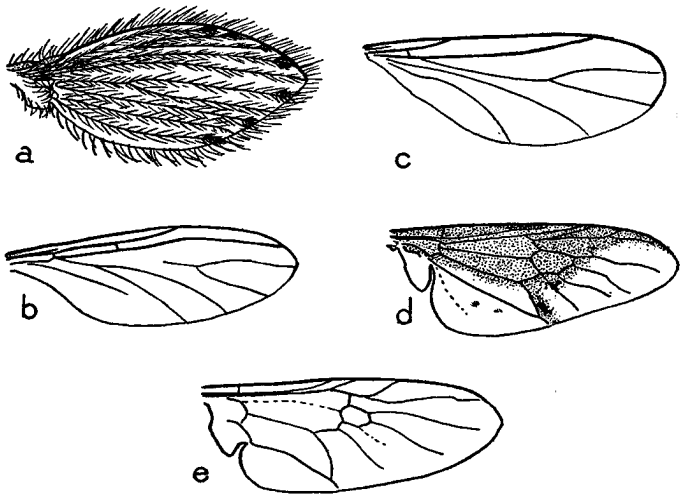

FIGURE 4.—Wings: **a**, *Psychoda alternata;* **b**, *Lycoria* sp.; **c**, *Psectrosciara brevicornis;* **d**, *Hermetia illucens;* **e**, *Microchrysa flaviventris.*

Psychoda sp. **a** (pls. 1, 9).

Adult: Minute fly, almost entirely covered with long white hairs; legs purplish; length 1.8 mm. *Egg:* Pearly, oval, laid in sheets; length 0.3 mm. (pl. 1). *Larva:* Body tergites each with a conspicuous median plate and a rosette of small ones; respiratory tube three times as long as broad; length 4 mm. *Pupa:* Anterior breathing tubes ten times as long as broad and gently arcuate; abdominal sternites each with two to four thornlike spines across middle; length 2.5 mm. (pl. 9).

Distribution: Guam.

Adults are attracted to decomposing foodstuffs around kitchens, garbage dumps, poorly kept villages, and so forth, coming indoors to light at night. The eggs are laid in flat masses on the broken surfaces of various rotting fruits and on fresh pig manure. We reared larvae from such rotting fruits as breadfruit, coconuts, and soursop, and from pig feces. In some rotting breadfruit the larvae were so numerous that they gave the liquefying material a gray, stippled appearance. Masses of breadfruit kept in the laboratory were used by several generations of the flies which mated and oviposited freely under gauze covers. Pupation took place in the remains of the larval food.

This species was extremely abundant around most garbage dumps and in native yards where breadfruit had dropped, and it was one of the commonest flies in our light traps. It is medically significant, as midges bred in fecal material might contaminate ripe fruit in kitchens. The best control is the disposal of decaying fruits and vegetables.

Genus **Brunettia** Annandale

This little-known tropical genus of psychodids is characterized by wing scales on the membrane. So far as we know, its larval habits have not been studied. Adults are attracted to lights and have been collected from houses on windows.

The Guam species is recognized by its very broad wings, with the membrane covered with black scales which have purplish or greenish iridescent reflections. The body is 1.2 mm. long; the wing, 1.5 mm. long.

Genus **Telmatoscopus** Eaton

This small genus has habits similar to those of most *Psychoda,* in that the larvae live in waters highly charged with organic materials.

Telmatoscopus albipunctatus (Williston).

Psychoda snowii Haseman.
Pericoma meridionalis Eaton.
Pericoma erecta Curran.
Pericoma legnothisa Speiser.

Adult: Body covered with blackish and whitish hairs; wings with long brownish-gray hairs on veins and margins, a spot of white hairs at apex of each vein and some spots of black hairs on basal portion of wing surface; length of body 2.6 mm.; wing length nearly 3 mm. *Egg:* Lenticular; in masses as in *Psychoda* sp. *Larva:* Linear, with distinct head-capsule and short caudal respiratory tube; all body segments provided with rows of bristles and dorsal sclerotized plates. *Pupa:* Anterior respiratory tubes short and straight; posterior margins of body segments with fringes of long bristles.

Distribution: Almost cosmopolitan.

Adults are frequent in privies and in houses, around plumbing and on windows. The eggs are laid in irregular masses. Larvae breed in polluted water and household drains; Efflatoun (18) found larvae breeding in a vat for macerating bones and in a contaminated well.

This species is very abundant in many parts of the world. It has not been found on Guam, but has been collected on Saipan. Like *Psychoda alternata,* it stops up pipes and disrupts sewage disposal. As it is for *P. alternata,* DDT would probably be effective in its control.

Family FUNGIVORIDAE (MYCETOPHILIDAE), Fungus Gnats

Adult: Laterally compressed, with long filiform antennae, flattened coxae and femora, and long legs with prominent tibial spurs.

The adult generally inhabits dark, damp places. The larva breeds in fungi, often in those growing in manure.

Genus **Lycoria** Meigen

Sciara Meigen.

Adult: Small, black, and fragile; wings with characteristic U-shaped branching of the posterior branch of the medius (fig. 4, *b*).

Members of this genus are generally referred to as the dark-winged fungus gnats, although their invasion of mushrooms usually follows that of other fungivorids. The larvae, according to Johannsen (52), are common in barnyard manure and also feed on seed corn, potatoes, and the young roots and shoots of various plants. Fertilizing fields with barnyard manure often introduces enough larvae to cause destruction to seeds and seedlings.

Adults of several unidentified species were collected on Guam from heaps of cow manure at the Government Farm and at the Pago garbage dump. It is assumed that the larvae fed on fungi developing in the cow manure and rotting corn at the garbage dump. Their medical significance is undoubtedly slight, involving the possible contamination of food near garbage, and of milk by organisms from manure in dairies. Some species "dance" in front of people's eyes and occasionally cause irritation by getting into the eyes, but this habit was not observed on Guam.

Family HELEIDAE (CERATOPOGONIDAE), Biting Midges

Adult: Minute, rather robust, with many segmented, filiform antennae, and generally with a pattern of hair patches on the wings.

The adults of most species are bloodsucking, but many are not. The larvae are generally aquatic or semi-aquatic, but some species breed in decaying vegetable material.

Dasyhelea species.

Adult: Minute yellow gnats with three longitudinal dark stripes on the mesonotum; length 0.8 mm.

The most abundant fly on the garbage dump at Pago, this species flew in dense swarms close to the surface of the garbage.

Members of the genus are not haematophagous. This species probably has no medical significance, but further study might show that it can contaminate kitchen foodstuffs.

Family SCATOPSIDAE, Dung Midges

Adult: Minute, intensely black, with antennae many-segmented but short and club-shaped, and with feeble venation on the posterior portion of the wing. *Larva:* With distinct head and a pair of widely separated posterior respiratory tubes. *Pupa:* Largely enclosed in the membranous larval skin and with a pair of bifurcating anterior respiratory tubes. Each abdominal segment bears a slender respiratory tube.

The larvae breed principally in rapidly decaying vegetable material, in human and other animal excrement, and under bark of dead trees. The principal genus, *Scatopse,* breeds in all of these situations.

Genus **Psectrosciara** Kieffer

No published accounts were found concerning the habits of this small genus. They are probably similar to those of its close relative, *Scatopse.*

Psectrosciara brevicornis Johannsen (fig. 4, *c*).

Adult: Characteristic wing venation, as shown in figure.

Distribution: Guam.

A single adult specimen was swept from low-growing vegetation at Pilgo River.

Family ITONIDIDAE (CECIDOMYIDAE), Gall Midges

Adult: Small and delicate, with long legs and antennae and broad, naked wings, which frequently have much reduced venation.

The larvae usually breed in living plants where galls of various descriptions are formed; some species, in decaying vegetation and fungi.

An Unidentified Genus and Species of Itonididae

Adult: Pale yellow; dorsum of thorax gray; antennae with 22 segments. Length of body, fully extended, 4 mm.; length of wing 3.8 mm. *Larva:* Pale pink; a pair of ventrally curved thornlike spines at posterior end used for springing; an elongate internal sclerotized structure present posterior to head on ventral side; head minute, but exserted; length 3.8 mm. *Pupa:* Pale pink; anterior respiratory tubes small and straight; abdomen arched dorsally and with caudal respiratory tubes short and contiguous; length 3.4 mm.

Adults are found in moist jungles, flying about decaying breadfruit. The larvae, which feed in decaying breadfruit, especially cellular core tissues, are very active and may leap repeatedly six or more inches at a time when disturbed. Pupation occurs slightly beneath the surface of decaying fruit and sometimes in the cellular core tissue.

Some of the breadfruit collected in deep shade had several hundred larvae of this species per fruit, and it is included here because its larvae are associates of more definitely filth-inhabiting flies, such as *Psychoda* and *Atherigona.* The adults were not conspicuous. The species has no medical significance, though it possibly causes false or accidental myiasis. Proper disposal of fruit is the suggested control.

Series BRACHYCERA, Short-horned Orthorrhapha

Adult: Antennae composed of fewer than five freely articulating segments, although with the last one sometimes distinctly annulate or bearing a terminal process; frontal

lunule and suture (external evidences of the ptilinum) absent. *Pupa:* Naked or with puparium, if present, splitting along dorsal longitudinal seam.

The larvae, and frequently the adults of most families, are predaceous on other insects, sometimes filth-inhabiting ones. Members of one important group (Stratiomyidae) have saprophagous larvae.

Family STRATIOMYIDAE, Soldier Flies

Adult: Recognized by the sharply defined, short discal cell in the center of the wing from which several veins radiate but do not reach the wing margin. Many of the members are fairly large, dorsally compressed, and frequently have an elongate annulated terminal segment. *Larva:* Flattened, very leathery, pigmented, bristled on the sides, tapered anteriorly and with the head distinctly exserted but small. The pupal period is passed within the last larval skin, which does not shrink or harden noticeably.

The adult is found chiefly on flowers or sunlit foliage in wooded areas. Some members of the family, such as *Hermetia,* are commonly found on windows and screens of houses or privies. The larvae are found in a large variety of situations. Many of the larger forms are aquatic scavengers, and most of the smaller forms breed in the souring cambium of dead trees. *Hermetia, Ptecticus,* and other genera breed commonly in human and other animal excrement, as well as in carrion, garbage, and highly organic soils.

Genus **Hermetia** Latreille

The larvae of this genus are, in general, scavengers in decaying vegetation and under the bark of trees. The principal species, *H. illucens* Linnaeus, has a wider range of habits.

Hermetia illucens (Linnaeus) (fig. 4, *d;* pl. 10).

Hermetia muceus Riley and Howard.

Musca leucopa Linnaeus.

Adult: Large, elongate, black, with antennal segments elongate, wings basally clouded, and base of abdomen with a pair of translucent areas; length 15-20 mm. (fig. 4, *d*). *Egg:* Smooth and ovate, gradually tapered toward the small end. *Larva:* Dorsoventrally flattened, leathery, dark brown, and slow moving; segments with transverse rows of strong bristles; length 20-25 mm. *Puparium* is almost identical with larva in external appearance, but somewhat more elongate and rigid (pl. 10).

Distribution: Cosmopolitan, temperate, and tropical.

The adult of *H. illucens* enters privies and houses freely where it is frequently seen on the screens and, in hot weather, flying around inside privy pits. It commonly buzzes about one's head, hence is often mistaken for a large wasp. It also visits many types of flowers in moist situations and rests on foliage near putrefying substances. On Guam, larvae were most commonly found breeding in rotting vegetables, especially corn, at the Pago garbage

dump. They were present in lesser numbers in heaps of cow manure at the Government Farm and in the decaying aquatic vegetation near Agana Spring. Many empty puparia were seen on the dirt floor of a large camp privy near the center of the island. According to published records the species breeds also in old carrion, including human corpses and dead crabs; in vinegar vats; in bee hives, where it feeds on wax, dead bees, and dead bee larvae; and in fermenting fruit. Tanada *et al.* (125) report its breeding in chicken manure in Hawaii. In California we have seen them in congregations in rich compost soils.

Probably because of the tightly closed spiracular cavity and the tough coating of silicious material, the larva is very resistant to insecticides and to concentrated solutions of acid, alcohol, and brine. On Guadalcanal, no privy seemed to be without them, in spite of the considerable chemical treatment which kept other flies at a low level. Development is slow, usually requiring over a month, which may explain why large accumulations of material are chosen for breeding purposes. The mature larva usually migrates at least several yards before it burrows an inch or more under the suface for pupation.

This species is not common in most areas on Guam, although it builds up in numbers wherever large masses of suitable breeding material remain long enough for it to complete its cycle. Because of its wide range of adult and larval food habits, there is considerable opportunity for the adult stage to carry pathogens from excrement and corpses into houses. Several cases of intestinal myiasis caused by the larvae have been recorded (James, 50). The large maggots give rise to severe gastrointestinal disturbance.

The best control is general sanitation, including proper disposal of sewage, garbage, and other wastes; the screening of houses; and proper construction and chemical treatment of privies. The larva is more resistant to DDT and paradichlorobenzene than are those of *Chrysomya megacephala* or rat-tailed maggots. The best results in privies are usually had by burning the larvae with ignited diesel oil sprayed from a gun.

Genus **Microchrysa** Loew

Chrysomyia Macquaert.

This is a small genus, whose known habits are to breed in manure piles and the frass of lepidopterous insect larvae.

Microchrysa flaviventris Wiedemann (fig. 4, *e;* pl. 10).

Adult: Dorsoventrally flattened; wings with pale yellowish veins; body brilliantly metallic, entirely green in female but with abdomen testaceous in male; length 6 mm. (fig. 4, *e*). *Larva:* Brown, leathery, dorsoventrally flattened; each segment with a pair of lateral clubbed bristles; length 7 mm. *Puparium:* Similar to the larva, but somewhat more elongate and rigid (pl. 10).

Distribution: Pacific islands, including Guadalcanal and the Admiralties.

The adult is found in the woods on flowers and vegetation, or flying in the open about manure piles and garbage dumps. It is not generally found in houses or privies. The larvae feed in rapidly decaying vegetable matter, such as muck taken from ponds, accumulations of cow manure, and silage. Maggots have not been found in isolated cattle droppings. Development is slow, usually taking more than a month from egg to adult.

This moderately abundant species is most common around silage, manure at the Government Farm, and the rotting aquatic muck at Agana Spring. It has little, if any, medical significance, but it might conceivably transmit pathogens from manure to milk in dairies. The proper use of compost, silage, and manure are the recommended controls.

Family EMPIDIDAE, Dance Flies

Adult: Hump-backed, with a horny proboscis adapted for piercing and with a terminal style on the antenna. The face is without a beard and the cubital wing cell is short.

Both adults and larvae are predaceous on soft bodied insects, the former sometimes frequenting carrion and garbage in search of suitable prey.

Genus **Drapetis** Meigen

Two species of this genus were taken frequently in bait traps and around garbage dumps on Guam. One is polished black with conspicuously red eyes, the other largely yellow except for shiny black areas on the dorsum of the thorax and abdomen. On the garbage dump at Pago, the black species was observed sucking blood from a newly emerged cypselid fly.

Suborder CYCLORRHAPHA, Circular-seamed Flies

Adult: Antennae composed of three or fewer segments, the apical one dominant, not annulated, and nearly always with a dorsal bristle. Frontal lunule usually present. *Larva:* Head largely retracted and with amphipneustic respiratory system. *Pupa:* Enclosed in a puparium (last larval skin), which splits along a transverse seam.

The adults and larvae of many families have varied predatory habits; but parasitic phytophagous or saprophagous modes of life are dominant.

Series ASCHIZA (Cyclorrhapha without a Ptilinum)

Adult: Like other Cyclorrhapha, except that the face is without a depressed lunule above the antennae (which is sometimes seen as an inverted U-shaped suture surrounding the antennal area); antennal bristle sometimes terminal. *Puparium* often with long, straight breathing horns piercing the anterior abdominal region.

The larvae of the only two important families in this section, Phoridae and Syrphidae, have very diverse habits and life histories. They are generally

terrestrial as larvae, but the Syrphidae has semi-aquatic members. Many members of both important families are social parasites or commensals of social insects.

Family PHORIDAE, Hump-backed Flies

The known phorid flies of Guam have been described in an earlier publication (Bohart, 6).

Adult: Less than 4 mm. long; generally compressed laterally, with strong, flattened coxae and femora; head spinose; tibial spurs long; flights short and movements jerky; frequently flying or running downward when disturbed; wingless members resemble book lice. *Egg:* About twice as long as broad, without paired filaments or a ventral groove, usually with conspicuous protuberances or short ridges. *Larva:* Short, broadened caudally, with mouth-hooks multidentate. *Puparium:* Dorsoventrally flattened; thoracic segments large; breathing trumpets long and emerging from anterior region of abdomen.

Adults of this family are phyto- or zoosaprophagous; some species hover over ant columns or frequent formicaria; some are found on vegetation in damp shady places. The eggs are scattered singly on decaying substances or fungi, and some species lay them in formicaria or directly upon ants or their grubs. The larvae are phyto- or zoosaprophagous or internally parasitic on arthropods, especially coleopterous and lepidopterous larvae. Some species are ectoparasitic on ants. Many species are omnivorous, feeding upon human excrement, carrion, garbage, or living animal tissue. Pupation occurs in the food, often in contact with semi-liquid materials and with the ventral surface of the puparium attached to substratum.

Phoridae are very common on the island of Guam, especially around dead sea life and moist carrion, and one species teems in decaying breadfruit.

They could be important in the carrying of pathogens from excrement to food, particularly in view of their omnivorous and house-frequenting habits. Several species have been identified in cases of transitory intestinal myiasis and one, *Megaselia scalaris* Loew, has been suspected in the transmission of human cholera.

Genus **Megaselia** Rondani

Apiochaeta Brues.

Adult: Winged in both sexes; radius branched apically; two pairs of proclinate bristles present on anteromedian projection of frons; hind tibia without single or paired bristles, except apically. *Larva* and *pupa:* Without long projections laterally and with posterior spiracles on a pair of adjacent, knoblike protuberances.

The habits of this genus are nearly as varied as those of the entire family; a single species may be zoophagous, saprophagous, or a true internal parasite in the larval stage.

Megaselia scalaris Loew (fig. 5, *a, b*; pls. 1, 4, 9).

Megaselia ferruginea Brunetti.

Megaselia xanthina Speiser.

Megaselia circumsetosa De Meijere.

Adult: Abdominal tergites black with anteromedian yellow areas, pleuron creamy; hind femur with dark apical spot; length 1.5 to 3.8 mm. *Egg:* Upper surface margined by a row of white subcircular scales and dotted with similar but smaller scales; length 0.9 mm. (pl. 1). *Larva:* Posterior end with distinct series of tubercles; large specimens often 6 mm. long (pl. 4). *Puparium:* Laterally with small tubercles but generally appearing rather smooth; length 4 mm. when well-developed (pl. 9).

Distribution: Pantropical, extending into temperate regions; prominent in seaport areas of Pacific islands.

The adults are phyto- and zoosaprophagous. They frequent houses and kitchens and oviposit freely on fresh and old moist carrion, decaying shellfish, moist human feces, freshly cooked vegetables, rotting insects, and (according to published records) lepidopterous and coleopterous larvae. The larvae develop rapidly in moist putrid substances, even in the presence of large numbers of blow fly or flesh fly larvae. They require little oxygen and no light for development, and pupate in or near larval food and in moist surroundings.

This is the commonest *Megaselia* on Guam and in most populated parts of the other Pacific islands. Because of its abundance, omnivorous tastes, and domestic habits, it is the most likely of all Guam phorids to transmit pathogens. On two occasions we saw it still active in refrigerators held at about 50° F. It has been recorded several times as a producer of intestinal, cutaneous and opthalmic myiasis. One record from Burma is of a patient who, despite precautions against re-infection, continued to pass eggs, larvae, pupae, and adults of this species for over a year (James, 50). This would indicate that it is able to complete a number of cycles within the intestine. Roberg (107) suspects this species of phorid in the transmission of cholera in the Philippine Islands.

It is very difficult to protect foods from oviposition by this fly, as we found in the laboratory. Despite tight cloth covers over our media these flies often succeeded in gaining entry to the dishes or forcing their ovipositors between the meshes of cloth. An adjacent laboratory, where examination of stools for intestinal parasites was conducted, had difficulty in keeping them out of covered cardboard cups of feces and there scattering eggs. Rapid incineration or burial of garbage, chemical treatment of privies, and prompt use of meats after cold storage or butchering are the best controls.

Megaselia stuntzi G. Bohart (fig. 5, *c*).

Adult: Small, dark brown, with abdomen entirely black and with costal fringe short; length 1.6 mm. *Puparium:* Minute lateral tubercles do not project beyond margin, except toward apex of abdomen; length 1.7 mm.

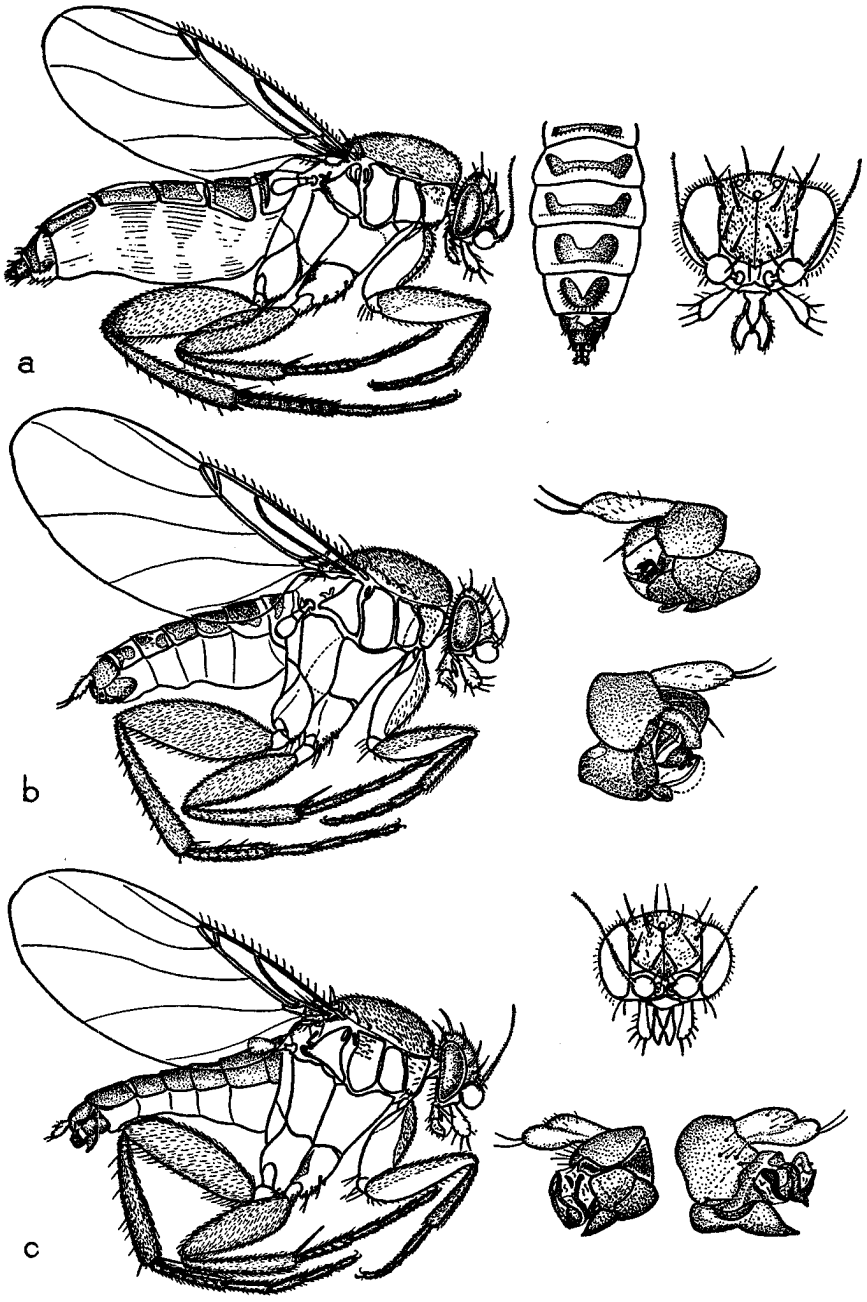

FIGURE 5.—Adults, including genitalia of males from right and left sides: a, *Megaselia scalaris,* female; b, *M. scalaris,* male; c, *M. stuntzi,* male.

Distribution: Guam.

The adult is attracted to carrion, and enters buildings to deposit eggs. Twice we reared larvae from decaying mollusks which had been left uncovered in the laboratory.

Recent examination of puparia preserved with and labeled as *M. scalaris* shows that this species was almost as abundant on mollusks as was *M. scalaris,* though apparently slower to develop. It is probably not generally significant medically because of its restricted food habits. The disposal of carrion and the protection of meats are the best controls.

Megaselia suis G. Bohart (fig. 6, *a*).

Adult: Small, yellow, bristly; abdomen yellow except baso-laterally and apically; thoracic pleura and frons creamy to yellow; length 1.3 mm.; length of wing 1.4 mm. *Larva:* Broad and smooth except for a few minute apical tubercles; spiracles testaceous, rounded, and slightly protuberant; length 2.4 mm. *Puparium:* Long, straight metathoracic respiratory tubes extend slightly beyond margins; lateral margins without visible tubercles; length 1.8 mm.

Distribution: Guam.

The adult was collected from vegetation, found flying close to feeding troughs in pig pens, and seen about houses and privies. The larvae breed in pig droppings in moist situations.

This species was collected from vegetation in various parts of the island but never commonly. If breeding is confined to pig feces, the medical significance is slight, if any. However, it would be well to clean up the pig pens.

Megaselia parabasiseta G. Bohart (fig. 6, *b*).

Adult: Posterior margin of mesopleuron has a bristle and a patch of small setae; length 1.2 mm.

The adult was collected but once, from dense jungle vegetation. Its life history is unknown.

Megaselia setifemur G. Bohart (fig. 6, *c*).

Adult: Ventral margin of hind femur with long basal hairs; mesopleural setae lacking; abdomen entirely black; length 1.3 mm.

We collected the adult in dense jungle vegetation. Its life history is unknown.

Genus **Parafannia** G. Bohart

This genus includes a single known species and has been taken only on Guam.

Parafannia molluscovora G. Bohart (fig. 7, *a*; pls. 1, 9).

Adult: Entire body sooty black, wings with radial vein unbranched; length 1.4 mm. *Egg:* Short-oval and covered with small, white, knobby protuberances; length 0.6 mm. (pl. 1). *Larva:* Strongly flattened dorsoventrally and with long, branched "*Fannia*-like"

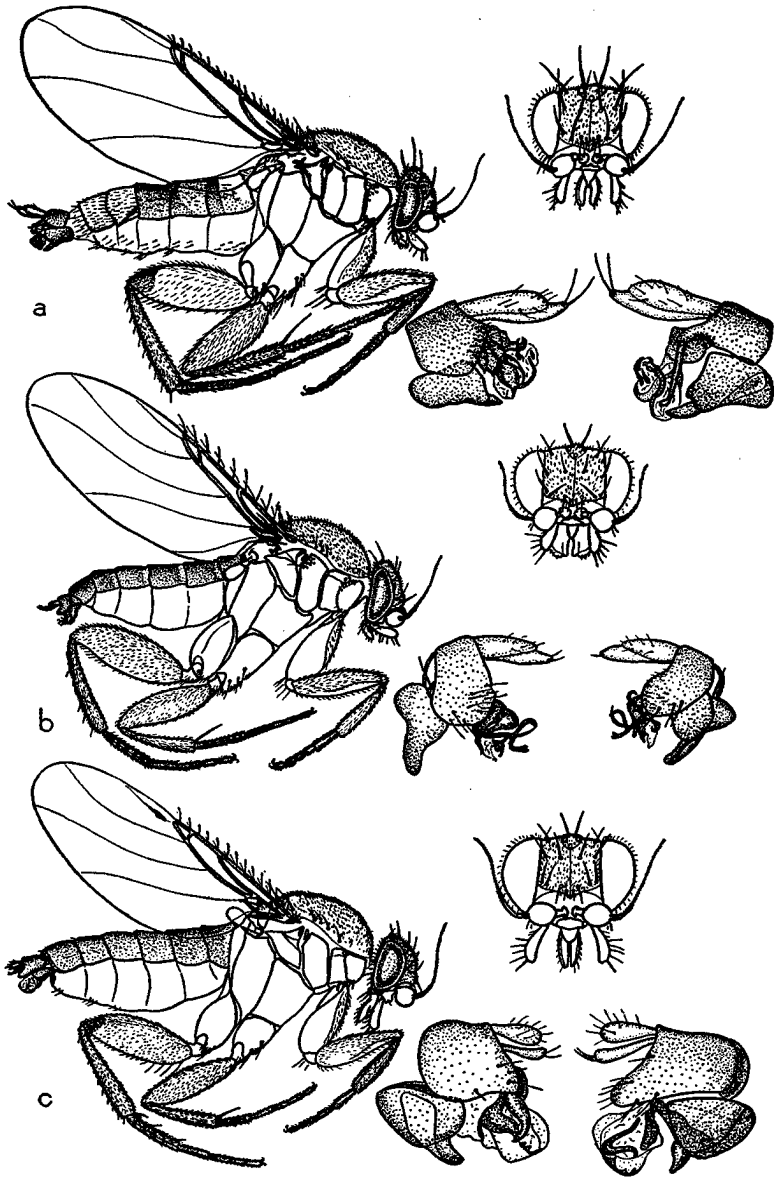

FIGURE 6.—Adult males, including genitalia from right and left sides: **a**, *Megaselia suis;* **b**, *M. parabasiseta;* **c**, *M. setifemur.*

projections laterally; posterior spiracles situated on a common protuberance; length 3 mm. *Puparium:* Similar to larva but with long straight metathoracic respiratory organs; length 3 mm. (pl. 9).

Distribution: Guam.

Adults were commonly seen flitting rapidly about on collections of decaying mollusks in the laboratory. When undisturbed, they walked over the surface of the shells and imbibed liquefied flesh until their abdomens were nearly spherical. The eggs were scattered singly in crevices of the shells, and the larvae generally fed along the edge of the liquefied contents of the shells. Many specimens were reared on woolen cloth saturated with liquefied mollusks.

This species is quite abundant on decaying shellfish but is seldom noticed because of its small size and its habit of crawling and flitting downward instead of upward when disturbed. It is probably not significant medically, but may hasten the spread and development of toxin-producing organisms on shellfish destined for human consumption, and intestinal myiasis might develop after the consumption of infested shellfish. Shellfish should be used promptly.

Genus **Diploneura** Lioy

Crepidopachys Enderlein.
Pronomiophora Enderlein.
Dohrniphora Dahl.

Except for *D. cornuta,* which is a general scavenger, most members of this genus are associated with ants.

Diploneura cornuta Bigot (fig. 7, *b*; pl. 9).

Dohrniphora venusta Coquillett.
Phora chlorogaster Becker.
Phora divaricata Aldrich.
Phora mordax Brues.
Phora cleghorni Bigot.

Adult: Anterior median bristle of frons directed backward; abdomen with first, anterior part of second, and anterior two-thirds of sixth tergites yellow; hind tibia with a pair of bristles on the basal third; length 2.3 mm. *Egg:* Oval, covered with small punctures, otherwise undifferentiated. *Larva:* Short, broad, especially posteriorly; laterally with processes which are at least one-fourth as long as body width and have short, appressed branches; length 2.8 mm. *Puparium:* Long straight metathoracic breathing trumpets beset on both margins with uniform setae; posterior end with long, spinose tubercles; length 2.7 mm. (pl. 9).

Distribution: Worldwide in tropical and temperate zones.

The adult, which we collected on sunlit vegetation and on milkweed blossoms, is also attracted to rotting vegetables and to meat on which it deposits scattered non-adherent eggs. The food habits of the larvae are apparently

nearly as extensive as those of *Megaselia scalaris*. *D. cornuta* has been reared in various parts of the world from such decaying vegetables as potatoes, onions, peas, and beans; from such decaying animal material as liver, dead insects, and rotting mollusks; from living grasshoppers; and from human excrement. On Guam, we reared it mainly on putrefying mollusks in association with several other species of phorids. There are also several records indicating that the larva may live in ant nests. Jones (55) gives an excellent account of the life history of this species feeding on dead insects in pitcher plants.

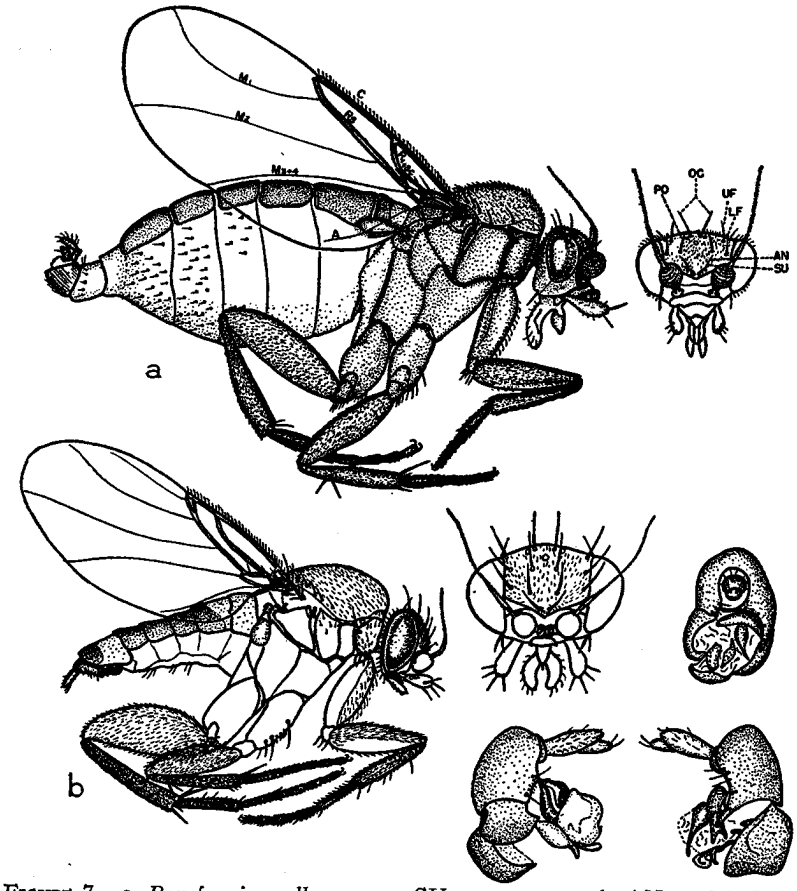

FIGURE 7.—**a**, *Parafannia molluscovora:* SU, supra-antennal; AN, antial; LF, lower frontal; UF, upper frontal; PO, pre-ocellar; OC, ocellar. **b**, *Diploneura cornuta,* adult male, including genitalia from right and left sides and from rear.

This fly is not as abundant on Guam as its associate, *Megaselia scalaris,* although collections of decaying mollusks usually attract it in numbers. Like *M. scalaris,* its omnivorous tastes and domestic habits make it a likely trans-

mitter of pathogens. As for *M. scalaris,* rapid incineration or burial of garbage, chemical treatment of privies, and prompt use of meats are the best controls.

Genus **Puliciphora** Dahl

Myrmomyia Sylvestri.

Adult: Female wingless, 1 to 2 mm. long; with a lunular gland on the fourth tergite; male minute, with unbranched radial vein and proclinate anterior frontal bristles. *Larva:* Broad and slightly tuberculate caudally, with spiracles on a short common protuberance, length 2 to 2.5 mm. *Puparium:* Very similar to that of *Megaselia,* but with posterior spiracles on narrower processes.

Distribution: Holarctica, Orient, and Australasia.

For adults, although members of this genus have been reported as inquilines in nests of ants and solitary bees, most of the records and our observations indicate that they are predominately scavengers on meat and other proteinaceous substances. The larvae also feed on meat, cheese, and other proteinaceous substances.

Puliciphora wymani G. Bohart (fig. 8, *a, b*; pls. 1, 9).

Adult female: Brown and wingless; posterior abdominal segments completely ringed with short setae; pleurae testaceous and frons generally indistinctly mottled with dark brown. *Adult male:* Genital capsule large and extending ventrally about one-third of the distance to the base of the abdomen. Length of both sexes about 1.5 to 2 mm. *Egg:* Short-oval, covered with longitudinal, interrupted white ridges; length 0.4 mm. (pl. 1). *Larva:* Caudal end broad and bearing 4 distinct subspiracular tubercles; posterior spiracles on conical protuberances which are joined from their bases to their middles; length 2 mm. *Puparium:* Similar in appearance to *Megaselia* puparium but with posterior spiracles closer and on more closely joined basal protuberances; length 1.6 mm. (pl. 9).

Distribution: Guam.

Adult females are especially attracted to mollusks and fish which rot in the dark. We found that mollusks buried under several inches of loose soil were soon infested with hundreds of them. The females adopt the typical phorid type of rapid, jerky gait. One individual was seen to engorge within five minutes until her abdomen was nearly spherical. The eggs are scattered singly in crevices at the margin of food materials. The larva breed in decaying mollusks and fish which are kept dark and moist. One dish of canned salmon bred so many of the species that the remains appeared to be a mass of puparia loosely glued together. Pupation occurs within or at the margin of the food, and the puparia are generally glued to the substratum.

This species is probably much more abundant than scattered collecting records indicate, because its preference for dark places and semi-subterranean situations makes it inconspicuous. It probably hastens spoilage in sea foods. Prompt use or preservation of meats and fish is advisable.

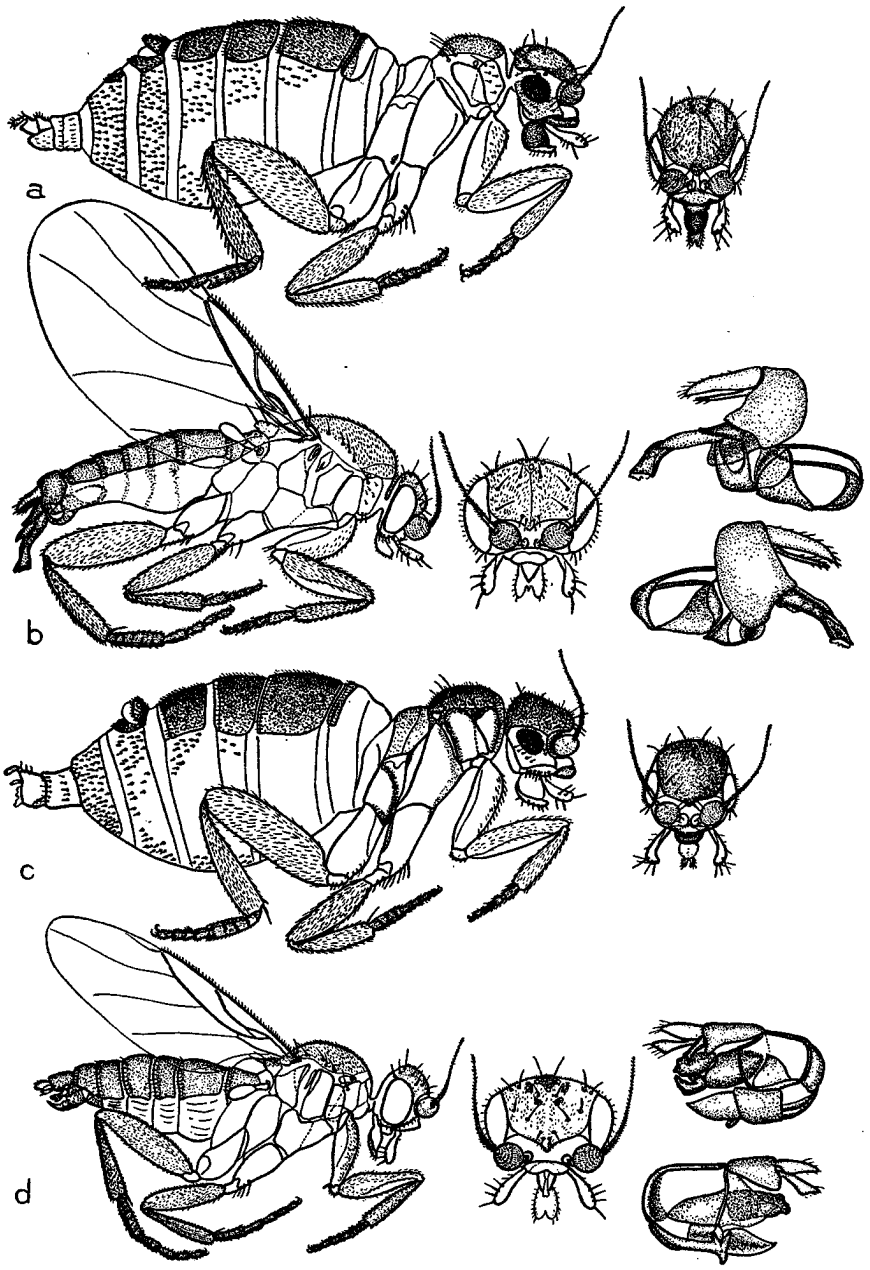

FIGURE 8.—Adults of *Puliciphora,* including genitalia of males from right and left sides: **a,** *P. wymani,* female; **b,** *P. wymani,* male; **c,** *P. nigriventris,* female; **d,** *P. nigriventris,* male.

Puliciphora nigriventris G. Bohart (fig. 8, *c*, *d*).

Adult female: Largely black, with frons entirely black and pleura extensively marked with black; fourth and fifth abdominal sternites bare laterally. *Adult male:* Resembles *P. wymani* but has smaller genitalia. The length of both sexes is about 1 to 1.5 mm. *Puparium:* Apparently identical with that of *P. wymani.*

Distribution: Guam.

We observed adults on rotting shellfish buried beneath several inches of loose earth and found their actions similar to those of *P. wymani.* A single large series of adults was bred from a collection of rotting shells.

Apparently this species is not as widespread as *P. wymani,* but we found it very numerous in one instance. When abundant, it probably hastens spoilage in sea foods. Prompt use of meats and fish is indicated.

Genus **Chonocephalus** Wandolleck

Adult female: Wingless, dorsoventrally flattened, and with a greatly enlarged frontal region; lacking conspicuous abdominal glands and with eyes smaller than antennae. The general appearance is that of a book louse (Atrophidae). *Adult male:* Winged, the wings covered with microtrichia; radial wing vein ending in a small loop and frontal region of head produced forward between antennal bases.

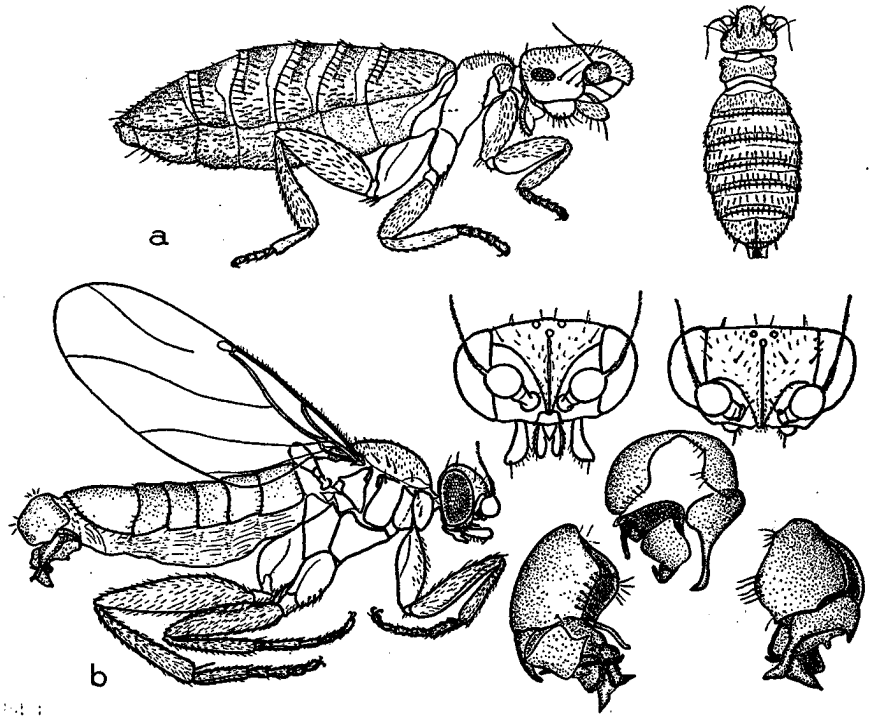

FIGURE 9.—*Chonocephalus hirsutus:* **a**, adult female; **b**, adult male, including genitalia from right and left sides and from rear.

As regards adult and larva, in spite of its great modification from the usual dipteran appearance, this genus does not seem to have particularly specialized habits. Available records indicate that known species are generally scavengers in detritus of vegetable origin or in decaying fruit (Schmitz, 112). However, unidentified larvae of this genus were collected on Guam in canned salmon exposed for bait. Males are attracted to lights, a habit which seems to be unusual among the Phoridae. Both of the Guam species were collected in light traps.

Chonocephalus hirsutus G. Bohart (fig. 9, *a, b*).

Adult female: Brown above and straw-colored beneath; dark abdominal bands fine and not extending to lateral margins; lateral border of abdomen with scattered hairs as strong as those of dorsal hair fringes; length 1.1 mm. *Adult male:* Similar to *C. subglaber* but with weaker frontal bristles and narrower median frontal groove.

Distribution: Guam.

One adult female was collected from pig dung at the Island Farm, and a male was swept from the air a few feet away. Another male was taken in a light trap. No definitely associated early stages of this species were found. It is possible that several *Chonocephalus* larvae found in canned salmon with larvae of *Puliciphora wymani* belong to this species.

Chonocephalus subglaber G. Bohart (fig. 10, *a, b*).

Adult female: Abdomen blackish brown above and creamy beneath, with dorsal black bands thick and complete; abdominal hair inconspicuous laterally on tergites except in subapical fringes; length 1.2 mm. *Adult male:* Like *C. hirsutus,* but with stronger and more regular frontal bristles. *Egg:* Short-oval and smooth but with a recurved, filamentous process at one end; length about 0.3 mm. *Larva:* Narrowed anteriorly and with a tubular caudal process several times as long as broad; length 2 mm. *Puparium:* Metathoracic spiracular tubes bifurcate from near their bases; caudal end of puparium with a tubular process; length 1.8 mm.

Distribution: Guam.

The adults are abundant on decaying woody materials and fruit, and are very common among dry debris in the leaf axils of dead *Pandanus* and the rotting stumps of papaya. In surface cavities of decaying breadfruit, where they are sometimes collected in solid masses, these flies have been observed to feed on fruiting bodies of fungi. We bred larvae from decaying papaya stump and from papaya fruit in the last stages of decay. They probably feed largely on fungi in such situations.

This is probably the most abundant fly on the island, since it can be found commonly in all sorts of decaying forest growth and is frequently found in swarms on decaying breadfruit. Its only medical significance is the possible occurrence of adults and larvae in stools of persons who have eaten infested fruit. Control of this species is probably impossible, and unnecessary under existing conditions.

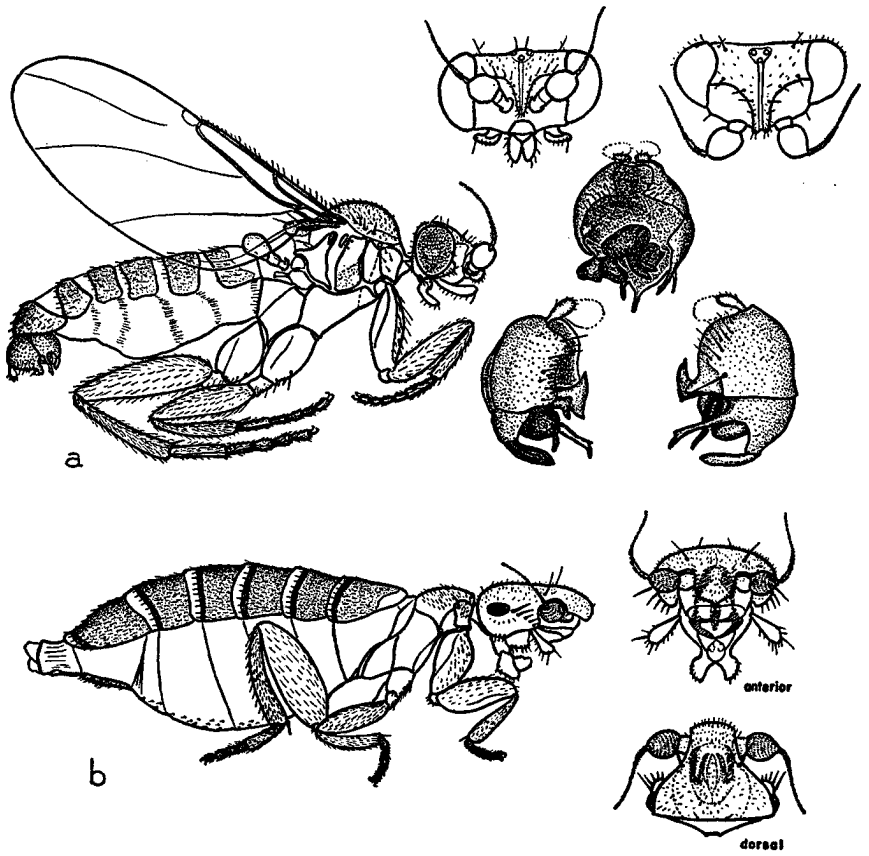

FIGURE 10.—*Chonocephalus subglaber;* **a,** adult male, including genitalia from right and left sides and from rear; **b,** female.

FAMILY SYRPHIDAE, FLOWER FLIES, HOVER FLIES

Adult: Moderate to large, without bristles, generally brightly marked; the wing with a spurious vein between R and M.

The larval habits of this large family are extremely varied, but one large section, the adult of which is characterized by a sharp downcurving of wing vein R_{4+5}, generally feeds on decaying organic materials in semi- or entirely aquatic environments, such as sewage, liquid mud, and water-filled privies.

Genus **Tubifera** Meigen (Drone Flies)

Eristalis Meigen.

Adult: Large and beelike, with vein R_{4+5} sharply downcurved before its apex. *Larva:* Rather robust, deeply wrinkled and provided with an extensible posterior breathing tube longer than the body when extended. *Puparium:* Breathing tube recurved dorsally and breathing trumpets appear through anterior abdominal portion of puparial sheath.

The adults frequent flowers and hover over highly organic liquids to deposit eggs. The larvae feed in liquid and semi-liquid wastes such as sewage, pig wallows, pools in garbage dumps, and water collected under animal sheds. They feed an inch below the surface, with the end of their respiratory tube making contact with the atmosphere.

Tubifera tenax, the commonest species in temperate regions, has been recorded in cases of intestinal and urinary myiasis (James, 50).

Tubifera arvora (Fabricius) (fig. 11, *a*; pl. 9).

Eristalis eunotata Bigot.

Eristalis quadrilineata Fabricius.

Eristalis tranquebarica Gmelin.

Adult: Large, brightly colored, with four longitudinal black stripes on the dorsum of the thorax and transverse black bands on the abdomen; length 10 mm. (fig. 11, *a*). *Egg:* Unknown, but eggs known for other species of *Tubifera* are laid upright in masses like those of *Culex* mosquitoes and have an embossed sculpturing of stellate bodies. *Larva:* Large and deeply wrinkled, with a posterior respiratory tube longer, when extended, than the body; length 14 mm. without respiratory tube. *Puparium:* Large, strongly arched dorsally; with long, dorsally recurved posterior tube and a pair of breathing trumpets dorsally on anterior portion of abdomen; length 9 mm. (pl. 9).

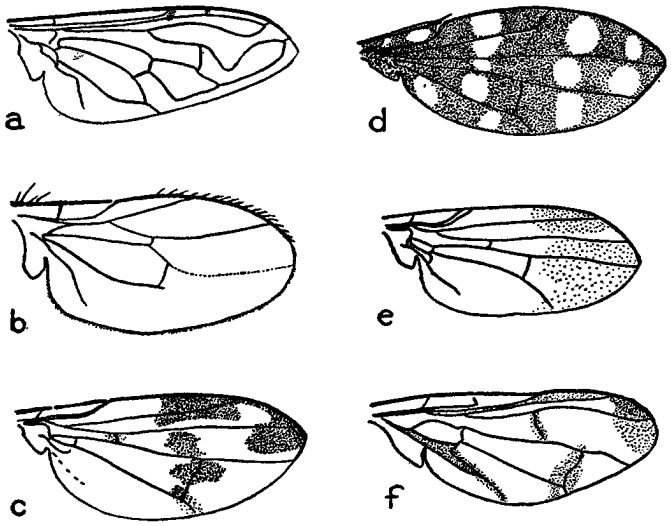

FIGURE 11.—Wings: **a**, *Tubifera arvora;* **b**, *Leptocera femorina;* **c**, *Discomyza maculipennis;* **d**, *Actocetor solitarius;* **e**, *Sobarocephala* sp.; **f**, *Dacus cucurbitae.*

Distribution: Central and eastern Asia and Pacific islands.

In common with most syrphids, this fly frequents blossoms from which it derives nectar and a few pollen grains. When not around flowers, it is seen hovering over foul water or mud. The eggs of related species are laid in masses directly upon water or liquid mud. On Okinawa, larvae were seen

breeding in city gutters which carried the run-off from outdoor toilets, and it was found in great abundance in outdoor toilet basins filled with rainwater and feces. On one occasion on Guam, a puparium was taken from a pile of mixed silage and manure.

This species is not common on Guam, perhaps because the porous coral rock of the island allows contaminated liquids to soak underground rapidly, hence it is not medically significant there. However, since it enters houses rather freely, it could carry fecal pathogens, especially to the milk which it sometimes visits in houses. Drains for liquid wastes should be covered or properly graded; and infested liquid should be treated with heavy deposits of DDT, though this syrphid is remarkably resistant in contaminated water.

Series SCHIZOPHORA (Cyclorrhapha with a Ptilinum)

Adult: "Typical" Cyclorrhapha, in possessing a frontal lunule and suture and a dorsal bristle on the third antennal segment. *Puparium:* Breathing horns of the anterior abdominal region minute or absent.

This is a very large group with diverse habits. The blood-sucking habit of the adult stage is common to both sexes. The larval stage is occasionally aquatic but the pupal stage is almost always terrestrial.

Section ACALYPTERATA (Non-Muscoids)

Adult: Calypteres (squamae) at wing bases absent or rudimentary; suture across anterior third of mesonotum incomplete or absent; second antennal segment without a dorsolateral seam. *Larva* and *puparium:* Spiracles generally protuberant and not in a sunken area.

This large group is one of diverse habits. The filth-inhabiting forms usually are secondary or tertiary invaders of concentrated substances such as meat or human excrement. This section is generally considered to be of no consequence in disease transmission, and its role is undoubtedly a lesser one than that of the muscoid section. Several genera in the Pacific, however, are a real menace under tropical living conditions.

Family CYPSELIDAE (SPHAEROCERIDAE, BORBORIDAE), Minute Scavenger Flies

Adult: Small, black or dark brown, with short, thick metatarsi, incomplete subcostal vein and short, nearly round antennae.

All known members of this family breed in moist decaying vegetation or in excrement. Adults are frequently seen swarming about piles of fresh horse manure or close to the surface of freshly turned swamp muck.

Genus **Leptocera** Olivier

Limosina Macquart.

Adult: Minute, thickset, with very strong bristles at the vibrissal angles; wings with discal cell sharply truncate apically and with the cubital vein ending at or a short distance beyond that truncation.

Though this large genus has frequently been reared from human excrement (Howard, 41), we did not find it in such material on Guam. However, it is probable that we would have found it with further investigation. It is most commonly observed breeding in manure from herbivorous mammals or in dense masses of rotting vegetation.

Leptocera femorina Richards[4] (fig. 11, *b*; pl. 12).

Adult: Wings with discal cell about two-thirds as wide at distal end as at middle (fig. 11, *b*); head and sides of thorax with considerable tawny yellow; length 1.2 mm. *Larva:* Anterior end of mature specimens has a pair of long, tapering processes; posterior spiracular plates with fingerlike projections; length 2 mm. *Puparium:* With a pair of processes on the anterior margin which are longer than the width of the puparium and curved like the horns of a steer. Anterior region slender and elongate; length 2 mm. (pl. 12).

Adults of *L. femorina* were seen on a variety of substances, including loose piles of garbage; swamp muck; human, bovine, and pig excrement; and breadfruit in the last stages of decay. Like members of the Phoridae they have rapid, running movements but take fewer short flights. They apparently feed on moisture and slime from decaying substances. They do not readily enter dwellings, but were abundant in open cattle sheds. We reared larvae from a pile of decaying aquatic vegetation, moist heaps of cow manure, and from fresh cattle droppings. The maggots seemed to prefer the dampest portions of the medium, but pupation occurred at the edge of the moist area.

One of the most abundant flies on the island, we found that large swampy areas near Agana supported a uniformly high population of this species. However, it is probably of little medical importance, since it does not frequent food or dwellings or human or animal bodies. However, it might contaminate milk in dairies. The practicality of any control is doubtful.

Five other species of *Leptocera* were collected on Guam, all of them by sweeping over the garbage dump at Pago; but their breeding habits were not investigated. (See footnote 4.)

Family EPHYDRIDAE, Shore Flies

Adult: Small, robust, with face more or less convex, often strikingly so, and usually with oral cavity very large; antennae usually broadly pectinate; wings with basal and anal cells incomplete or absent.

[4] Richards' paper includes descriptions of *Leptocera femorina, L. collinella,* and *L. conica,* new spp., and a record of *Leptocera atoma* Rondani, all from material collected on Guam in the course of the present study.

The adults characteristically fly close to the water surface skating on it when disturbed. However, some species frequent flowers of aquatic plants and others are attracted to carrion and human excrement. The larvae are usually aquatic or semi-aquatic and frequent saline waters. Many species breed in muddy puddles, many of which are highly impregnated with animal feces.

Genus **Chlorichaeta** Becker

Apparently nothing has been known previously about the habits of this genus.

Chlorichaeta tuberculosa Becker.

Adult: Polished, black, with milky wings and a shining but strongly tuberculate face; length about 1.8 mm.

In May 1945, adults of this species were very abundant and troublesome at a Naval rest camp, where they persistently flew about eyes and noses, especially those of people who were perspiring heavily. A month later, it was much less common and displayed little of this annoying habit; but it was collected in rather large numbers over a large septic tank in which it may have been breeding. On other parts of the island it was taken occasionally in traps baited with carrion and was observed to visit fresh deposits of human excrement.

This fly was moderately common in cleared areas, but we saw it in pestiferous numbers only once. Like eye flies of the chloropid genus *Hippelates,* it is a potential mechanical carrier of opthalmic infections and of other surface infections, such as yaws. Its liking for excrement makes it a possible carrier of enteric diseases, especially when it is abundant enough to be accidentally ingested. Significant outbreaks of adults could probably be controlled by area spraying of DDT from airplanes or large aerosol generators. Not enough is known of the larval habits to recommend a control for this stage.

Genus **Hecamede** Haliday

One species of *Hecamede,* perhaps the same as the one on Guam, was found commonly along sea beaches in the Solomons, where it fed in large numbers on garbage which had been washed onto the beach during storms.

Hecamede persimilis Hendel (pl. 11).

Adult: Small, very robust, pearly gray, with a round, bare callosity at the middle of the face below the antennae. *Puparium:* Strongly segmented and robust, with a steep declivity on the anterior face of the fourth segment; posterior end without tubercles and with spiracles projecting knoblike; length 1.2 mm. (pl. 11).

Distribution: Pacific islands.

Adults are abundant along sea beaches, where they frequent moist sand

and low-growing beach vegetation and where several specimens were seen about dead fish trapped by low tide. They were also collected, though rarely, by sweeping vegetation in coconut groves a mile or more from the sea. On one occasion, the maggots were observed in large numbers in damp, foul-smelling sand beneath a human carcass in company with puparia of *Chrysomya "nigripes"* and *Pseudeuxesta prima*. Puparia were found with the larvae.

This is an extremely common fly along the sea beaches but its numbers dwindle rapidly inland. It is probably of no medical significance. Adults of the same or a related species were almost completely eradicated along a beach on Guadalcanal by use of a thermal aerosol generator dispersing DDT.

Genus **Allotrichoma** Becker

Like most ephydrids, this genus is commonly collected on drying mud puddles, along the edges of waterholes, and in similar places.

Allotrichoma species (pl. 11).

Adult: Minute, dark gray, with smooth, gray-green face and with antennal arista bearing four long bristles dorsally; length 1.8 mm. *Larva:* Robust, with posterior end encircled by 10 distinct tuberculae; length 2 mm. *Puparium:* Posterior end broad and ringed with 10 tuberculae; breathing trumpets absent; length 1.6 mm. (pl. 11).

Adults swarm around foul-smelling mud and puddles and are especially abundant in the mud of pig pens around feeding troughs where contamination by garbage and pig feces is heavy. The larvae breed in pig droppings and pupate at the surface of the droppings. Although maggots were not observed in the contaminated mud of pig pens, it is probable that most of them develop there.

This fly is extremely common wherever found. It is apparently not present around mud which is free from contamination. It probably has no medical significance, and control is unnecessary.

Genus **Discomyza** Meigen

Notiphila Fallen.
Homalura Meigen (of Wiedemann, in part).

Larvae of *Discomyza incurva* and *D. maculipennis* have been reported breeding in mollusks, the former sometimes in living land snails.

Discomyza maculipennis (Wiedemann) (fig. 11, *c*; pls. 1, 11).

Notiphila maculipennis Wiedemann.
Homalura maculipennis Wiedemann.
Discomyza obscurata Walker.
Discomyza balioptera Loew.
Discomyza pelagica Frauenfeld.
Discomyza amabilis Kertesz.

Adult: Large ephydrid; abdomen flat; thorax mottled and sculptured with silvery gray; face bright metallic green and transversely rugose; wings with five gray areas. Length 3.5 to 4 mm. (fig. 11, *c*). *Egg:* Nearly oval and somewhat flat on the bottom which is covered with small oval chalky white depressions; upper side with coarse, elongate reticulae; length 0.9 mm. (pl. 1). *Larva:* Dorsoventrally flattened and rather elongate; laterally and posteriorly with long leglike processes, most of which bear short lateral spines and a basal branch; posterior spiracles on a dorsally directed prominence; length about 7.5 to 8.5 mm. *Puparium:* Similar in size and shape to larva but amber-colored and rigid; pupa contained within posterior two-thirds of puparium; length 8 mm. (pl. 11).

Distribution: West Indies, southeastern Asia, Formosa, the Philippines, the Solomons, Guam, and Hawaii.

Most of our records of *D. maculipennis* are from carrion-baited traps and from large carcasses in the field. One trap, baited with rotten tomatoes, attracted several individuals; and they were also collected from the garbage dump at Pago. This fly mates readily when reared and held captive in small tubes, a mating pair remaining in contact for as long as 15 minutes. Eggs are laid within a few hours after mating and are scattered freely, whether food is present or not. Larvae were collected in the field from a human carcass several weeks old in which most of the maggots were in deep muscle tissue. They were also taken in company with phorids and *Fannia pusio* in collections of rotting mollusks; and in the laboratory, they were reared readily on liver. The maggots are very active and, when disturbed, raise their hind portions in the air. They do not shrink upon pupation, but stay on the food substance and plaster themselves rather firmly to it.

Although our bait traps usually contained this species, the number was generally small. As it may hasten spoilage of mollusks and other meat, proper use and disposal of meat and carrion is advisable. Its presence in cadavers may be of some medico-legal importance.

Genus **Paralimna** Loew

Adults of this genus are characteristic inhabitants of areas with wet muddy soils. Pig pens seem to furnish ideal conditions for several species.

Paralimna aequalis Cresson (pl. 11).

Adult: Medium-sized, dark, dull greenish, with long bristles; face strongly convex and smooth; arista with about 10 long branches above; length 3 mm. *Larva:* Moderately robust; with posterior spiracles on knoblike protuberances; anterior spiracles with two fingerlike processes; length 4 mm. *Puparium:* About two-fifths as long as broad; anterior portion strongly depressed; anterior spiracles divided into two fingerlike processes on a short stalk at each anterolateral angle of the puparium; length 3.5 mm. (pl. 11).

Adults—which swarm about organic muds, contaminated road puddles, and so forth—are especially abundant around bogs below Agana Spring and in the Government Farm pig pens. Pig droppings are likely to be covered

with feeding individuals of this species. We found the larvae breeding in moist pig droppings and suspected them of breeding in mud contaminated with feces and garbage, although limited observation failed to reveal the latter.

This species is extremely common around suitable muds, but probably has no medical significance. No control is necessary.

Genus **Octhera** Latreille

This genus is aquatic in the larval stage and predaceous upon aquatic insect larvae in the adult stage. Adults fly close to the water surface and skate upon it for short intervals in order to grasp their prey with their raptorial fore legs.

Octhera canescens Cresson.

Adult: Large ephydrid, with greatly enlarged fore femora and apically produced fore tibiae; length 6 mm.

Adults were common around road pools near the Pago garbage dump, where their prey consisted mainly of *Culex* mosquito larvae; but several individuals visited nearby deposits of human excrement, perhaps in search of maggots.

Genus **Placopsidella** Kertesz

No records have been found on the habits of this small genus.

Placopsidella cyanocephala Kertesz.

Placopsidella leparoides de Meijere.

Adult: Robust, with very short bristles, simple arista, and a bare median ridge along face and clypeus; length 3 mm.

Distribution: Java, New Guinea, Guam.

A few specimens of this species were taken in traps baited with echinoderms or sea cucumbers.

Genus **Actocetor** Becker

This genus is apparently not associated with aquatic environments. We have seen two specimens of the species in the National Museum which were labeled "from foliage" and "from decaying fruit infested with fruit flies."

Actocetor solitarius Cresson (fig. 11, *d*).

Adult: Small, black, with black wings which have a pattern of circular white spots arranged in transverse rows; length 2 mm. (fig. 11, *d*).

Distribution: Marianas Islands.

A strikingly marked fly, this species was abundant on large leaves of breadfruit, papaya, and so forth in and around native villages. It was also

collected a number of times in carrion-baited traps and on the garbage dump at Pago, and was observed on deposits of human excrement. It has been reported as common in army latrines on Saipan.

Though a common species, we never saw *A. solitarius* in the swarms of mud-loving species encountered. It is of possible significance in the mechanical transmission of enteric pathogens, particularly where kitchens and eating places are partially or wholly outdoors. Area spraying with DDT by airplanes would probably temporarily eradicate adults.

Genus **Brachydeutera** Loew

The National Museum collection contains specimens of *Brachydeutera argentata* collected around puddles in the United States. One specimen, collected by Sanborn, is mounted with its puparium and has a label note to the effect that the pupae are always found on pools with the ventral side in contact with the surface. The pupa, by virtue of its long, bifurcate process, is quite distinct from those of ephydrids of other genera which were found on Guam.

Brachydeutera longipes Hendel.

Adult: Medium-sized ephydrid; dark brown above and blue-gray laterally and below; abdominal sterna and basal half of coxae straw-colored; bristles inconspicuous; mouth opening very large; length 3.2 mm.

Adults are abundant around muddy water, in company with *Paralimna aequalis,* especially on the contaminated liquid mud of carabao wallows. However, we did not see it in pig pens at the Government Farm. It is probable, in view of the habits of other species of the genus, that the larva breeds in carabao wallows and other small bodies of stagnant water.

Genus **Parydra** Stenhammer

No published records were found on the habits of this genus.

Parydra species.

Adult: Medium-sized, dull brownish to brownish-green ephydrid, resembling *Paralimna aequalis* but with shorter bristles; length 3.2 mm.

This species was collected from carabao wallows together with *Paralimna aequalis.*

Family CLUSIIDAE

According to Curran (13), adults of this family are found in moist places about decaying wood and their larvae generally feed under bark. He states also that the larvae leap readily, using a pair of anal horns for this purpose.

Genus **Sobarocephala** Czerny

Several species of this genus have been reared from rotting wood, and the maggots are often found under dead bark. *Sobarocephala lachnosterna* was collected in Virginia by Shannon from rotten wood. Its puparium has the posterior spiracles on a pair of thornlike, upcurved projections.

Sobarocephala species (fig. 11, *e*).

Adult: Small, slender, testaceous, with abdomen, frons, posterior half of mesonotum, and upper part of mesopleuron shiny black; apical third of wing cloudy; length 2.1 to 2.5 mm. (fig. 11, *e*).

The adult was collected several times on human feces and was taken in traps baited with carrion. It was also caught in light traps.

Family Tephritidae (Trypetidae, Trupanaeidae), Fruit Flies

This is a large and economically important family of flies, whose maggots usually feed in growing and ripe fruit. The melon fruit fly, *Dacus cucurbitae,* is included in this paper because its larvae sometimes occur on cucurbits. These might cause temporary intestinal irritation or be mistaken for parasites when discovered in stools. Another reason for its inclusion is its association with true scavengers in rotting cucurbits.

Genus **Dacus** Fabricius

Chaetodacus Bezzi.
Bactrocera Guérin-Menéville.

This is a large genus of fruit flies, the members of which are often quite specific as to the family or genus of fruit they attack.

Dacus cucurbitae Coquillett (fig. 11, *f*).

Adult: Medium-sized, pale brown, with ivory-colored thoracic markings and dark bands along the costal margin and posterior cross-vein of the wing; length 7 mm. (fig. 11, *f*). *Egg:* White, slender, elliptical, subacute anteriorly, and narrowly rounded posteriorly; surface smooth, ungrooved; length 1.2 mm. *Larva:* Posterior spiracles weakly pigmented except for the slits, which are brownish and transverse so that those of one spiracle are in line with those of the other; length 10 mm. *Puparium:* Straw-colored, short, and cylindrical, with non-projecting spiracles which have the slits arranged as in larva; length 5.5 mm.

Distribution: Pacific islands and Asia.

The adult is seen commonly around plantings of cucurbits, where it feeds on the blossoms and forces its ovipositor into the young fruits at about the time the corolla withers. In common with other fruit flies and various families of acalypterates, the adult rotates its wings while perched on plants. The larva feeds in growing cucurbit fruits, usually green ones. However, mag-

gots are sometimes found in cucumbers ripe enough for the table. When the cucumbers are quite rotten, the maggots are found in company with those of *Atherigona orientalis* and with adult *Chonocephalus*. Pupation takes place in the soil near the fruits.

This species is common in vegetable gardens, and it can cause transitory false intestinal myiasis. Late blossoms and young fruits of cucurbits can be protected by bagging.

Family Tylidae (Micropezidae, Calobatidae), Stilt-legged Flies

According to Curran (13), the adults frequent moist, wooded situations and the larvae are frequent scavengers, some species breeding in excrement.

Genus **Mimegralla** Rondani

This genus is closely related to several genera in the subfamily Calobatinae, most of which are strongly attracted to human feces in damp, shady places and may breed in them to some extent. The adults characteristically have pale front tarsi which they wave in the air.

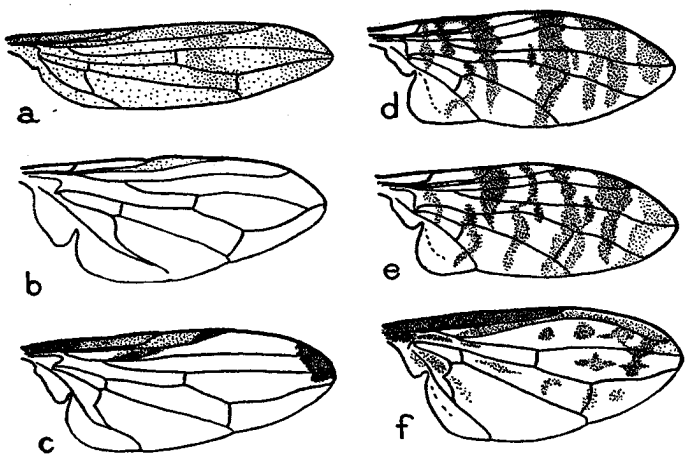

Figure 12.—Wings: a, *Mimegralla albimana galbula;* b, *Chrysomyza aenea;* c, *Acrosticta apicalis;* d, *Scholastes aitapensis;* e, *S. hirtiventris;* f, *Notogramma stigma.*

Mimegralla albimana galbula Osten-Sacken (fig. 12, *a*; pl. 3).

Adult: Long, slender, with extremely long legs and long wings; body black, face black, silvery and pale; femora testaceous; tarsi whitish; length 7 mm. (fig. 12, *a*). *Egg:* White, fusiform, subacute at anterior end and rounded posteriorly; surface is marked with faint, longitudinal subrectangular reticulations; length about 1.0 mm. (pl. 3). *Larva:* Elongate, without tubercles; anterior spiracles semicircular; posterior spiracles developed into short thornlike processes dorsolaterally; length 11 mm. *Puparium:* Elon-

gate oval, slightly compressed dorsoventrally, but rounded at sides and without lateral margins; posterior end with a few strong concentric carinae and with each spiracular plate developed into a thornlike process dorsolaterally; length 7 mm.; breadth 1.9 mm.

Distribution: Ryukyu Islands, Botel-Tobago (Kotosho) Island, Guam, and the Philippines.

The adult of this species, which is found on vegetation in damp shady places, particularly near filthy situations, is commonly attracted to human feces and to garbage. The flies run about or walk on leaves, trunks, or filthy surfaces, generally waving their fore legs in the air. Larvae were reared on Guam in 1938 by R. G. Oakley from banana roots. (*Mimegralla albimana albimana* was reared from under bark of dead trees in Guadalcanal.)

This species is moderately common in shady places. It gathers quickly around fresh deposits of excrement. Because it is attracted to human feces, garbage, and food, it could transmit pathogens to human food, especially when meals are eaten in shady out-door places. The proper disposal of wastes and the protection of food from the flies are the correct controls.

Family DROSOPHILIDAE, Pomace Flies, Small Fruit Flies

Adult: Small, usually yellow to reddish brown; third antennal segment oval or nearly round and with plumose arista; subcosta incomplete; costa broken twice; anal cell present and second basal cell generally not differentiated.

The larva is usually found in fungi, sap, ripe fruit, and spoiling vegetables; and it is generally believed that the maggots feed on yeasts and fungi developing in such substances. Several species breed in nearly empty milk bottles and others, on occasion, breed in carrion and excrement.

Genus **Chaetodrosophilella** Duda

This genus has been considered a subgenus of *Drosophila* by some authors. Its habits appear to be typical of that genus.

Chaetodrosophilella quadrilineata (de Meijere) (pls. 1, 12).

Adult: Large drosophilid with six longitudinal dark stripes on its thorax, the median pair extending along the scutellum and the lateral pair ending at the wing bases; length 3.2 mm. *Egg:* Oval, with four long filaments at the anterior end, the longer pair about two-thirds as long as the egg and twice as long as the shorter pair; length 0.6 mm. (pl. 1). *Larva:* Moderately elongate, with dorsally directed posterior spiracular stalks about twice as long as broad and mounted on a common protuberance of similar length, the whole apparatus a little shorter than vertical portion of caudal end; posterior spiracles surrounded by two pairs of prominent basal tubercles; length 5 to 6 mm. *Puparium:* Anterior spiracular stalks over five times as long as broad, with the longest processes about two-thirds as long as stalks; posterior spiracles about twice as long as broad; length 4.2 mm. (pl. 12).

This is one of the most abundant drosophilids on the island, and it is more conspicuous than the others because of its large size and bright markings. The adult is common on all sorts of decaying fruits. It feeds on oozing portions, and when disturbed, flies slowly around the fruit for a few seconds before resettling. Eggs are thrust into cut or broken moist surfaces or into oozing cracks of the fruit. Generally, only the filaments of the eggs remain exposed. The larva feeds in decaying fruits, presumably on yeasts developing therein. We reared specimens from breadfruit, bananas, mangoes, and papayas. Pupation occurs at, or close to, the surface of the fruit, the anterior end of the larva generally in contact with it. Some larvae migrate an inch or more from the fruit before pupating.

Flies from dumps containing garbage and human wastes contaminate food; and transitory or false intestinal myiasis can result from eating infested ripe fruit. Therefore, ripe fruit should be well-covered, dropped fruit should be gathered and disposed of, and garbage should be buried quickly.

Genus **Drosophila** Fallen

Adult: Small, slow-flying, tawny, with six or more rows of presutural acrostical bristles and four rows of bristles between the dorsocentrals. *Egg* has paired filaments of various sizes and shapes surrounding a flattened area at the anterior end. *Larva:* Posterior spiracles on a pair of adjacent cylindrical processes which may be long or short. *Puparium:* Dorsoventrally compressed and dorsally depressed on the anterior third; anterior spiracles on long or short stalks and divided into numerous long fingerlike processes.

Adults are commonly attracted to ripe fruits and to sap from trees, but many species also visit vinegar vats, rotting vegetables, and human excrement. They can be baited with various chemicals in the acetate series and with the essential oils of most fruits. Larvae normally breed in decaying fruits or vegetables or in flowing tree sap, and the larval food is supposed to consist of yeasts developing on these substances. Laboratory cultures of maggots have been reared on various types of yeasts. Some species have more generalized larval habits, however. Sturtevant (123) records *D. ananassae* larvae in human excrement, and labels on specimens of *D. buskii* in the United States National Museum include "living on cadavers in medical research laboratory" (T. H. Parker) and "reared in numbers from horse manure in Michigan" (A. F. Shull). According to Lesne (66), *D. funebris* was reared from cesspools in France. All of the above species normally breed in decaying fruits and vegetables.

Several of the following species were taken only in incidental collecting, but further biological studies on Guam would probably reveal occasional instances of coprophagous habits for most of them.

Drosophila ananassae Doleschall (pls. 1, 12).

Adult: Small, tawny, with abdominal tergites dark, at least subapically, and with thorax and face unicolorous orange; length 2.5 mm. *Egg:* Anterior end with two long, clubbed filaments; length 0.7 mm. (pl. 1). *Larva:* Rather elongate, active; posterior spiracles on parallel tubes about three times as long as broad; length 4.5 mm. *Puparium:* Anterior spiracles on stalks about twice as long as broad and with numerous knobbed filamentous branches. Posterior spiracles on divergent stalks about three times as long as broad; length 2.9 mm., breadth at middle 0.8 mm. (pl. 12).

Distribution: Oriental, Australasian, and Neotropical regions.

This adult feeds on and buzzes slowly around decaying fruits and souring saps, and a few specimens were taken in a trap baited with human feces. The eggs are inserted in many types of fermenting and souring substances, including fruits or vegetables still on the plant. Larvae were reared on Guam from breadfruit, bananas, apples, papayas, and sour sop. As previously mentioned it has been found breeding in human excrement in tropical America.

This is the most abundant drosophilid on Guam, especially around villages where fallen fruit is allowed to accumulate. Adults occasionally visit human excrement and commonly frequent houses and kitchens where they feed on milk and on banana and other preparations. As larvae may be ingested and cause some irritation to the bowels and considerable anxiety when discovered in stools, such foods should be kept covered. Dropped fruit should be disposed of and garbage buried quickly.

Drosophila melanogaster Meigen.

Drosophila ampelophila Loew.

Chyliza persicorum Weyenberg.

Adult: Very similar to *D. ananassae,* but paler in color and with a comb on the tarsus of the male. *Egg:* Anterior end with two long filaments slightly thickened terminally. *Larva* and *pupa:* As we confused the early stages of this species with *D. ananassae* in our rearing, they are evidently quite similar at this stage.

Distribution: Worldwide, in both temperate and tropical regions.

The adult has habits much like those for *D. ananassae,* but this species is more commonly seen in kitchens and garbage dumps. (There are numerous published accounts concerning its habits in laboratory cultures but they are outside the scope of this study.) Because of its attraction to pickles and vinegar, it is sometimes called the vinegar or pomace fly. Our larval records for this species on Guam are confused with those of *D. ananassae,* as we have pointed out. In the course of many attempts to colonize it for genetic studies various students have cultured the larvae on a wide variety of materials on which yeasts develop, and in agar suspensions of the yeasts themselves. The species does well in confinement and mates and lays eggs in rather small containers.

A tally of adult specimens taken on Guam shows that *D. melanogaster* is nearly as common as *D. ananassae* and can be controlled similarly.

Drosophila species **a** (pls. 1, 12).

Adult: Small, with black abdomen and entirely creamy thorax; scutellar bristles with anterior pair only one-half as long as posterior pair; length 2 mm. *Egg:* Anterior end surrounded by six subequal filaments, each about two-thirds as long as the egg; length 0.4 mm. (pl. 1). *Larva:* Posterior spiracular processes plus their common basal protuberance, when extended, at least one-third as long as the larva; length 4.5 mm. *Puparium:* Anterior spiracles on very short, scarcely visible stalks; posterior spiracles on long, contiguous tubes; length 4 mm. (pl. 12).

The adult, which is common around rotting breadfruit on the ground, is less common in dwellings than *D. melanogaster.* The eggs are inserted in oozing interplacular grooves of breadfruit and cut or broken surfaces; in the latter, sometimes so thickly that the whole surface is covered with their radiating filaments. The larva, very common and active in decaying breadfruit and probably in other fruits, is the most active species of drosophilid larvae on Guam.

Although adults were not encountered as frequently as some of the other drosophilids of Guam, eggs were more abundant in fallen breadfruit during the period of maximum fruit drop than were those of any other. These flies, like *Chaetodrosophilella quadrilineata,* go from garbage dumps and human waste to food, and infested fruits can cause transitory or false intestinal myiasis. Therefore, ripe fruit should be kept covered; dropped fruit should be disposed of; and garbage, buried.

Drosophila polychaeta Patton and Wheeler.

Adult: Large, with three pairs of strong mesonotal bristles; length 3.2 mm.

This species was collected flying over the garbage dump at Pilgo River. Its habits are presumably similar to those of other *Drosophila.* It is apparently uncommon.

Drosophila takahashii Sturtevant (pl. 1).

Adult: Moderately large with rather strong thoracic vestiture; anterior scutellar bristles two-thirds as long as posterior ones; length 2.7 mm. *Egg:* With four long filaments, the longest pair longer than the egg; length (without filaments) 0.8 mm. (pl. 1).

Both the adult and the larva are similar in habits to those of *D. ananassae,* but are less common and more restricted in food habits. Eggs were found only in breadfruit on Guam.

Drosophila species **b.**

Adult: Moderately large, with abdominal segments black on apical two-thirds; thoracic vestiture minute; anterior scutellar bristles only half as long as posterior ones; length 3 mm.

This is the most abundant species on the garbage dump at Pilgo River. Its habits in all stages are probably similar to those of most other *Drosophila.*

Genus **Microdrosophila** Malloch

This is a small genus whose habits are probably similar to those of *Drosophila.*

Microdrosophila congesta Zetterstedt.

Adult: Rather small, with antennal arista bearing at least 10 branches.

A few adults were collected on the garbage dump at Pilgo River.

Genus **Mycodrosophila** Oldenberg

This genus is generally considered purely fungivorous but has been reported as infesting decayed fruit.

Mycodrosophila species.

Adult: Body pale testaceous, except for broad grayish area at middle of thorax; length 2 mm. *Egg:* Unknown, but those of related species are without filaments.

We collected adults from fungous-covered dead wood in dense jungles.

Genus **Leucophenga** Mik

Like *Mycodrosophila,* this genus is largely fungivorous and inhabits damp, shady places.

Leucophenga nigriventris Macquart.

Adult: Abdomen jet black and posterior portion of thorax dark gray; length 2.4 mm.

Adults were collected on dense jungle foliage, and a few were taken in light traps.

Family LONCHAEIDAE, the Lonchaeids

Adult: This family includes small black or metallic species with long wings and with the abdomen broad basally and attenuated posteriorly. The arista is rather long, sometimes bristly and sometimes bare. The costa is unbroken.

The adults of this family sit on the ends of twigs, and most species are attracted to a wide variety of putrefying substances, including human feces. The larvae are recorded as predaceous on larvae under bark and as scavengers in various roots, stems, fruits, nuts, bulbs, and carrion. Howard (41) records *Lonchaea polita* maggots from human excrement and mentions a European species found in a cadaver.

Genus **Lonchaea** Fallen

The remarks under the family Lonchaeidae apply mainly to members of this genus, which is the largest in the family and the only one on Guam.

Lonchaea (Carpolonchaea) filifera Bezzi (pls. 4, 11).

Adult: Body black; squamae white; wing yellowish; antenna with very long, bristly arista; length 3.4 mm; length of wing 3.3 mm. *Larva:* White, elongate, enlarged caudally as in *Stomoxys;* spiracles small, but prominent, subdorsal, each with a transparent thorn-like process; length 7 mm. (pl. 4). *Puparium:* Short, rather broad, shining but with finely striated surface; posterior spiracles prominent, roughened, projecting dorsally; caudal end with strong transverse striae meeting at the impressed midline; length 3.2 mm. (pl. 11).

Distribution: Pacific islands and East Indies.

Adults, which are found around animal and human excrement, pig pens, and other filthy situations, were taken commonly in privies both in Guam and Saipan. In the Philippines, W. D. Pierce baited them with sugar and molasses. The larvae feed in pig manure. A number of maggots form a cell inside the manure, eating on the surface of the cell toward the outside. They are extremely active when disturbed and jump readily and repeatedly.

This species was moderately common on Guam, and frequently was caught in traps baited with carrion. Since it is attracted to feces, carrion, and sweets, it could easily carry pathogens from privies to food. However, as it is rather wary and does not readily enter houses, it must be considered of minor importance. As it probably breeds in a wide variety of substances, general sanitation and protection of food from flies are the only practical recommendations for its control.

Lonchaea species.

Adult: Dark metallic blue to blue-green with bronzy reflections; arista bare; ovipositor of female long; length, including ovipositor, 4 mm.

We collected adults regularly and sometimes abundantly from traps baited with either carrion or human feces. They were collected once in the field from a pile of garbage and several times from isolated deposits of human excrement.

This species is moderately abundant, especially around carrion; but its medical significance is probably slight, since it is not commonly seen around human habitations or on food. Nothing specific can be recommended as a control since the larval habits are unknown.

George Steyskal is planning to describe this species in a forthcoming paper covering several acalypterate families in the Pacific area.

Family PIOPHILIDAE, Cheese Flies

This is a small family, mostly inhabiting temperate to arctic regions, and apparently it is always a scavenger on proteinaceous substances such as meat, old hides, and cheese.

Genus **Piophila** Fallen

This genus, like the rest of the family, is largely of temperate or arctic distribution and develops on proteinaceous substances. *P. casei,* or the cheese

skipper, which has a wide climatic range, is by far the most abundant and well-known species.

Piophila casei (Linnaeus).

Musca putris var. *casei* Linnaeus.
Musca atrata Fabricius.
Musca petasionis Du Four.

Adult: Medium-sized, shiny black, somewhat compressed dorsoventrally; face reddish with frons polished black; coxae and tarsi testaceous; length 4 mm.; wing length 4.5 mm. *Egg:* Ovate, reticulate, with a distinct nipple at anterior end but otherwise without grooves, ridges, or protuberances. *Larva:* Pale, tapering anteriorly, somewhat convex posteriorly; with two pairs of tubercles and a pair of slender processes on last segment. As the name indicates, the larva jumps. *Puparium:* Pale reddish brown, somewhat dorsoventrally compressed, flattened anteriorly; anterior spiracle with 11 or 12 lobes; posterior segment with a pair of fairly prominent upcurved hooklike processes and a pair of smaller tubercles above them; length 4.4 mm.

Distribution: Almost cosmopolitan.

Adults are found about decaying food of various sorts; and they are common in houses, abattoirs, and packing establishments. Each female is said to lay about 30 eggs. Larva breeds in cheese, fat of human corpses, ham and bacon, smoked meats, figs, putrid beef, and human feces. It is said that some types of cheese are not considered ripe in France until infested with "skippers."

This species is generally abundant in infested food storage areas, but is rarely observed in the wild. It was collected on Guam only as larvae, from stools of a soldier who had been serving in Okinawa. Because it commonly breeds in human food such as cheese and cold meats, it is a common cause of intestinal myiasis in human beings. The maggots may mature and pupate in the intestines. Control measures are the proper packing and care of cheeses and meats, the screening of houses and packing establishments, and the disposal of waste meat and dead bodies.

Information on this species was gathered mainly from the literature (see Alessandrini, 1) and from specimens in the United States National Museum collection.

Family Milichiidae (Phyllomyzidae), the Milichiids

Adult: Very small, black, with short, broad wings conspicuously broken in two places near the base of the costa; antennae short, nearly round; oral vibrissae present but weak. *Larva:* Very slender and active, with posterior spiracles prominent and directed outward. *Puparium:* Elongate and tapered toward both ends from the middle; anterior spiracles prominent, sometimes on short stalks; posterior end transversely carinate.

Adults of this family are fond of sunlit places on blades of grass, stones, fence posts, and the like. On Guam, they are abundant in such places as lawns, open fields, low beach vegetation, and open palm groves. They are not often seen on carrion, but some species visit human excrement. Larvae breed pri-

marily in decaying vegetation and excrement of herbivores, but a few species have been reared from human excrement (Howard, 41).

Genus **Milichia** Meigen

Species of this genus are sometimes taken as larvae in tubers, according to Malloch. The United States National Museum collection has several species taken on cattle dung in India.

Milichia orientalis Malloch.

Adult: Small, robust, uniformly dull silvery gray, with broad wings and a short, vertical face; arista bare; antenna orbicular; length 2.6 mm.

Distribution: Guam, Hawaii.

We collected adults several times in dark places, including a storage room for rodent food and caves containing nesting swiftlets. We also reared them from a collection of swiftlet guano which was composed almost entirely of dry insect fragments, and from a mixture of rodent food and rodent droppings. Unfortunately, we did not examine these materials for early stages.

This apparently common species of scavengers on dry waste accumulations probably has no medical significance, and control is unnecessary.

Genus **Milichiella** Giglio-Tos

Adults of this genus are commonly taken in pastures and in barns around manure and cattle feed.

Milichiella lacteipennis Loew (pl. 12).

Adult: Minute, shiny black in both sexes, with slightly milky wings and pale veins; halteres dark brown and tarsi reddish; head short, retreating below; length 2 mm. *Larva:* Elongate, active, with prominent divergent posterior spiracular knobs above the truncate caudal region; anterior spiracles with short, rounded processes; length 4 mm. *Puparium:* At least four times as long as broad, with posterior spiracles divided into three short fingerlike protuberances; length 3 mm. (pl. 12).

Distribution: Cosmopolitan.

Adults are found principally about decaying vegetation and sunlit spots in forested areas. They enter barns and dairies freely to oviposit on manure. We collected feeding adults several times from human excrement and piles of garbage. Larvae were bred on Guam from decaying aquatic vegetation and from cattle and horse manure. They were recorded by Illingworth (48) from hen manure and animal excrement in Hawaii, and by Malloch from guinea pig manure in Samoa. This species is very common in rank vegetation and manure.

Because of its abundance, its ready entry into buildings, and its scavenging habits it could contaminate milk in dairies and carry fecal pathogens to food. Proper disposal of animal manure might effect some reduction in the number of flies but would not affect natural breeding in decaying vegetation. Periodic

airplane spraying of DDT should be effective. Residual treatment of barns, dairies, screens, and the like with DDT should reduce their numbers in buildings.

Milichiella lacteiventris Malloch.

Adult: Similar in size and shape to *M. lacteipennis* but has pale halteres and squamae and black tarsi; abdomen of male silvery white; length 3 mm.

Most of our specimens were taken from light traps, where they were very abundant; but some were swept from rank vegetation growing in abandoned coconut groves.

Genus **Desmometopa** Loew

Habits of this genus are similar to those of *Milichiella,* but these flies are more often seen on human excrement. Evidently some species take rides on larger insects and feed from their prey (Knab, 59). Howard (41) reared *D. latipes* from various deposits of human excrement in Washington, D. C.

Desmometopa tarsalis Loew (pl. 12).

Adult: Minute, sooty black, with slightly depressed thorax and a somewhat horizontal frons which has a pair of silvery interfrontal stripes; palpi black, not especially large; length 2 mm. *Larva:* Elongate, very active, with posterior spiracles on rather long divergent stalks (fork-tailed); anterior spiracles with long, fingerlike processes; length 4 mm. *Puparium:* About four times as long as broad, with posterior spiracular stalks longer than broad and tipped with a slender pale portion; anterior spiracles not stalked but with distinct processes; length 3 mm. (pl. 12).

Distribution: Cosmopolitan.

The adult is usually seen in company with *Milichiella lacteipennis* around vegetation in the sun in such places as open marshes and manure sheds. It is extremely abundant in light traps and common around house lights. We collected feeding adults from human excrement several times. One was observed and collected while flying in short hops and holding in its legs a live weevil as large as itself. The larva is very common in decaying aquatic vegetation, and in moist cattle excrement, both fresh droppings and when piled as manure. A few maggots were also collected from the decaying stump of a papaya tree.

This is one of the commonest flies on Guam, but is easily overlooked because of its small size and drab appearance. Like *Milichiella lacteipennis* it is common in rank vegetation and manure; and because of its abundance, ready entry into buildings, and scavenging habits, could contaminate milk and carry fecal pathogens to food. Its stronger attraction to lights in dwellings might make it more dangerous than *M. lacteipennis.* Screens, of course, do not hinder its progress appreciably. Periodic spraying with DDT by airplane and residual treatment of barns, dairies, and screens with DDT are the best forms of control.

Family CHLOROPIDAE (OSCINIDAE), Frit flies

These flies bear a general resemblance to the Drosophilidae. They are small and robust, with a large shining triangular area around the ocelli and a slight jog, or offset thickening, on the cubital vein. In some genera (principally *Hippelates*), the adult feeds on secretions of the eyes and nose and causes great annoyance, irritation to the mucosa, and the spread of eye infections. Other genera are attracted to putrefying substances of various sorts but many have no association with filth. The larvae are quite varied; some genera are stem borers and leaf miners, others are predaceous on soft-bodied insects, and still others are general scavengers in putrid substances.

Genus **Rhodesiella** Adams

Macrostyla Lioy.

No reference to the biology of this genus was found.

Rhodesiella boharti Sabrosky.

Body shiny black; tarsi white; frontal triangle blue-black; length 2.5 mm.

The adult is frequently taken in traps baited with carrion, and in light traps. In the field, it was collected on dense vegetation and on fresh deposits of human excrement. The early stages were not studied. It may have some importance as a purveyor of fecal pathogens, but too little is known of its habits to make a definite statement.

Genus **Cadrema** Walker

Prohippelates Becker.

This is a small genus, whose habits are known only for the two races of the principal species, *Cadrema pallida pallida* and *C. pallida bilineata.*

Cadrema pallida bilineata (de Meijere) (pl. 11).

Prohippelates bilineata de Meijere.

Adult: Thorax with a pair of longitudinal sublateral dark stripes; body otherwise tawny or pale testaceous; hind tibia with a long, black apical spur; length 3 mm. *Larva:* Elongate, active, jumps readily when disturbed; length 5 mm. *Puparium:* Over four times as long as broad, with strong transverse carinae anteriorly and posteriorly, the posterior ones flangelike; length 4 mm. (pl. 11).

Distribution: Pacific islands, East Indies, and West Indies.

Adults are strongly attracted to decaying flesh and human excrement, and rotting coconuts attract them. Shellfish furnish the best bait. Larvae were reared from decaying mollusks, rotting coconuts, and pig excrement. Malloch mentions that they have been reared from shellfish in Samoa.

During May, this fly was the commonest one in our bait traps, and abundant at all times. Because of its numbers and its wide larval and adult food

selection it could be a significant carrier of fecal pathogens to food, especially where cooking and eating are done out of doors. It does not readily enter houses. Area spraying with DDT should greatly reduce the number of adults. Not enough is known of its larval habits to recommend specific control measures for larvae.

Genus **Lasiopleura** Becker

Parahippelates Becker.

No reference to the habits of this genus has been found by us.

Lasiopleura virilis Malloch.

Adult: Rather elongate, entirely tawny, somewhat darker above; thorax with indistinct median dark stripe as well as broad sublateral dark areas; length 4.4 mm.

This species was taken frequently but not abundantly in carrion-baited traps; a few times, in traps baited with human excrement. Medically, it is not generally significant because of its scarcity. However, it might be a carrier of fecal pathogens where locally abundant.

Family OTITIDAE (ORTALIDAE), Pictured-Wing Flies

Adult: Generally medium-sized, with pictured wings which rotate in the air; wings with subcosta complete and free from the radial vein and with anal and basal cells complete; oral vibrissae absent. *Egg:* Slender, rather tapered at both ends, without distinct reticulation or irregularities of any kind, except for a slight anterior nipple; anterior end with a transverse translucent line appearing like a faint slit or groove; usually laid in small groups, and often inserted into the substratum. *Larva:* Rather elongate and smooth, sometimes with small tubercles around upper part of caudal end, which is generally rounded and not particularly expanded; posterior spiracles usually rather centrally located and not farther apart than the diameter of one of them; mouthparts with hypostomium usually elongate. *Puparium:* Slightly compressed dorsoventrally, rather short and rounded, shining but with distinct fine transverse striation; posterior end is generally rounded, more strongly striate; pupal breathing horns not visible; anterior spiracles not stalked.

This is a large and rather important family in filthy environments. Although most of the species are more definitely associated as larvae with decaying fruits and vegetables than with excrement or carrion, nearly all of the adults visit the latter materials. Larvae of many species, whereas normally breeding in decaying fruit, are on occasion sarcophagous or coprophagous. Adults of most species visit flowers and the exposed flesh of ripe fruit as well as filthy substances.

Genus **Chrysomyza** Fallen

Ulidia Meigen.

Several species of this genus in the United States National Museum collection were taken as adults in bait traps. Larvae are apparently saprophags in stored grains, silage, and the like, and coprophags in the feces of herbivores.

Chrysomyza aenea (Fabricius) (fig. 12, *b*; pls. 3, 4, 10).

Ulidia clausa Macquart.

Griphoneura clausa Schiner.

Chloria clausa, Van der Wulp.

Ulidia melanopsis Walker.

Ulidia divergens Walker.

Ulidia fulviceps Walker.

Adult: Medium-sized, fairly stout; brilliant metallic blue-green; eyes iridescent, multicolored; legs ochraceous; wings colorless, not pictured; length 6-9 mm. (fig. 12, *b*). *Egg:* White, slightly arched, narrowed and rounded at each end, somewhat nipplelike anteriorly, with a groove extending one-fifth length of egg on each side from nipple; length 0.8 mm. (pl. 3). *Larva:* Creamy yellow; caudal end truncate above, rounded beneath; posterior spiracles reddish brown, slightly transverse, separated by a distance less than the diameter of one, slightly raised above surrounding surfaces; spiracular plates with well-pigmented borders and pigmented areas between the slits; length 9 mm. (pl. 4). *Puparium:* Dark reddish brown, highly polished, with strong transverse carinae; caudal end with radiating ridges; spiracles raised, about one-half as high as wide, separated by less than the diameter of one; length 5.6 mm.; breadth 1.8 mm. (pl. 10).

Distribution: southern Asia, Mauritius, Pacific islands.

Adults of this species are found in many situations, walking on the surfaces of rotting fruits, garbage, rotting vegetation, carrion or feces, including human excrement. While sitting or walking, the flies commonly wave their front legs in the air. During May, this species was the most abundant, along with *Cadrema bilineata,* of the flies caught in traps baited with carrion. The eggs are scattered singly in moist but aerated spots in the food material. Larva feeds primarily in rotting vegetation and grains, and in manure heaps. It was the commonest maggot in the pond muck at Agana Spring and in rotting corn at the Pago garbage dump. It was not collected in isolated cow droppings, but was abundant in moist heaps of cow manure. The specimens that emerged in our laboratory mated and laid eggs on beef, and we raised a considerable number of flies. And we had no difficulty obtaining adults from eggs placed on human feces. Illingworth reared it in Hawaii from cow peas.

One of the commonest of the larger flies on Guam, this species is probably important medically, as it is abundant; has a wide variety of adult foods, including human feces; and enters buildings rather readily. It is perhaps the most likely of the non-muscoids on Guam to carry intestinal diseases. The thin spreading of manure and compost, the incineration or burial of garbage, and the operation of fly traps during periods of high population are advisable controls. This species was found to be more resistant to DDT than *Musca sorbens,* less resistant than *Chrysomya megacephala.*

Genus **Acrosticta** Loew

The larvae of one species in this genus (*A. apicalis* Williston) are reported to breed in fruits of tangerine and *Attalea.*

Acrosticta apicalis (Williston).

Acrosticta pallipes Grimshaw (fig. 12, *c*).

Adult: Largely bluish gray, with yellow fore coxae and femora and yellowish, transversely rugose frons; wings dark at apices and along basal two-thirds of costal margins; length 3.6 mm. (fig. 12, *c*).

Distribution: Hawaii, other Pacific islands, and Bolivia.

Adults were taken by us regularly but not abundantly in traps baited with carrion and human excrement, and specimens in the field were collected on decaying breadfruit. Several were seen on drying fish in a native village.

As this widespread species is never abundant, it seems to have no medical significance, but its wide range of food habits and presence in villages might make it a menace if it were locally abundant. Since it probably breeds in decaying fruit, elimination of fruit fallen from trees should reduce its numbers.

Genus **Scholastes** Loew

Adult: Large otitid, with numerous dark spots and bars over all the wing surfaces; with more or less distinct pale bands along lateral margins of thoracic dorsum and dorsal margins of thoracic pleura; head with two transverse dark bars on frons and one at lower margin of antennal grooves.

Members of this genus occur throughout the Pacific and are commonly called coconut flies because of their association with that fruit. It is unlikely, however, that their larvae breed only in coconuts, since the nuts were probably recently introduced into islands which have developed endemic species of *Scholastes*. The adult stage of several species has been observed to frequent privies and visit human feces.

Scholastes aitapensis Malloch (fig. 12, *d*; pls. 3, 4, 10).

Adult: Tawny, with pale thoracic bands only slightly paler than the general ground color; length 7.5 mm. (fig. 12, *d*). *Egg:* About six times as long as broad and distinctly curved, with a faint longitudinal groove at the micropylar end, otherwise without surface irregularities; length 0.87 mm. (pl. 3). *Larva:* Elongate, generally with a peculiar slate-blue color, rather inactive but will "skip" when sufficiently disturbed; posterior end with a small tonguelike projection above the anus; length 11 mm. (pl. 4). *Puparium:* Robust, dark brown, with close, fine, transverse striae; posterior spiracles prominent laterally but nearly flush medially; length 6.5 mm. (pl. 10).

Distribution: Guam.

This fly is most commonly seen on piles of old coconuts but is also found on carrion, human and cattle excrement, and rotting papayas. The eggs are laid on moist fibers of crushed coconuts. We reared larvae only from coconuts, both on the meat and the fiber. Development of the larval stage was very slow in most cultures (30 days or more), but in one rotting coconut that smelled like a diarrhetic stool it was more rapid (eight days). In general, coconuts crushed into road ruts or perforated by a small hole yield the most larvae. Pupation occurs among the coconut fibers.

Next to *Chrysomyza aenea,* this is the commonest otitid on Guam. It is especially common in coconut groves.

Because of its size, habits, abundance, and prevalence in populated areas, it is probably among the more important carriers of fecal pathogens, especially in native villages. Its larva, frequently mistaken for that of *Musca* or *Chrysomya,* is probably responsible for clean-up programs directed against fallen coconuts. Burning, burial, or other methods of destroying coconuts on the ground are the best controls.

Scholastes hirtiventris Malloch (fig. 12, *e*).

Adult: Black, with strongly contrasting pale bands around thoracic dorsum and dorsal border of thoracic pleuron; length 8 mm. (fig. 12, *e*). *Egg:* Similar to that of *S. aitapensis* but with a more pronounced nipple at micropylar end.

Distribution: Guam.

Adults frequent piles of coconuts, along with *Scholastes aitapensis,* but it is often collected in dense jungles away from coconut trees. It has also been collected in numbers on human excrement and to some extent on carrion, including a human corpse. Its liking for human excrement is perhaps stronger than that of *S. aitapensis.* The larvae probably breed principally in coconuts although we were unsuccessful in finding them in the field.

S. hirtiventris is less common than *S. aitapensis,* but it is abundant at certain localities. It is probably more important than *S. aitapensis* as a carrier of fecal pathogens when it is abundant because of a strong attraction to human feces. Destruction of fallen nuts is the best control.

Genus **Notogramma** Loew

No reference to the biology of this genus was found, except for *N. stigma,* the most important species.

Notogramma stigma (Fabricius) (fig. 12, *f;* pls. 3, 10).

Musca stigma Fabricius.

Dacus obtusus Fabricius.

Notogramma cimiciformis Loew.

Adult: Dorsoventrally flattened, with rugose frons and with striking bars and spots of silver on thorax; wings with numerous small gray spots on membrane; length 4.8 mm. (fig. 12, *f*). *Egg:* About four times as long as broad, entirely smooth except for a small nipple and longitudinal line at micropylar end, somewhat pointed at both ends; length 0.7 mm. (pl. 3). *Larva:* Elongate, white (not at all yellowish); posterior spiracles placed in a shallow oval excavation and protruding equally on all sides for about the equivalent of their diameters; length 8 mm. *Puparium:* Dark brown, robust; posterior end with distinct longitudinal carinae and with peglike spiracles set in a depression as in larva; length 3.8 mm. (pl. 10).

Distribution: Australasian region, West Indies, Texas, and South America.

Adults were frequently taken in carrion-baited traps, sometimes in large

numbers. It was also collected in traps baited with human feces and seen on garbage dumps and in vegetable gardens, where it oviposits in cracks at the stem end of tomatoes. The flies alternately wave their wings in the air and hold them flat against their backs with the tips bent downward. They are sluggish and easily captured. The eggs are often seen in company with those of *Atherigona orientalis*. In the laboratory, this fly laid eggs on carrion and adults were reared from the eggs without difficulty. We reared larvae from rotting tomatoes, rotting immature coconuts, and liver (laboratory oviposition). Severin and Hartung reared it from bananas in Hawaii. The maggots are active and skip readily.

This is a rather common fly on most parts of the island, but because of its sluggish habits, it is not conspicuous. It is probably of minor importance as a carrier of fecal pathogens. The eggs and larvae in nearly all of the tomatoes on the island might cause it to be ingested and thus be mistaken for an intestinal parasite upon its appearance in the stools. The fruit should be eaten or destroyed before it rots.

Genus **Pogonortalis** Malloch

This is a very small genus of Pacific flies whose habits have not been studied.

Pogonortalis fulvofemoralis Malloch (fig. 13, *a*).

Adult: Easily recognized by its extremely broad oral cavity and characteristic wing pattern (fig. 13, *a*); length 6 mm.

Distribution: Guam.

This fly occurs in densely wooded areas, especially near Point Ritidian. Our specimens were collected primarily from human feces.

As the species is not common, except in localized areas of forest, its medical significance is probably slight. However, its liking for human excrement might make it a menace wherever it is locally abundant. Lacking its life history, no control can be recommended.

Genus **Pseudeuxesta** Hendel

No references to the habits of this small genus could be found.

Pseudeuxesta prima Osten-Sacken (fig. 13, *b;* pl. 10).

Euxesta semifasciata Malloch.

Adult: Moderate-sized otitid, with smooth frons and three dark spots along the costal margin of the wing, the middle one extending in a solid or interrupted band about halfway across the wing; length 5.2 mm. (fig. 13, *b*). *Larva:* Posterior spiracles nearly flush with caudal end, with a sclerotized rim complete, but without a button, the pair of opposing

dorsal spiracular slits about in a straight line, the ventral ones forming an angle of about 45 degrees; length 8 mm. *Puparium:* Spiracles similar to those of larva but darker; puparium polished but with strong transverse ridges, especially around posterior end; anterior end somewhat produced; length 5 mm. (pl. 10).

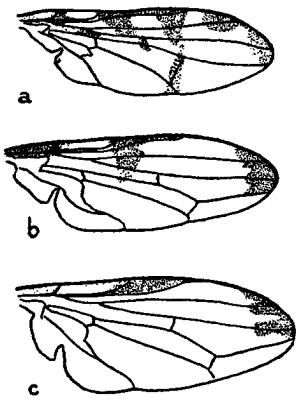

FIGURE 13.—Wings: **a**, *Pogonortalis fulvofemoralis;* **b**, *Pseudeuxesta prima;* **c**, *Neoeuxesta* sp.

Distribution: Pacific islands.

Occasional specimens were collected in traps baited with carrion and a few were taken on one occasion at Point Ritidian, on human feces. When the previously mentioned corpse at Point Ritidian was about three weeks old, adults of *P. prima* were seen nearby on the damp sand. When adults were seen on the human corpse, examination of the flesh and ligaments close to the bones revealed mature maggots of this species and of *Discomyza maculipennis.*

This species is generally uncommon, hence its medical significance is slight.

Genus **Neoeuxesta** Malloch

The habits of this genus are unknown.

Neoeuxesta species (fig. 13, *c*).

Adult: Similar to *Pseudeuxesta prima* but without a transverse dark area in the middle of the costal region of the wing; length 5 mm. (fig. 13, *c*).

We took this fly rather frequently, but in small numbers, from carrion-baited traps; and a number of specimens were collected from fresh human excrement in the forest at Point Ritidian.

The species is generally uncommon, but is likely to be seen in small numbers in the jungles. Its medical significance is probably slight or non-existent under usual circumstances. No control is necessary.

The species will be described in a forthcoming paper by George Steyskal.

Section MUSCOIDEA (CALYPTERATA), Muscoid Flies

Adult: Usually medium-sized to large flies with large, round or semicircular squamae; second antennal segment with a longitudinal, sublateral, impressed line; dorsum of thorax with a complete transverse suture anterior to the wing bases.

This large assemblage of families, with diverse habits in all stages, includes most of the important filth-inhabiting and myiasis-producing flies. The adults feed on vertebrate blood (Hippoboscidae and various genera of Muscidae), on decaying substances and sweets (Calliphoridae, Sarcophagidae, Anthomyidae, and various genera of Muscidae), or not at all (Cuterebridae, Oestridae, and Gasterophilidae). The larvae may develop within the body of their parents (Hippoboscidae and *Glossina* in the Muscidae), be deposited as young maggots (most Sarcophagidae and some Anthomyidae), or hatch from deposited eggs (most Muscoidea). The last two types of larvae may develop in the following ways: (1) As internal parasites in other arthropods (Tachinidae and certain species in other families); (2) as endodermal parasites of vertebrates (Cuterebridae and Oestridae); (3) as intestinal parasites of vertebrates (Gasterophilidae); (4) as ecto-parasites of vertebrates (certain Calliphoridae and Anthomyidae); (5) externally in wounds or damaged tissue of vertebrates, either by choice or by chance (members of various families, but principally Calliphoridae and Sarcophagidae); (6) in flesh of dead animals (members of most families); (7) in excrement (members of most families); (8) in decaying vegetation (mainly Anthomyidae and Muscidae); (9) in living plant tissue (mainly Anthomyidae); (10) as aquatics, feeding on various substances (a few Anthomyidae). Some genera and families are quite specific in regard to their mode of larval existence, whereas others tend to be generalized. Most of the species that inhabit filth have rather generalized larval habits. In most of the families the larvae show a strong tendency to migrate from their moist food media to drier and more protected situations for pupation. They may stay in the larval food medium to pupate if it begins to dessicate.

Family ANTHOMYIDAE

Adult: Small to medium-sized, usually rather slender type of muscoid; wing vein R_{4+5} not curved upward; hypopleural and pteropleural bristles absent; proboscis never developed for piercing. *Egg:* Usually strongly reticulate and with borders of dorsal groove developed into strong flanges. *Larva* and *puparium:* Variously shaped but with posterior spiracles protuberant, heavily sclerotized and with short slits.

Most species of Anthomyidae feed on highly odorous decaying substances, such as putrid flesh and human excrement, whereas others feed largely on the nectar of flowers or on other sweets. Many species feed on both sorts of material. For the most part, members of this family are rapid fliers and many

are capable of hovering, poised in the air. The eggs are usually deposited singly. The larvae of most species are vegetable feeders, many of them breeding in living plant tissue. A few species are carnivorous by preference, living in nests of vertebrates whose blood they suck. Species in one genus, *Mydaea,* are subcutaneous parasites of birds. Of the 10 species of anthomyids on Guam, all are associated in some way with filth.

Genus **Dichaetomyia** Malloch

Mydaea Robineau-Desvoidy (part).

Adult: Large anthomyid with slight or no pruinosity and usually with tawny colors; arista with numerous rather long branches above and below.

Larva records for this large genus show that most species breed in bovine and human excrement, but one species was reared from the larva of a pyralid moth. Apparently these flies breed by preference in fresh cattle droppings instead of in piles of manure (Cuthbertson, 15).

Dichaetomyia saperoi G. Bohart and Gressitt (pl. 3).

Adult: Large anthomyid with an orange thorax and a black abdomen which is orange basally and apically; length 7 mm. *Egg:* With broad distinct dorsal groove, the margin of which is developed into weak flanges at the strongly flattened micropylar end; length 2 mm. (pl. 3).

Distribution: Guam.

Adults were collected on foliage in dense forests and in traps baited with carrion and with human excrement. The edges of small villages usually produced the largest catches. The habits of the larva are not known, but it probably breeds in excrement.

This rather uncommon species is probably of slight medical significance because of its scarcity and its jungle-dwelling habits. Control is unnecessary.

Dichaetomyia nigroscuta G. Bohart and Gressitt.

Adult: Large authomyid, with black scutum and legs and with orange scutellum and abdomen; length 8 mm.

Distribution: Guam.

The adults inhabit dense jungles and fly in the shade. Several specimens were collected from human excrement at Point Ritidian.

This species is apparently quite rare, hence it probably has no medical significance. Control is unnecessary.

Genus **Fannia** Robineau-Desvoidy

Homalomyia Bouche.

This well-known genus of filth-inhabiting flies is frequently known collectively as the lesser house flies. *F. canicularis,* in particular, is very common

in houses in temperate regions where it soars and hovers for hours without attempting to land. Most of the species breed in excrement and carrion and in the nests of birds. Several are inquilines of other insects, especially bumble bees. *F. scalaris* breeds frequently in cesspools and latrine pits and is known officially as the latrine fly. Maggots of all species are characteristically leathery, flattened, and provided with long, branched processes on each segment. Thomson (130) discusses and illustrates the life histories of several holarctic species.

Fannia pusio Wiedemann (pls. 3, 13).

Homalomyia femorata Loew.
Limnophora exilis Williston.
Fannia trimaculata Stein.
Fannia femoralis Stein.

Adult: Small, black anthomyid, with uniformly dark, dull silvery head and thorax; abdomen of female shiny black, that of male flattened and with broad silvery areas laterally; arista bare; length 3.8 mm. *Egg:* Dorsal flanges well-developed and equal at both ends; ventral (upper) surface not distinctly reticulate; length 0.8 mm. (pl. 3). *Larva:* Dorsoventrally flattened, leathery; each segment provided with long, branched appendages; posterior spiracles widely separated and stalked; length 4.8 mm. *Puparium:* Similar to larva but darkened and rigid (pl. 13).

We took the adult of *F. pusio* frequently and rather abundantly in traps baited with carrion and human excrement. It was collected only once indoors, at which time three females were seen on a piece of beef which had just recently hung in the poorly screened outdoor enclosure of a hospital kitchen. Examination of the beef showed about 25 *Fannia* eggs scattered along a moist crease in the meat. The appearance of eggs on fresh beef is apparently unusual because meat set out for oviposition rarely contained eggs or larvae of *Fannia* until it had obtained a characteristic "old carrion" smell associated with the presence of larder beetles and red-legged ham beetles. Adults were also seen occasionally on rotting papaya and breadfruit, and a number of males were seen soaring in the shaded doorway of a native house and in the doorway of the adjacent privy. We reared larvae principally in old carrion and in putrefying shellfish. The human corpse at Point Ritidian did not contain *Fannia* larvae until the meat had become leathery and largely rotted away from the bones. In putrid shellfish, the maggots were associated with and difficult to distinguish from those of the phorid, *Parafannia*. Tanada *et al.* (125) found them in chicken manure on Oahu. Although some *Fannia* are reported to be predaceous, this habit was not observed with *F. pusio*. When feeding, larvae are generally in folds of the meat, partially exposed at the surface, or on the soil underneath the meat instead of being deep in its tissues. Literature records show that this species can also breed in dead, soft-bodied insects and in rotting papaya stems (Illingworth, 46). Pupation generally

occurs in the soil a few inches from the food source and with no apparent shrinkage or other change in general body form.

Although adults of this species were not commonly seen in the field and trap catches of them were only moderately high, their eggs and larvae were more frequently observed than were those of many apparently more common flies. Its medical significance is probably slight on Guam because of its retiring habits as an adult. However, there is danger of intestinal myiasis from the larvae, although the meat in which it usually occurs would not likely be eaten by humans. The disposal of waste meats and the proper protection of fresh carcasses are advisable. Also, investigations should be made to determine whether or not it breeds in latrines, as seems probable. Tanada *et al.* (125) report that DDT in a 0.25 percent emulsion gives excellent control of larvae in chicken manure.

Genus **Atherigona** Rondani

Adult: Medium-sized, rather slender, with short leg bristles and bare aristae. *Larva* and *puparium:* The extreme truncation at both ends of the puparium seems to be a generic characteristic, as are the long, black spiracles of both larva and puparium.

Most biological records of the larvae of this genus concern the principal species which occurs on Guam, *A. orientalis.* Several species are reported as destructive to plant shoots and young cereal crops. Probably the larval habits of most species are more varied than would appear from published records.

Atherigona longipalpus Malloch (pls. 3, 13).

Adult: Entirely tawny, without pruinosity; arista bare; length 5 mm. *Egg:* With strong lateral flanges flanking the dorsal groove; dorsally reticulate but not distinctly so on ventral (upper) side; length 0.9 mm. (pl. 3). *Larva:* Active, moderately elongate, with long black pegs bearing the spiracles; pegs swollen basally, projecting apically; length 9 mm. *Puparium:* Cylindrical, truncate at both ends; spiracular pegs swollen basally and narrowed subapically; length 6 mm. (pl. 13).

Distribution: Guam.

We collected adults frequently, but not abundantly, in carrion-baited traps. Specimens were also taken feeding on human excrement, flying around a rotten coconut, and on a garbage dump. Adults were reared from rotting breadfruit found hanging on the trees. Eggs laid by adults in vials hatched and were reared without difficulty on both canned peas and spoiled beef. The rate of growth on both was about the same but the specimens on beef emerged later and grew larger.

This species was widespread on the island, but nowhere did we see it in large numbers. It is a potential menace because of the wide range of the adult, but its scarcity probably renders it unimportant. As habits of larvae in the field are not known, no specific control can be recommended.

Atherigona orientalis (Schiner) (pls. 3, 5, 13).

Coenosia excisa Thomson.
Acritochaeta pulvinata Grimshaw.
Atherigona trilineata Stein.
Atherigona magnipalpus Stein.
Atherigona varia Meigen (of Malloch).
Atherigona triseriata Walker.

Adult: Small, yellowish gray pruinose, with a pair of sublateral black spots on third, fourth, and fifth abdominal tergites; leg bristles short; arista bare; length 3.8 mm. *Egg:* Dorsal groove flanked by broad flanges developed into a pair of short processes at micropylar end; ventral (upper) surface with distinct, coarse reticulation; length 0.9 mm. (pl. 3). *Larva:* Similar to *A. longipalpus* but smaller and with a subapical swelling on the posterior spiracular peg; length 7 mm. (pl. 5). *Puparium:* Similar to *A. longipalpus* but differing in the same particulars as the larva; length 5 mm. (pl. 13).

Distribution: Cosmopolitan; temperate and subtropical.

The adult feeds on an exceptionally wide variety of substances, including all sorts of carrion, spoiling fruit and vegetables, table food of nearly all kinds, and human excrement in fresh, isolated deposits. It was nearly always the most abundant muscoid in the traps baited with carrion and with human excrement and was always present in large numbers around such materials as spoiling potatoes, onions, and breadfruit. The eggs are scattered singly and may be buried in the soft parts of rotting substances so that only the "wings" of the micropylar end are visible. On tomatoes, the eggs are laid as soon as the fruit begins to crack or has any indentations at the flower end. In cucurbits, the fly oviposits in the wounds left by the ovipositor of *Dacus cucurbitae.* Specimens reared in the laboratory and allowed to escape scattered eggs freely on available pieces of meat, breadfruit, and in a cup containing human excrement. We reared larvae from fresh and old carrion; rotten potatoes; *Dacus*-infested cucurbits; cracked and rotting tomatoes; breadfruit, especially the core tissue; rotting ears of corn; rotting coconut meat, juice, and fibers; rotting green papayas; and human excrement. In the cucurbits, it attacked and drained the contents of *Dacus cucurbitae* larvae. Generally, cucumbers infested with eggs and young larvae of both species ended up with mature larvae of *Atherigona orientalis* alone. The same predaceous habit was observed in breadfruit, where *A. orientalis* was isolated with *Limnophora plumiseta.* Malloch (76) records it as breeding in root crops in the field and in oranges and bananas. The maggots usually encase themselves tightly in a network of whatever fibrous material is available before pupating and leave only the truncate anterior end of the puparium exposed.

Atherigona orientalis is the most abundant muscoid fly on Guam during most seasons, and we found it to be equally common in and around villages and around camp kitchens. After *Chrysomya megacephala* and the two species

of *Musca,* it is probably the most important carrier of fecal and other filth-borne pathogens. It is third in importance because it is not inclined to enter dark holes such as the privy pit. Furthermore, its frequently predaceous habits as a larva may mitigate some of its offenses as an adult. Since the bulk of breeding seems to occur in rotting fruits and vegetables, a clean-up of fallen fruits and coconuts, the proper storage of vegetables, and the burial or incineration of garbage should reduce its numbers. Exceptionally large populations could probably be decimated by the heavy spraying of DDT from planes.

Genus **Pygophora** Schiner

No published records were found concerning the biology of this genus, although Seguy (114) lists 21 species from various parts of Africa and the Orient.

Pygophora lobata Stein.

Adult: Slender and moderate in size with considerable gray pruinosity; arista with basal half widely branched above and below; tibiae, coxal apices, palpi, bases, and apices of abdominal segments yellow; length 7 mm.

Only a few specimens were collected. One of these was from the cover of a septic tank and another was on a pile of manure in the field.

An Unidentified Genus and Species of Anthomyidae

Small, pruinose gray species, with antennae, tibiae, palpi, and first abdominal segment yellow; arista widely branched above and below to the apex; hind tibia with four pairs of long bristles; length 4.5 mm.

Of the few specimens collected, two were taken in a trap baited with carrion. Another was swept from vegetation in a coconut grove.

This fly is rather close to the genus *Coenosia* but is evidently distinct. It may prove to represent a new genus.

Genus **Limnophora** Robineau-Desvoidy

Adults of this genus are recorded as found on umbelliferous flowers and resting on stones in a stream. According to published accounts, the maggots breed in cow dung, presumably isolated droppings. One species, however, *Limnophora arcuata,* according to Howard (41), was bred several times from human feces. Malloch (76) states that the larvae are aquatic.

Limnophora plumiseta Stein (pls. 3, 13).

Adult: Small, black anthomyid, with silvery pruinosity laterally and posteriorly on prescutum, posteriorly on mesonotum, and medially and laterally on abdominal tergites; arista pubescent; length 3.5 mm. *Egg:* Micropylar end depressed and produced into three winglike lobes; length 1 mm. (pl. 3). *Larva:* Posterior spiracles produced into long pegs,

as in *Atherigona,* but with pegs brown instead of black; length 6 mm. *Puparium:* Posterior spiracles produced peglike and posterior segments narrowed; anterior end not strongly truncate; length 4 mm. (pl. 13).

Distribution: Solomon Islands and Guam.

We took adults frequently, but not abundantly, in carrion-baited traps, especially those set in or along the edge of wooded areas. Specimens were also collected on human excrement in dense forest shade and on fallen breadfruit in similar situations. The only oviposition noted was on fallen breadfruit in shady, moist situations. Here the eggs were scattered on oozing areas, frequently with only the anterior "wings" exposed. We reared larvae only from decaying breadfruit, in which preference was shown for the core tissue. Mortality was frequently high, due to the predatory attacks of *Atherigona orientalis* larvae. Pupation occurred at the edge of the fruit, but no attempt was made by the larva to enclose itself in a fibrous sheath.

As this species is common only in a few densely wooded areas, its medical significance is probably slight and confined to small villages in wooded areas or around isolated farm houses surrounded by breadfruit trees and taro or other shade-producing plants. The best controls are the cleaning up of fallen fruit and the clearing out of jungle surrounding eating places.

Genus **Ophyra** Robineau-Desvoidy

Malloch (76) states that members of this genus soar and hover like those of *Fannia. Ophyra aenescens* Wiedemann, according to Shannon and del Ponte (117), is abundant in kitchens in Guatemala, walks about on tables and food as does *Musca domestica,* and is not attracted to windows indoors. According to Seguy (114) the larval stage is coprophagous, saprophagous, and zoophagous. *Ophyra leucostoma* Wiedemann is reported as breeding in human and canine carcasses on battlefields in Europe. Maggots have been taken from nests of swallows, where they were apparently feeding on blood from nestlings; and from dead rats, manure pits, and manure in the field (Keilin and Tate, 57). Howard (41) reared it from isolated deposits of human feces. *Ophyra nigra* Wiedemann was reared from carrion by Buxton and Hopkins (8).

Ophyra chalcogaster Wiedemann (pls. 3, 5, 13).

Adult: Shiny, jet black, large anthomyid with no pruinosity; arista bare; length 5 mm. *Egg:* Dorsal groove rather narrow, its bordering ridges not prominent but completely encircling the groove; reticulation very feeble; length 0.9 mm. (pl. 3). *Larva:* Polished creamy yellow and tough; posterior spiracles projecting laterally but nearly flush medially; length 9 mm. (pl. 5). *Puparium:* Short and cylindrical as in *Musca;* spiracles projecting as in larva; metathorax with a pair of thick, strongly curved breathing horns; length 6.5 mm. (pl. 13).

Distribution: Oriental region and Pacific islands.

Adults were taken frequently and rather abundantly in traps baited either with carrion or fresh human excrement. They are common around cattle feeding troughs and on dense vegetation bordering pastures, and we observed oviposition on fresh cattle droppings, where the eggs were tucked into folds of the droppings in groups, usually of three or four. We reared larvae from natural infestations of many materials including cow and horse manure, both in isolated droppings and in piles; swine feces in hoof tracks; isolated human feces; decaying aquatic vegetation; old carrion, principally rats; and putrefying shellfish. Tanada *et al.* (125) found them in chicken manure on Oahu. It was reared in the laboratory on liver and the core tissue of breadfruit, although it developed poorly on the latter. The maggots are remarkably tough and elastic and are able to withstand more dessication than *Musca* or *Stomoxys* with which they occur in manure heaps; they frequently occupy the drier portions where *Musca* and *Stomoxys* pupate. Pupation occurs a few inches away from the food, usually in slightly moist soil. Puparia formed in dry soil are elongate and annulate and show a high mortality.

O. chalcogaster is widely distributed. Although the flies are not seen swarming on any materials, a dozen or more generally quickly appear around fresh human excrement or putrid carrion. Apparently cattle droppings furnish the principal breeding medium, for few still moist droppings are without them. Although this species is not common indoors, it comes quickly to various foods in unscreened or poorly screened outdoor places. Where common, they probably rank with *Musca sorbens* as purveyors of fecal pathogens. Several control methods are advisable: The general sanitation and thin-spreading of manure, grass cuttings, and compost heaps; the gathering and disposal or proper storage of cattle droppings; and residual treatment of dairies and dairy barns. Tanada *et al.* (125) report excellent control of the larvae in chicken manure with a 0.25 percent DDT emulsion.

Family MUSCIDAE, House Flies and Related Genera

Adult: Medium-sized to rather large, robust, gray pruinose, usually with distinct longitudinal black stripes on the dorsum of the thorax; either hypopleural or pteropleural bristles present; basal bristles of abdomen absent or weak; arista plumose to apex; wing vein M_1 curved upward toward apex. *Larva:* Rather elongate and smooth; posterior spiracles usually with sinuous slits. *Puparium:* Short, cylindrical and rounded at the ends; generally smooth posteriorly and not transversely striated.

Most of the species are divided into the following two groups according to adult habits: (1) those which pierce the skin of vertebrates and feed on their blood (Stomoxidinae, Glossininae); (2) those which lap liquids from putrid substances and sweets (other muscids). Some members of the latter group also feed on secretions from the bodies of animals and on blood when

it is available at the surface. One group, sometimes placed with *Musca,* has mouthparts developed to some extent for piercing as well as for lapping. Most species breed in excrement, spoiling vegetables, and rotting vegetation; but a few are carnivorous by preference. *Glossina* (tsetse fly) larvae develop within their parents. The larval and adult habits of many genera and species were summarized by Seguy (114).

Subfamily STOMOXYDINAE

This subfamily includes several closely related genera of muscids with lancetlike mouthparts and with cell R_5 only moderately narrowed. The adults feed primarily on the blood of livestock, and the larvae breed in their feces, although some species also breed extensively in other decaying material of vegetable origin.

Genus **Stomoxys** Geoffroy

Adult: Distinguished principally by its long proboscis, small palpi, and the arista which is haired on the upper side only.

The biologies of most species of this genus are little known, other than the fact that they feed mainly on the blood of ruminants and breed in their feces. The commonest and most widespread species, *Stomoxys calcitrans,* has been extensively studied biologically and with regard to its disease-carrying role.

Stomoxys calcitrans (Linnaeus) (pls. 2, 6, 14, 16).

Stomoxys aculeata Robineau-Desvoidy.
Stomoxys aurifacies Robineau-Desvoidy.
Stomoxys claripennis Robineau-Desvoidy.
Stomoxys cunctans Robineau-Desvoidy.
Stomoxys dira Robineau-Desvoidy.
Stomoxys flavescens Robineau-Desvoidy.
Stomoxys infesta Robineau-Desvoidy.
Stomoxys inimica Robineau-Desvoidy.
Stomoxys labatrix Robineau-Desvoidy.
Stomoxys praecox Robineau-Desvoidy.
Stomoxys pungens Robineau-Desvoidy.
Stomoxys sugillatrix Robineau-Desvoidy
Stomoxys vulnerans Robineau-Desvoidy.
Stomoxys geniculata Macquart.
Stomoxys nebulosa Fabricius.
Stomoxys tessellata Fabricius.
Stomoxys korogensis Grun.

Adult: Resembles the housefly but has generic and subfamily characters as previously described; length 7 mm. (pl. 16). *Egg:* White, with dorsal groove completely margined by a ridge and about one-fourth as wide as egg; surface, except for groove, distinctly and finely reticulate; length 1 mm. (pl. 2). *Larva:* Elongate, very active, with small, subtriangular, widely separated posterior spiracles; length 10 mm. (pl. 6). *Puparium:* Short, cylindrical and smooth, as in *Musca,* but with small spiracles separated by twice the diameter of one of them (pl. 14).

Distribution: Worldwide, temperate and tropical.

S. calcitrans, the stable fly, apparently prefers the blood of horses to that of other animals but takes blood rather freely from cattle and occasionally from human beings, especially just prior to rains or when animal hosts are scarce. Shortly after the invasion of Okinawa by United States troops, enormous numbers of *Stomoxys* bred in the unharvested cabbage crop. When the flies emerged to find all the livestock killed, human blood was freely used for food. Records show that they also feed on chickens and other birds. They seem to prefer the legs of cattle, though they also bite elsewhere; but they are found as commonly on the flanks of horses as on the legs. From either host, they take flight rather quickly when disturbed. The adults are also attracted to some flowers and to moist decaying vegetation from which they obtain moisture and in which they oviposit. The eggs are laid in groups of 15 or 20, sometimes smaller numbers, in creases of cattle droppings, between pieces of horse manure, and under leaves in decaying vegetable material.

On Guam, we reared larvae of *S. calcitrans* primarily from cattle droppings, piles of cattle manure, and a large pile of decaying aquatic vegetation, although Smart (120) states that in England the larvae never breed in cattle dung. Horse manure is supposed to be the preferred medium, but on Guam, maggots were found in it only when it was in large accumulations. They were found on one occasion in pig feces. On Okinawa, cabbages rotting in the field were infested with *Stomoxys* maggots; and in various parts of the world other fleshy leaves or stalks, such as celery and prickly pear, are used for larval food. It was reared once on Guam from old carrion, but this was apparently unusual. Adults were reared in the laboratory from eggs placed on human excrement, but development took twice as long as it did on cattle feces. Mortality in this case was low, however, and the flies that emerged were exceptionally large. According to published accounts, the species breeds also in birds' nests and on sewage disposal filters (Seguy, 114) and in rain-soaked chicken manure (Illingworth, 48). The larvae, which are very active and subject to dessication, generally inhabit the dampest part of their medium and leave it only to pupate. Pupation occurs in the drier portions of large masses of food or, in the case of isolated cattle droppings, just beneath the surface of the ground under the dropping. Hammer (31), Mellor (80), and Thomson (130) give illustrations and good accounts of the ecology of the stable fly in northern Europe.

While the stable fly is very abundant around cattle (including carabao) and horses on Guam, it is not generally troublesome to human beings. It is not important as a carrier of fecal pathogens because of its lack of interest in human excrement or table food. However, through annoyance and blood-letting, a large infestation can cause horses and cattle to lose weight, give less milk, and so forth. In some parts of the world it has been shown to be a carrier of surra (trypanosomiasis of horses); and experiment shows it capable of transmitting several bacillary and protozoal epidermal and blood infections of livestock. In California, it has been shown to carry the bacillus of tularemia. It has also been suspected as a transmitter of neural viruses but experimental evidence is largely negative.

The following controls are suggested: thin spreading of manure and decaying vegetable material; elimination of seaweed thrown up on beaches during storms; and residue spraying of livestock shelters with DDT. Manure may be stored as described in the section for the control of *Musca vicina* (pp. 36, 38), and the direct spraying of infested animals with a DDT suspension in water might have good results. Trials of this sort are in progress and show promise.

A small chalcid wasp, *Spalangia muscidarum,* was a frequent pupal parasite of this fly on Guam.

Genus **Haematobia** Lepeletier

Lyperosia Rondani.

Adults of all the species of this genus whose habits are known feed primarily on the blood of ungulates, but there are scattered records of their biting men. We have found no published accounts stating that their larvae breed in anything but the feces of herbivores.

Haematobia exigua (de Meijere) (pls. 2, 6, 14, 16).

Haematobia australis Malloch.

Lyperosia flavohirta Brunetti.

Lyperosia exigua de Meijere.

Adult: Small, slender, pale-gray muscid with short proboscis, long, expanded palpi, and an arista with dorsal branches only; length 4.5 mm. (pl. 16). *Egg:* Dorsal groove broad, slightly expanded around micropyle; egg yellowish brown and distinctly reticulate in groove as well as elsewhere; length 0.8 mm. (pl. 2). *Larva:* Elongate and active, as in *Stomoxys,* but with posterior spiracles slightly protuberant and separated by about half the diameter of one of them; spiracles black except for three reniform spots; length 6 mm. (pl. 6). *Puparium:* Short, cylindrical, and smooth as in *Stomoxys* and *Musca,* but with spiracles shiny black and close together; length 3.2 mm. (pl. 14).

Distribution: Australia, East Indies, Marianas.

The habits of this species are apparently the same as those of *H. irritans* of the Holarctic Region. On Guam, it was found solely on cows and carabao, except for a few scattered complaints of its biting human beings. Adults tend

to feed in patches around the shoulders, neck, and horns of the animals and are not readily disturbed or dislodged by efforts of the host to get rid of them. The eggs, which are deposited on blades of grass or other objects adjacent to the dropping before it forms a crust, are brownish in color and thus difficult to see. The larva develops rapidly in moist cattle droppings and pupates just beneath them before they show signs of drying out in the middle. Maggots were never found in manure heaps. As in *Stomoxys,* the maggots are highly susceptible to dessication while in the feeding stages. Handschin (32) and other Australian authors deal with the habits and control of this species.

This serious pest of cows and carabao is especially abundant in pastures where droppings are not disturbed, but the carabao spend part of their time in mud wallows, which habit serves to rid them temporarily of this pest. It is probably of no sanitary significance, though its harm to the general welfare of the cattle is usually considerable and it can transmit surra in regions where this disease occurs in cattle. It is advisable to clean up cattle droppings frequently or break them up to allow rapid dessication. Spraying the droppings with oil solutions of DDT might be effective and spraying animals not intended for meat or milk production directly with DDT suspensions should yield excellent results. Methoxychlor should be sprayed on meat and dairy animals and on dairy structures.

Genus **Siphona** Meigen

Haematobia Lepeletier (of Seguy).

This genus is apparently somewhat intermediate between *Stomoxys* and *Haematobia* in both morphology and biology. *Siphona stimulans,* like *Stomoxys,* feeds on the blood of various large animals but apparently breeds only in animal feces. Others, like *Haematobia,* restrict their adult and larval activity to one type of host.

Siphona carabao G. Bohart and Gressit (pls. 2, 6, 14, 16).

Adult: Medium-sized, robust, olive green to brownish, with short proboscis; palpi long and dilated; arista branched above and below; length 6 mm. (pl. 16). *Egg:* Dull chocolate brown and distinctly reticulate only in the dorsal groove which is narrow except for a strong expansion around the micropyle; length 0.9 mm. (pl. 2). *Larva:* Similar to that of *Haematobia exigua* but with spiracles separated by nearly a spiracular diameter, situated nearer to the top of the caudal declivity, and completely flush; length 9 mm. (pl. 6). *Puparium:* Similar to that of *Haematobia* but with spiracles differing as in the larva; length 3.6 mm. (pl. 14).

Distribution: Guam, Saipan, and probably elsewhere.

Adults of this species, like *Haematobia,* feed in patches on cows and carabao, but they tend to collect on the belly and flanks of the animal. They feed quietly and are not readily disturbed or dislodged. Like *Haematobia,*

they generally mate on bare patches of ground near the animals. The eggs are deposited in small numbers on each dropping after it falls. The larval habits of the species appear to be the same as those of *Haematobia.* In general, adults of *S. carabao* are somewhat more conspicuous on carabao than are *Haematobia,* but less so on cows.

Like *Haematobia,* this fly is harmful to the general welfare of cattle and is capable of transmitting surra, hence droppings should be cleaned up, broken up, or sprayed with DDT oil solutions; also the draft animals might be sprayed with DDT suspension, and the dairy and meat animals with methoxychlor.

Subfamily MUSCINAE

This family includes muscids with wing cell R_5 (apical cell) sharply bent upward and with the mouthparts usually developed for lapping instead of piercing. However, some *Musca* and their close relatives have their mouthparts partially developed for piercing. In general, the adults are domestic or semi-domestic, the larvae wide-ranging scavengers.

Genus **Musca** Linnaeus

Although all species of *Musca* are commonly referred to as house flies, some are more domestic than others. Nearly all of them have long branches above and below on the arista; alternating black and pruinose silver bands on the thorax; yellow markings laterally on the abdomen, at least in the males; and eyes nearly contiguous in the males.

Members of this genus, especially *Musca domestica,* are more often than any other flies involved in the transmission of filth-borne pathogens. They undoubtedly deserve this distinction, although other genera may assume the dominant role in some areas and under certain conditions of fly breeding. For instance, in the Marianas and in Okinawa, *Musca* probably ranks after *Chrysomya megacephala* in importance. However, because of its wide-ranging larval habits, *Musca* is more difficult to control by ordinary sanitary measures than is *Chrysomya.* On the other hand, it is much more susceptible in the adult stage to DDT used as a spray or an aerosol.

It has been generally assumed that the various species of *Musca* have much the same habits and should be susceptible to the same control measures, but the two species on Guam clearly refute this supposition.

Musca sorbens Wiedemann (pls. 2, 5, 14, 16).

Musca angustifrons Walker.

Musca biseta Hough.

Musca bivittata Thompson.

Musca conducens of Patton.

Musca dichotoma Bezzi.
Musca euteniata Bigot.
Musca humilis Wiedemann.
Musca latifrons Wiedemann.
Musca mediana Wiedemann.
Musca promusca Aurati.
Musca scapularis Rondani.
Musca sordidissima Walker.
Musca spectanda Wiedemann.

Adult: Distinct from *M. vicina* in its two black scutal stripes and the lack of yellow abdominal markings in the female; length 6 mm. (pl. 16). *Egg:* White, reticulated more distinctly above than in the groove which is narrow and extends the length of the egg; length 1.4 mm. (pl. 2). *Larva:* Creamy white, moderately active and elongate; caudal end surrounded by a series of low tubercles; spiracles nearly approximate; length 8.5 mm. (pl. 5). *Puparium:* Short, cylindrical, and smooth, with spiracles nearly touching and semicircular; length 5 mm. (pl. 14).

Distribution: Old World tropics and subtropics.

M. sorbens is common around garbage dumps, pig pens, native yards, privies, carrion, and various types of excrement. It does not enter houses as freely as *M. vicina,* but is fairly common in the usual open native homes. It feeds readily on all sorts of sweets in the open and on food being processed —drying cycad fruits, fish fillets, jerked meat, and the like—and is especially fond of body exudates such as sweat, mucous, and that from sores. The fly scrapes the sore until the scab is perforated and lymph or pus begins to exude. It can apparently sense the presence of a sore from some distance, because as soon as a sore is exposed, it is usually completely ringed by flies which come from all directions. When brushed off, they return before the motion of the hand stops. In the Solomons, over 50 flies were seen feeding on a single open sore of yaws.

The larvae of *M. sorbens* probably breed in a wide variety of materials, but they were found on Guam only in pig dung, horse droppings, once in cow manure in a shed, and once in an isolated deposit of human excrement. They were never found in latrines or in cattle feces in the open either as droppings or as piles of manure. Buxton (8) states that they were usually present on human feces in Samoa but could not be found in any other material. Meng and Winfield (88) report that in West China dog manure is its most suitable and important breeding material but that small numbers of the flies were bred from pig and cow manure and from semi-liquid human feces. Unfortunately, dog manure was not investigated on Guam, but it is unlikely that there was enough of it to account for much of the peak population. Sometimes it is impossible to determine where the huge numbers of these flies can breed. Though rotting coconuts have been suggested, we

never found this to be the case. In pig manure the maggots make galleries which they enlarge to about twice their own diameter. Pupation occurs in the soil, sometimes an inch or more deep.

This species is usually one of the commonest flies on Guam, especially toward the southern end of the island, where native habitations and livestock are most abundant. It became quite scarce during the rainy month of August and September of 1945, as it was observed to do on Florida Island in the Solomons during a rainy period in March. On the other hand, the number of *M. vicina* on Guam actually seemed higher than usual during and shortly after the rainy period.

On Guam, *M. sorbens* is probably next to *Chrysomya megacephala* in importance as a carrier of fecal pathogens and is of paramount importance in the spread of epidermal infections. And its liking for mucous makes it suspect in the spread of tuberculosis. Harris and Down (33) found significantly fewer intestinal protozoans and helminths contaminating *M. sorbens* than *Chrysomya megacephala,* even when both species were collected from the same latrine. Under conditions of indoor living, where kitchens are moderately well-screened and dining tables are distant from the outside, this species is not likely to visit table food.

Apparently, the enforced use of toilets or privies and the cleaning up of pig pens would eliminate most *M. sorbens* breeding spots, but not enough is known of their breeding habits to be certain of this. Area treatment with heavy doses of DDT from thermal aerosol generators or airplanes yields at least temporary relief from the adults.

Musca vicina Macquart (pls. 2, 5, 14, 16).

Musca flavifacies Bigot.

Musca flavinervis Thompson.

Musca flavipennis Bigot.

Adult: Medium-sized, robust, gray, with four longitudinal dark stripes on the mesonotum and a pair of large, diffuse laterobasal yellow areas on the abdomen of both sexes; eyes of male separated by less than one-fourth the width of one of them; normal length 7 to 8 mm. (pl. 16). *Egg:* Dorsal groove rather broad and incomplete posteriorly, the bordering ridge not definable to the posterior end of the egg or around the posterior margin of the groove; reticulation of groove as distinct as elsewhere; length 1 mm. (pl. 2). *Larva:* Moderately elongate, creamy in color, quite smooth and rounded posteriorly; posterior spiracles separated by about one-third the diameter of one of them; length 12 mm. (pl. 5). *Puparium:* Similar to that of *M. sorbens* but generally larger and without the series of minute caudal tubercles; length 7 mm. (pl. 14).

Distribution: Africa, India, East Indies, Pacific islands, and Tropical America.

M. vicina is considered by many entomologists to be a race or merely a climatic variant of *M. domestica,* the common house fly. It differs primarily

in the close approximation of the eyes of the male. Its habits are probably very similar to those of *M. domestica* but, because of its more tropical distribution, it has a more rapid life cycle and somewhat different relationship to houses than is ordinarily seen with *M. domestica* in the United States or Europe.

The adult of *M. vicina* feeds on almost any sort of food that has a moist surface. It is particularly fond of milk; sweets; meats; fresh, moist excrement; and masses of liquefying garbage. Although it is not as persistent in seeking body secretions and exudations as is *M. sorbens,* it does feed on such substances. On Guam, we found it most commonly at the Island Dairy and at the large, well-supervised garbage dump nearby. It invades houses and buildings readily but does not seem as content to remain inside as does *M. domestica* in the United States. However, it does seek houses for shelter during rains. It commonly enters privies; but it does not penetrate into unlighted, deep privy pits, as do *Chrysomya megacephala* and *Hermetia illucens.* It mates indoors quite commonly, but oviposition is not frequent in confinement. The only way we could make it and most other species of muscoids lay eggs in captivity was by crowding a large number into a glass jar. In the field, eggs are laid upright in small clusters, generally under or in folds of the prospective larval food. Although adults are abundant on fresh cow droppings and isolated deposits of human excrement, we never found the maggots in such situations. However, it is probable that at times the species does breed in these materials, since *M. domestica* has been found to do so on occasion. It is interesting to note that, whereas Thomsen and Hammer (129) state that the larvae of *M. domestica* in Denmark are found most often in pig manure and not at all in cow manure, we found the reverse to be true in the case of *M. vicina* on Guam. Maggots were also found in the garbage dump at Pago, feeding in canned stew and on the moist inner sheaths of rotting ears of corn. In piles of cow manure, they occupied an intermediate zone between the wettest material, which contained *Stomoxys,* and the drier outside layers, which contained *Microchrysa.* Before pupating, most of the larvae migrated laterally to near the periphery of the piles. We reared larvae of *M. vicina* from field infestations of piled cow manure and horse manure.

This species is less common, in general, than *M. sorbens* but more abundant around dairies and inside houses. In areas of the Pacific where it breeds more heavily than it does on Guam, it is probably the principal insect carrier of the bacterial and intestinal fauna of man. On Guam, under the conditions existing during our studies, *Chrysomya megacephala, Musca sorbens,* and perhaps even *Atherigona orientalis* had more opportunities to carry disease. Also, *Musca vicina* is less likely than *M. sorbens* to spread cutaneous afflictions, because it is less attracted to sweat and sores.

On Guam, the principal methods for reducing populations of *M. vicina* would be the rapid incineration or deep burial of garbage and the thin spreading of manure every three days, or storage of it by one of the methods recommended under the section on general fly control (p. 35). Of course, people should not be allowed to drop feces in the open and privies should be kept screened and have tight boxes. The screening of houses and buildings and the operation of clean kitchens would keep most of them outdoors. Residual sprays of DDT about the doorways and on the walls and ceilings in houses affords partial protection for several weeks. Dairy animals and structures should be sprayed with methoxychlor.

Consult papers by Meng and Winfield (81-89), Tao (126), and Yao, Yuan, and Huie (133) for detailed accounts of the habits and disease carrying abilities of this and other muscoid flies in China.

Genus **Synthesiomyia** Van der Wulp

Of the two species in this genus, the habits of only *S. nudiseta* are known.

Synthesiomyia nudiseta Van der Wulp (pl. 14).

Synthesiomyia brasiliana Brauer.

Synthesiomyia grisea Giglio-Tos.

Synthesiomyia schmitzi Becker.

Adult: Large, robust, gray muscid, with bright orange antennae, palpi, and apical abdominal segment; mesonotum with four dark longitudinal stripes; length 8.5 mm. *Larva:* Large, smooth maggot, without tuberculae and somewhat swollen caudally; spiracles scarcely projecting but heavily sclerotized internally and separated by nearly the diameter of one of them; slits S- or U-shaped; length 15 mm. *Puparium:* Short and rounded; spiracles as in larva; length 8 mm. (pl. 14).

Distribution: Africa, Australia, Pacific islands, Tropical America.

Adults were taken consistently but usually in small numbers in traps baited with carrion. We also collected them in the field from decaying mollusks. Otherwise the only specimens we saw at large were on the summit of Mount Tenjo, where they were landing and mating on a wooden tower. Buxton (8) reared the larva once from human feces and several times from carrion in Samoa. Most records show that it prefers carrion for larval food. According to Illingworth (47), it breeds commonly in carrion in Hawaii, where the maggots start out with *Sarcophaga* in fresh carrion but develop slowly and pupate with the late-coming *Ophyra nigra*. Buxton (8) found that in carrion they were always predaceous and even devoured the usually predaceous maggots of *Chrysomya rufifacies*. They burrow into the ground before pupation and form there an earthen cocoon of particles which they cement together with a whitish glue. A number of the cocoons collected in Hawaii by J. C. Bridwell are in the United States National Museum collection.

Though not common on Guam, the species was fairly abundant during May. It was not seen at all in September. According to Buxton, it is also seasonal in Samoa. It is not medically significant on Guam because of its rarity. The best control is the disposal of carrion and garbage.

Family CALLIPHORIDAE, Blow Flies

Adult: Usually rather large, robust blue or green metallic, but sometimes black or variously colored; hypopleural and pteropleural bristles present; propleuron and prosternum densely pilose; arista plumose to apex. *Egg:* Generally with micropylar loop of dorsal groove at extreme tip of egg and truncate or nearly so apically. *Larva:* Posterior two-thirds usually broad, rather wrinkled, and with numerous minute tubercles; posterior end with a distinct series of toothlike tubercles around spiracles which are not set in a deep cavity but are frequently in a shallow transverse depression; spiracles with straight slits and usually a complete rim enclosing a "button." *Puparium:* Broadly rounded, not deeply invaginated caudally; tubercles present but often inconspicuous around spiracles which are constructed as in larva but are darker.

The adults of most species of this family are attracted to putrefying substances such as carrion, fresh excrement, and garbage, and to sweet and fermenting substances such as cut sugar cane and smashed breadfruit. They are not usually attracted to body secretions or exudations, but they sometimes visit fresh wounds or odoriferous sores to feed and oviposit. Some are semi-domestic in habits, others seldom visit villages or dwellings. The eggs are usually laid upright in rather large clusters. The larvae of most species breed best in carrion and in excrement of carnivorous or omnivorous animals, but many also breed in the fresh excrement of herbivores. One group (Rhininae) is supposed to feed largely in ant and termite nests, and a common domestic genus in the United States (*Pollenia*) breeds in living earthworms. The larvae migrate from their food and burrow into the ground to pupate.

Genus **Chrysomya** Robineau-Desvoidy

Chrysomyia (Macquart 1835, not 1834).

Somomyia Rondani.

Microcalliphora Townsend.

Adult: Large, with face and cheeks largely or wholly testaceous or reddish; base of radius with a row of setae along its posterior margin; Guam species metallic dark blue or blue-green.

Adults of this genus feed on carrion, but some species also feed on sweets. The larvae of all species feed in carrion, and some also feed in excrement. Most of them, on occasion, feed in living or necrotic tissue of living animals. One species, *C. bezziana,* which is found in the Orient, is specifically a human myiasis-producing fly.

Chrysomya megacephala (Fabricius) (pls. 2, 7, 15, 16).

Musca dux Escherich.
Musca flaviceps Macquart.
Musca remuria Walker.
Musca bata Walker.
Musca combrea Walker.
Somomyia saffranea Bigot.
Somomyia pfeifferi Bigot.
Somomyia dives Bigot.
Somomyia cyaneocincta Bigot.
Chrysomyia duvaucellii Robineau-Desvoidy.
Chrysomyia gratiosa Robineau-Desvoidy.

Adult: Large, metallic blue to blue-green, with dark reddish frontal stripe and orange antennae, face, cheeks and palpi, the orange color not at all obscured by the pubescence which is also orange; length 10 mm. (pl. 16). *Egg:* Dorsal groove narrow with micropylar loop broadly triangular; length 1.4 mm. (pl. 2). *Larva:* Stout, wrinkled, transversely banded with dark brown minute, blunt tubercles; caudal end with ten triangular toothlike tubercles surrounding spiracles; length 15 mm. (pl. 7). *Puparium:* Moderately smooth but covered with alternate transverse series of striations and minute tubercles; caudal end not constricted and with tubercles usually minute; length 8 mm. (pl. 15).

Distribution: Oriental and Australasian regions.

Adults of *C. megacephala* are strongly attracted to carrion, human excrement, and sweets. In our trapping work on Guam and the Solomons, we found that crushed crabs made the best bait. Dead echinoderms, when sufficiently rotted, were also highly effective. Dead rats and large masses of fresh excrement were about equal to each other in attracting power. Smashed breadfruit and syrups, although highly attractive in the open, were not very successful in traps. Old carrion and feces which had dried on the surface had little attraction, even when quite pungent. Certain types of flowering trees attracted great numbers of the flies, particularly the *Tournefortia,* which grows along the beach. When very numerous, the flies form large clusters on branches near their breeding material. This was particularly noticeable on Okinawa near the outdoor native toilets, and on hot days around open wells. When disturbed, the clusters dispersed but quickly reformed. The same phenomenon was reported on Guam in the early days of American occupation, when breeding in corpses was heavy. In southern Shensi Province of China, according to an unpublished manuscript by W. L. Brown, clustering during the heat of day was of universal occurrence on the lower and middle branches of willows surrounding open well pits. The species enters houses readily and feeds on sweets. On Okinawa, it seemed to enter houses more readily than on Guam and to stay indoors longer. While crawling over food, these flies do not regurgitate as often as do *Musca,* but do scatter their feces freely. When once attracted to food they are sluggish and

not easily driven away. Although *C. megacephala* adults enter caves and dark privy pits to oviposit and feed, they do not lay eggs readily in captivity, except when crowded into moist jars. In the open, they seldom lay eggs on isolated deposits of human feces but do so regularly on large masses of fecal material. A preference is shown for ovipositing on or under fresh, rather than old, carrion. The eggs are usually laid in large clusters; sometimes a highly gravid female deflates herself with one or two deposits of eggs.

The larvae of this species breed equally well in carrion and human excrement, but not in feces of herbivores. Tanada *et al.* (125) found them abundant in chicken manure on Oahu. The only plant material in which we found it breeding was coconut, and the nut was in the peculiar stage of rotting in which the contents smell like diarrhetic stools. Only a few such coconuts were seen on Guam, but they were found in great numbers in the Philippines during April 1945. The maggots in carrion and excrement are very active and voracious and generally crowd out competitors, save for the predaceous *Chrysomyia rufifacies* and the phorid *Megaselia scalaris*. When their food supply dwindles, they become extremely active and writhe about one another in apparently frenzied masses. In native toilets on Okinawa, partially grown maggots were seen to leave the shallow concrete pits in countless thousands after all fecal material and anything stained by feces had been consumed and feces were no longer being dropped among them. This migration proceeded in all directions, and groups of several hundred maggots formed writhing balls during the progression. In camp latrines, the maggots quickly liquefy the entire mass of fecal material and then consume all contents of the pit, including the paper. When ready to pupate, the maggots crawl several feet to several yards away from their food and burrow an inch or more under the surface of loose, dry soil. When large numbers of maggots migrate for pupation at the same time, as happens in large carcasses, they progress in an orderly fashion, quite in contrast to their "hunger marches." Such a migration, from a human carcass four days old, was seen on the beach at the north end of Guam. The sand on the seaward side of the carcass was carpeted for several yards with maggots all traveling in the same direction but with their ranks thinning as individuals burrowed into the sand.

C. megacephala is the commonest muscoid on Guam and the species with the most uniform population throughout the season. However, its numbers on Guam were small when we were there compared to what they were several months earlier when unburied corpses were abundant, or compared to Okinawa native villages where toilets were not emptied for manurial purposes. According to W. L. Brown, it is also the commonest fly in much of northern China, particularly in Shensi Province. It is unquestionably the greatest menace of any of the flies on Guam with regard to the spread of

fecal pathogens, and it is apparently the greatest menace on most Pacific islands and much of the oriental mainland. Chang (9) found in Chengtu, Szechnan Province, West China that 42 percent of 146 *C. megacephala* examined bore forms of human intestinal parasites, a rate seven times that of the closest competitor. The following factors contribute to its ability to spread disease: (1) large populations, (2) domestic habits, (3) ability to feed on and breed in large masses of human fecal material under a wide variety of circumstances, (4) strong attraction to human foods, especially sweet sticky substances, (5) large quantities of material which it consumes and defecates while feeding, (6) ability to maintain high populations in nature (probably in dead toads on Guam and dead crabs in the Solomons), (7) large size and sluggish nature while feeding, which leads to gross contamination from drowned or mired flies. In the Orient, the larvae have been taken fairly often from sores in animals but only rarely in human beings. They do not feed in healthy tissue, according to Senior-White (116).

The following control measures are recommended: properly constructed privies thoroughly treated with DDT or sodium arsenite; rapid incineration or deep burial of all garbage, especially meats; destruction of coconuts when they are in attractive condition for breeding; removal of dead toads from roads; removal of principal attractions, such as ripe breadfruit and cut sugar cane, from the vicinity of habitations; and screening of kitchens and dining halls. When very numerous, fly traps should be used near, but not adjacent to, eating places. Area spraying with DDT from airplanes may be effective in killing adults if the dosage is heavy and the swaths are contiguous. Special methods may be necessary within range of populated areas where night soil is used for fertilizer. (See page 38.) W. L. Brown in recent preliminary, unpublished studies in China found that drastic reduction of adult *C. megacephala* populations in native towns apparently resulted from repeated heavy applications of DDT to their favorite clustering places.

Consult papers by Chang (9), Chow (10), Jettmar (51), Meng and Winfield (81-89), and Tao (126) for detailed accounts of the habits and disease carrying abilities of this and other species of flies in China.

Chrysomya rufifacies Macquart (pls. 2, 7, 15, 16).

Lucilia orientalis Macquart.
Lucilia pavonina Schiner.
Somomyia melanifera Bigot.
Somomyia barbata Bigot.
Somomyia micropogon Bigot.
Chrysomya cordieri Seguy.
Chrysomya putoria Patton (*nec* Wiedemann).
Chrysomya albiceps of authors (*nec* Wiedemann).

Adult: Rather large, metallic blue-green, with frontal stripe and under parts of cheeks nearly black and with face and upper parts of cheeks yellow to orange and covered with silvery pubescence that obscures the ground color of the cheeks from some angles; antennae brown; length 8.5 mm. (pl. 16). *Egg:* As in *C. megacephala* but with micropylar loop crescentic; length 1.2 mm. (pl. 2). *Larva:* Tough and brownish; each segment with a ring of long hornlike tuberculae and numerous small black tuberculae; length 15 mm. (pl. 7). *Puparium:* Barrel-shaped but tuberculate as in larva; length 10 mm. (pl. 15).

Distribution: Oriental and Australasian regions.

Adults of *C. rufifacies* (the hairy sheep maggot) greatly prefer carrion in the early stages of decomposition. They find human excrement fairly attractive, ripe fruit slightly attractive; and they take nectar readily from certain flowering trees. This species is seen occasionally in privies, almost never in houses. It generally oviposits in the folds or fur of carrion after the putrifactive odors are strong but before the "old carrion" smell is evident; and it apparently prefers to oviposit in meat containing other species of maggots. According to Mackerras (73), *C. rufifacies* oviposits in living sheep but generally in wounds or areas already infested with *Lucilia cuprina* or other primary blow-fly larvae. We reared larvae on Guam only in carrion, and it is not mentioned in the literature as breeding in other substances. [Fuller (26) gives a good account of the role this species plays in the ecology of carrion in Australia.] The larva is largely predaceous on other maggots, when they are available, and often cleans a carcass of them when the supply of flesh becomes low. However it is also necrophagous, as we demonstrated by rearing adults from single eggs placed on maggot-free media. Mackerras states that in wounds of sheep it preys on other larvae but also causes extensive injury to the sheep. Generally it enters and leaves carcasses somewhat later than *C. megacephala* but at about the same time as *C. "nigripes."* As in the case of *C. megacephala,* the maggots migrate several feet from their food before pupating. Well-developed tubercules enable them to crawl around it for several hours before settling down to pupate.

Although not nearly as common on Guam as *C. megacephala, C. rufifacies* ranks next in abundance among the calliphorids. Its medical significance is probably slight because of its relative lack of interest in human excrement and human food. Either incineration or deep burial of dead animals and waste meats is advised for control. First stage blow-fly larvae, as shown by Fuller (24), are quite capable of penetrating a number of inches into the ground to breed in buried meat. Thorough soaking or dusting of a carcass with DDT or sodium arsenite before burial usually prevents breeding of the primary and secondary necrophagous flies.

Chrysomya (Microcalliphora) near **nigripes** Aubertin (pls. 2, 15, 16).

Adult: Moderate-sized, dark metallic blue to blue-green, with frontal stripe and antennae pitchy and with face and cheeks black or dark brown and with silvery pruinosity

and pubescence; male with frons wider than oral cavity; length 7.6 mm. (pl. 16). *Egg:* Dorsal groove broad and emarginate at the micropylar end; length 0.95 mm. (pl. 2). *Larva:* Tan-colored above and without strong tuberculae; surface between segmental rings of small tuberculae covered with microtrichia when viewed with high magnification; posterior segment flaring apically; length 13 mm. *Puparium:* Similar to *C. megacephala* but with apical segment constricted basally and flared apically; length 6.5 mm. (pl. 15).

Distribution: Guam and possibly the south Pacific.

This species is close to, but probably distinct from, *C. nigripes* which is known only from Ceylon. It seems to belong to the same species as specimens collected on Guadalcanal and the New Hebrides.

Adults were taken only in the traps baited with carrion, especially that in an advanced state of putrefaction. Many specimens were also collected on flowers of the *Tournefortia* tree near the corpse at Point Ritidian. Adults were not collected in houses, although they invaded one of our rearing tents to oviposit on dead rats. We reared the larva only from field infestations of putrefied to somewhat dessicated carrion. The larva is apparently a late secondary invader of carrion. Its peak of abundance in the corpse at Point Ritidian and its sudden appearance as an emerged adult on nearby flowers was nearly a week after that of *C. rufifacies* and two weeks after *C. megacephala.* Most of the maggots burrowed into the sand directly under the corpse in order to pupate.

This least common of blow flies seen in the field is a common larval invader of putrid carrion. It is probably of no medical significance on Guam, except in the competition it affords other species. Although it is probably a beneficial necrophile under most conditions, further study may show that it sometimes visits human excrement and invades houses. In this case, control could be obtained by deep burial or incineration of waste meats.

Genus **Lucilia** Robineau-Desvoidy

Phaenicia Robineau-Desvoidy.
Phymonesia Villeneuve.
Bufolucilia Townsend.
Francilia Schiner.
Argoracrites Seguy.
Caesariceps Rohdendorf.
Dasylucilia Rohdendorf.
Roubaudiella Seguy.
Luciliella Malloch.
Viridinsula Schiner.

Most species of *Lucilia* are attracted principally to carrion but also feed readily on human excrement and various souring animal and vegetable materials in garbage dumps. Many of them enter kitchens and feed on sweets,

meat, and the like. Apparently, all species oviposit principally in meat and lay large masses of rather yellowish eggs. The larva is usually considered a meat-eater only, though several species have been reared from field infestations of human excrement. Several species are frequent invaders in cutaneous areas of living animals, sometimes in healthy tissue. Some have also been found to complete their larval development in the human intestine.

Lucilia (Phaenicia) cuprina Wiedemann (pls. 2, 7, 15, 16).

Lucilia anuca Robineau-Desvoidy.
Lucilia elegans Robineau-Desvoidy.
Lucilia argyricephala Macquart.
Lucilia pallescens Schiner.
Musca fucina Walker.
Musca serenissima Walker.
Musca temperata Walker.
Somomyia pallifrons Bigot.
Strongyloneura nigricornis Senior-White.

Adult: Medium-sized, dull bronzy green; cheeks silvery on a dull-brown background; abdomen rather tapered; base of radius completely bare; length 7 mm. (pl. 16). *Egg:* Dorsal groove gradually tapered, not more than twice as wide at anterior end as at middle; reticulation coarse; length 1.2 mm. (pl. 2). *Larva:* Rather elongate for a calliphorid; posterior end slightly emarginate from a lateral view; spiracles enclosing a distinct button; length 13 mm. (pl. 7). *Puparium:* Smooth and barrel-shaped, the caudal end rounded; spiracles each enclosing a button on their inner margins and with oval, straight, parallel slits; length 6 mm. (pl. 15).

Distribution: Temperate and Tropical America, Africa, and Oriental and Australasian regions.

Adults are attracted in moderate numbers to carrion but apparently prefer to feed on large masses of liquefying garbage. They were collected in the field from isolated deposits of human excrement and from several privies. They were also commonly seen around kitchen doorways feeding on soil moistened by overflow from slop pails. In Australia, *L. cuprina* is now recognized as the principal species of fly making primary strikes in sheep. It shows a preference for ovipositing on rather fresh, or at least not highly decomposed, meat. The eggs are generally tucked under the food. On Guam, we found *L. cuprina* maggots in a green cowhide on the beach and in a turkey carcass at the edge of a garbage dump. Tanada *et al.* (125) report *Phaenicia* species (probably referring to *L. cuprina*) as breeding in chicken manure. When we crowded adult females into a jar with human excrement, they deposited several batches of eggs and the larvae grew as rapidly and with as little mortality as did some of the eggs placed on liver. Lennox (65) found that *L. cuprina* and other species of *Lucilia* could be reared on a sterile culture of the following composition: Agar solution, 93 percent; baker's yeast,

6.7 percent; and sodium chloride, 0.3 percent. They developed as rapidly on this as on beef. On sheep, especially in Australia, the flies oviposit in wool wet with urine and stained with feces, and the hatching maggots break through the skin and invade healthy tissue. The invaded areas are, as shown by Mackerras and others, then subject to oviposition by *Chrysomya rufifacies,* whose maggots prey on those of *L. cuprina.*

This species was not abundant in our traps, but we saw it rather commonly around kitchens, village dumping grounds, and the large garbage dump near the Government Farm. Since it is common around habitations and visits both human feces and human food it must be considered a potential disease spreader. Usually attention is directed to *Lucilia* primarily because of its myiasis producing proclivities. No evidence of its attack on man or domestic animals was observed on Guam, although a comprehensive survey was not made. The prompt disposal of carrion and garbage and the protection of feces from visits by the flies are the best control measures.

Subfamily RHINIINAE

Adult: Medium-sized, usually brightly marked, with face and cheeks strongly projecting below, giving the head a flattened appearance; Guam species with thorax bronzy above a yellow longitudinal pleural stripe composed of hairs and minute scalelike pubescence.

This is a large subfamily in the Orient whose members are usually seen visiting flowers, resting on foliage, or hovering over the ground in groups. Many of the species are attracted to freshly opened ant and termite nests, according to Senior-White (116). He also states that they are not attracted to carrion, but we found this did not apply to the species on Guam and Guadalcanal. According to Senior-White, *Stomorhina discolor* was reared in India from an ant nest; and several references to various species being associated with ants are found in the literature. Nothing more seems to be known of the bionomics of the genus.

Genus **Rhinia** Robineau-Desvoidy

Beccarimyia Rondani.

Rhinia testacea appears to be the only species of this genus for which any life history is known.

Rhinia testacea Robineau-Desvoidy (pls. 2, 7, 15).

Idia flavipennis Macquart.
Idia tripartita Bigot.
Idia fulvipes Bigot.
Beccarimyia glossina Rondani.
Rhinia apicalis Wiedemann.

Adult: Brightly marked, dorsoventrally flattened, with abdomen and legs orange and with a sulphur-colored pubescent stripe along the side of the thorax; apical cell closed apically and appendiculate; length 6 mm. *Egg:* About four times as long as broad, distinctly reticulate and with a few longitudinal creases; length 1.3 mm. (pl. 2). *Larva:* Rather smooth and moderately elongate; caudal end slightly convex in lateral outline and surrounded by ten slender, unchitinized tubercles; length 9 mm. (pl. 7). *Puparium:* Smooth but densely covered with minute tubercles; caudal tubercles as in larva but somewhat shrunken; spiracles prominent, with slits in clover-leaf pattern; length 5 mm. (pl. 15).

Distribution: Africa, the Orient, and Pacific islands.

On Guam and on Florida Island in the Solomons, this species was found principally near the coastal beaches and in coastal villages. On Florida Island, it was taken abundantly in traps baited with crushed crabs. On Guam, it was taken on dead fish stranded by receding tides, and on the human corpse at Point Ritidian. At the recreational beach along Tumon Bay large numbers of gravid adults were found on blossoms of *Tournefortia*; several expressed eggs when captured. Nearby, a number of flies were seen to deposit eggs in beach sand where leftovers from picnics and small dead beach animals were scattered. The eggs were deposited singly as the female raised the anterior part of her body and forced her ovipositor into the sand. According to Villeneuve, the same species oviposits in ant nests in Nigeria.

This species is fairly common near beaches and some jungle clearings. It is probably of no significance medically, and control is unnecessary.

Genus **Stomorhina** Rondani

Idia Meigen.
Stomatorrhina Kertesz.
Eridiella Townsend.

One species, *S. discolor,* was reared by Senior-White (116) from an ant nest in India. A species in the Solomons was seen hovering over a fresh catch of fish on the beach in a group of about a dozen.

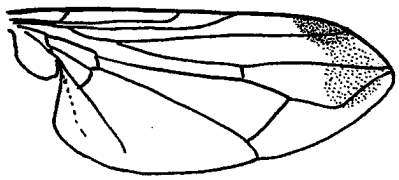

FIGURE 14.—Wing of *Stomorhina quadrinotata.*

Stomorhina quadrinotata Bigot (fig. 14).

Adult: Black and tan, with whitish stripe along the side of the thorax and a dark spot at the wing tip; apical cell not closed before the wing margin (fig. 14); length 6 mm.

Distribution: Orient, Australasia.

We collected adults in numbers from the human corpse at Point Ritidian when it was about two and one-half weeks old, and took occasional specimens in traps baited with sea cucumbers. On one occasion about a dozen of them were seen hovering over a shrub in the corner of an open field; on another, several were collected from flowers of *Tournefortia.*

This species is generally uncommon, probably has no medical significance, and needs no control measures.

Family SARCOPHAGIDAE, Flesh Flies

Metopiidae (of Curran, part).

Adult: Mostly medium-sized to large, tesselated gray and black, with strong bristles on the body including the basal portion of the abdomen; postnotum not developed into a convex lobe.

As its name implies, the flies of this family are strongly attracted to meat and many of the species breed in it. However, the excrement of carnivores is nearly as attractive, both for adults and as a breeding medium for larvae. Perhaps over half of the species are principally parasites of other arthropods or of land snails, and some of these are not particularly attracted to carrion or excrement.

The largest and most conspicuous genus is *Sarcophaga,* which comprises a tremendous assemblage of species which look very much alike. Although it is sometimes divided into a number of genera, only one is recognized for the purpose of this study.

Genus **Sarcophaga** Meigen

Blaesozipha Linnaeus.
Ravinia Robineau-Desvoidy.
Helicobia Coquillet.
Boettcheria Parker.
Glaucosarcophaga Townsend.
Parasarcophaga Johnston.

Adult: Medium-sized to large, black and gray, with three more or less distinct longitudinal black lines on the mesonotum and a shifting checkerboard pattern of gray and black on the abdomen; arista long plumose on basal two-thirds. *Egg:* All species deposit first stage maggots. *Larva:* Rather stout, wrinkled, with broad rings of minute tuberculae and with posterior spiracles sunken into a deep pit and without complete rims. *Puparium:* Barrel-shaped, with broad areas of minute tuberculae and with spiracles in a deep, transversely oval pit.

Nearly all species, all of those on Guam, are strongly attracted to carrion and human excrement and are not particularly attracted to sweets. Relatively few show much attraction to decaying vegetable material or the feces

of herbivores. Several species invade houses readily and larviposit on meats or meat products, or on one's hand when they are captured. A "swatted" sarcophagid female nearly always produces a wriggling mass of young maggots. Flesh flies are usually among the first on the scene when meat or fresh human fecal material is exposed and they deposit their larvae immediately. Many species are parasitic in other arthropods or land snails, but a number of them also act as scavengers in meat or excrement. Others, apparently, are always scavengers. Numerous species have been reported in cases of cutaneous myiasis of man and animals. Because their larvae are easily ingested with meat, they frequently cause intestinal myiasis and sometimes complete their larval development in the intestine, causing such symptoms as nausea and diarrhea. A much larger number of reported cases of intestinal myiasis are based upon the discovery of young maggots in stools dropped in the open but most of these maggots were deposited by early visiting flies. Growth of the maggots is rapid but the prepupal and pupal periods are often rather long. Pupation occurs in the ground around the food supply, although parasitic forms may remain in the host, especially when the latter first dies and dessicates.

The Guam species are described by Hall and Bohart (30).

Sarcophaga ruficornis Fabricius (pls. 6, 15, 17).

Adult: Large species with orange antennae, palpi, and genital segments; length 12 mm. (pl. 17). *Larva:* Yellowish when mature, almost completely covered with microtuberculae dorsally and with a ring of rather distinct low tuberculae on each segment; posterior spiracles separated by about two-thirds the diameter of one of them and with very narrow slits; length 20 mm. (pl. 6). *Puparium:* Microtuberculae cover the entire dorsum but leave narrow striate ventral areas; the microtuberculae generally with transverse lenticular-shaped bases fitting closely together; length 11 mm. (pl. 15).

Distribution: India, Africa, and Pacific islands.

The adults were taken regularly and abundantly in traps baited with carrion and human excrement, less abundantly in papaya-baited traps. This species enters houses more readily than any other fly on Guam, except *Musca vicina.* When meat is exposed indoors, this species congregates on the outside of screens; and once inside, it flies immediately to the meat in order to larviposit and then feed briefly. It also comes quickly to fresh deposits of human excrement and is seen occasionally in privy pits. We reared larvae from field infestations of dead mollusks, echinoderms, and mammals, and found that they often completed their growth before the meat was completely putrefied. *S. ruficornis* was reared in the laboratory in human feces, but infested human droppings were not found in the field. The adult flies entered the laboratory when the door was opened and deposited larvae on the covers of our rearing jars. The young maggots worked their way through loose meshes and soon crowded out other cultures on meats, except *Chrysomya.*

Several horse droppings containing these larvae were found in the stables at the Island Farm.

S. ruficornis is third in abundance among the *Sarcophaga* on Guam, but it is the commonest in houses and dining halls. Medically, it is the most important of the Guam *Sarcophaga* because of its domestic habits. It is a potential source of fecal contamination of meats and of intestinal myiasis brought about by eating maggotty meat. It has also been reported (Senior-White, 116) in a case of cutaneous myiasis of a dog in India. The following control measures are recommended: disposal of carcasses and waste meats; forbidding of indiscriminate defecation; proper construction of privies; thin spreading of horse manure in the sun; screening; and protection of meats.

Sarcophaga gressitti Hall and G. Bohart (pls. 8, 17).

Adult: Small, pale, with fine, indistinct thoracic stripes, especially in the female; propleuron with a few hairs; vein R_1 with a row of stout setae; length 7 mm. (pl. 17). *Larva:* Tuberculation similar to *S. ruficornis,* but with ventral rings developed as low bosses only; spiracular cavity shallower than in other species; spiracles about two-thirds as far apart as the diameter of one of them and with rather short straight slits; length 10 mm. (pl. 8). *Puparium:* Similar to that of *S. ruficornis,* but much smaller, somewhat smoother, and with a shallower spiracular cavity; length 6 mm.

Distribution: Guam and Saipan.

Adults were taken frequently and abundantly in traps baited with carrion and somewhat less abundantly in traps baited with human excrement. In the field, it was seen most commonly along the beaches, where it visited the fish and other sea life stranded by high tides and the deposits of human excrement dropped below high tide level by villagers. It visited the human corpse at Point Ritidian most abundantly when it was over a week old, at about the time that *Chrysomya megacephala* larvae were leaving for pupation. D. G. Hall tells us that on Saipan the species bred commonly in dead land snails of the common large species that was introduced onto that island and onto Rota. Individual flies sometimes entered the laboratory on Guam to larviposit on meat cultures, but not as frequently as did *S. ruficornis.* The only larvae we found in the field were along the beaches. Two specimens were collected from human excrement washed ashore by high tide and lodged in the roots of a tree; a number were reared from the creases in a pig hide; and many puparia were collected in the sand beneath the corpse at Point Ritidian along with those of *Chrysomya "nigripes."* In the laboratory, we reared it in putrid liver.

Except along beaches, this species is less common than any sarcophagid other than *S. stricklandi,* though we took it in fair numbers in most of our traps, especially those set near coastal villages. Considering the coastal location of most of the native towns and of many military camps, together with the defecating habits of the natives, this species may be one of the more impor-

tant disease spreaders on the island. Thus the clean-up of beaches and coastal villages, the control of offal discharged from ships, and the prevention of human defecation along beaches are recommended controls.

Sarcophaga near **peregrina** Robineau-Desvoidy (pls. 8, 17).

Adult: Rather large, boldly marked, with black antennae and brownish genital segments; propleuron with a tuft of long hair at the middle; male genitalia as in plate 17; length 10 mm. *Larva:* Posterior spiracles separated by less than one-third the diameter of one of them; body with broad smooth or striate areas, especially ventrally; length 15 mm. (pl. 8). *Puparium:* Posterior spiracles as in larva; body tubercles take on the appearance of short transverse ridges surmounted by tiny teeth; length 7.5 mm.

Distribution: Guam.

This is an undescribed species very close to *S. peregrina* but differing in details of the male genitalia. Another undescribed species on Saipan is in the same complex but also differs from true *S. peregrina.*

Our early records on the species are lost because we confused it with *Sarcophaga dux.* After differentiating it, we found specimens in our preserved trap material from carrion but not from human excrement. Later we found it regularly in carrion-baited traps which were set by certain villages. Hall collected hundreds of them from a trap baited with liver. Our first rearing was from dead toads. Later it was reared from liver set out in pans and from a coconut that smelled like diarrhetic stools. Illingworth (48) found it breeding in rain-soaked chicken manure on Oahu.

This species seems to be less common than *S. ruficornis, S. dux,* and *S. knabi* with which it was usually trapped. However, Hall found it quite as common as *S. dux* near the village of Dededo. It is of slight importance from the standpoint of possible intestinal or cutaneous myiasis, but it may visit human excrement even though it was not found to do so on Guam.

Disposal of waste meat and carcasses and the clean-up of toads on the roads are advocated as control measures. Disposal or chemical treatment of human excrement and chicken manure may be necessary during exceptionally wet weather.

Sarcophaga dux Thompson (pls. 8, 17).

Sarcophaga tuberosa Parker.

Sarcophaga subtuberosa Parker.

Sarcophaga ceylonensis Parker.

Sarcophaga misera of authors (*nec* Walker).

Adult: Large, strongly marked, with black antennae, palpi, and genital segments; male genitalia as in plate 17; length 12 mm. *Larva:* With broad striated areas dorsally and ventrally; length 17 mm. (pl. 8). *Puparium:* With broad deeply striate areas dorsally and ventrally; length 9 mm.

Distribution: Palearctic, Orient, Australasia.

Adults were taken regularly and abundantly from traps baited with all types of carrion and human excrement, less commonly in traps baited with cow and pig feces, rotten coconuts, rotten tomatoes, and breadfruit. It was usually, with *S. knabi,* the first visitor to human excrement dropped in the open and made up over half of all the *Sarcophaga* taken on dead toads along the roads. It was also the commonest species collected by R. M. Bohart from dead land snails on Rota. Most of the flesh-fly larvae we collected in the field from carrion were of this species. According to Senior-White's work in India (116), it does not breed in human excrement; but we found it larvipositing on excrement several times and reared it through with no difficulty. Once its maggots were found in a pan of rotten tomatoes; and Senior-White reared it from rotten cucumbers. On the corpse at Point Ritidian, we found its larvae in about the same stage of development as *Chrysomya rufifacies.*

To judge from our bait trapping records, this is the commonest *Sarcophaga* on Guam; but had we used human excrement more often as bait, *S. knabi* might have appeared to be more abundant. Medically, it is less dangerous than *S. ruficornis* or *S. gressitti* because of its less domestic habits, and less dangerous than *S. knabi* because of its relative reluctance to larviposit in human excrement. As for *S. ruficornis,* the best control measures are disposal of carcasses and waste meats; the forbidding of indiscriminate defecation; proper construction of privies; thin spreading of horse manure; screening; and protection of meats.

Sarcophaga knabi Parker (pls. 8, 17).

Adult: Moderately large, boldly marked, with black antennae and genitalia and black palpi with brown apices, male genitalia as in plate 17; length 9 mm. *Larva:* Rather tapered at the posterior end, with spiracular cavity nearly filled by huge bright-orange spiracles that are close together; surface of maggot entirely covered by microtuberculae; length 12 mm. (pl. 8). *Puparium:* Spiracles as in larva; tuberculation similar but degenerate; length 7 mm.

Distribution: Oriental region, China, and Pacific Islands.

Adults were taken regularly and abundantly in traps baited with carrion and human excrement, less commonly in traps baited with cow dung, pig dung, and rotten coconut. This species was the most consistent of the early visitors to human excrement in the open and the most frequently encountered flesh fly in privies. In the field, it was taken most abundantly around the pig pens at the Government Farm, somewhat less abundantly around the horse stables. It was usually the first species to larviposit on human excrement, and in wooded areas it could be counted on to deposit larvae in feces before the person who dropped them had proceeded on his way. We reared larvae several times from human excrement; but apparently the principal population comes from moist pig feces, which are nearly always infested. The maggots are very sluggish

in their food medium, and several together hollow out and constantly enlarge a chamber in the dropping. When the chamber is opened, the maggots bury their heads in its floor and present their strikingly large and bright orange spiracles to view. They were also found in moist separate horse droppings in which they exhibited similar habits. Larvae were not taken from privy pits, but research was not conducted sufficiently to say that they do not occur there. Adults were reared once from a field infestation of dead rats. Tanada *et al.* (125) found the larvae as frequent inhabitants of chicken manure on Oahu.

S. knabi is probably about as common as *S. dux*. In general, these two species ranked in abundance in our traps after *Chrysomya megacephala* and *Atherigona orientalis* among the muscoids and sometimes after *Musca sorbens* as well. Although it is not a frequent visitor to houses, the almost certain contact of this fly with feces of pigs or human beings makes it a definite menace wherever it can get at meats or other animal products.

The controls are the same as for *S. ruficornis* (disposal of carcasses and waste meats, banning of indiscriminate defecating, proper construction and chemical treatment of latrines, and so forth) with special emphasis on keeping human excreta away from the flies. Weekly DDT spraying of pig feces in pens might be a worthwhile control measure.

Sarcophaga stricklandi Hall and G. Bohart (pl. 17).

Adult: Medium-sized, with bluish-black abdomen and orange wing bases and calypters; length 9 mm. (pl. 17). *Larva:* Posterior spiracles separated by about two-thirds the diameter of one of them and with their ventral margins short; anterior spiracles with at least 21 branches in two or more irregular rows; length 14 mm. *Puparium:* Anterior and posterior spiracles as in larva; surface tuberculae appear like reclining transparent teeth, contiguous in oblique series; length 8 mm.

Distribution: Guam and Saipan.

Adults were not plentiful in traps baited with carrion and human excrement. Most of our specimens were collected from human excrement in the dense jungle on top of the cliff at Point Ritidian and in similar situations near the villages of Barrigada and Ukudu. Hall collected most of his Saipan material in dense jungles, some from liver-baited traps, and some by net-collecting on foliage. Few of the females trapped were ready to deposit maggots, but those obtained from one female were reared on meat without difficulty. It is suspected, however, that this is not the normal breeding material for the species. It may be found to be parasitic on other arthropods.

This is the rarest of Guam flesh flies, but it is not infrequently seen in dense jungles. Its medical significance is probably slight because of its rarity and jungle-dwelling habit, but it shows a marked fondness for human excrement. Too little is known of its biology to recommend a specific control.

Family Larvaevoridae (Tachinidae), Tachina Flies

Adult: Composed mostly of moderate-sized to large gray or tesselated flies characterized by strong posterior abdominal bristles and a swollen, convex metanotum. The species on Guam can all be told from the Sarcophagidae and Muscidae, which they most resemble, by their bare aristae and the concealed abdominal sternites.

The adult, which is found commonly on flowers and foliage, rarely visits decaying materials to parasitize saprophagous flies. The larvae are nearly always found as internal parasites of terrestrial arthropods or other invertebrates.

This family is mentioned because its species are easily confused with filth-inhabiting forms. Three species were found on Guam, all of them uncommon.

CONCLUSIONS

We conclude that *Chrysomya megacephala* and *Musca sorbens* are medically the most important filth flies on Guam and probably on other Pacific islands.

Apparently, it has not been well understood outside of China[5] that *Chrysomya megacephala,* which is as generally abundant as any fly in the Pacific, freely feeds on and breeds in large masses of human excreta and, in addition, is strongly attracted to various sorts of human foods including sweets. Results of examinations of the feces of these flies made by Harris and Down (33) on Guam prove conclusively their ability to spread many types of intestinal protozoans and helminths. Indications are that, even in the face of strict measures of ordinary sanitation, this and other species of flesh-eating maggots can maintain natural populations at a relatively high level from such materials as dead toads, land snails, and land crabs.

Musca sorbens apparently plays an important role in the spread of intestinal and cutaneous infections.[6] Its strong attraction to perspiration and lymphatic discharges makes it much more dangerous than *M. domestica* or *M. vicina.* It is, however, less domestic than the ordinary house fly and may be of little importance as a disease carrier in well-enclosed buildings. The number of larvae we found in human excrement and pig manure seemed insufficient to account for the enormous population of *M. sorbens* on Guam during the spring and summer of 1945. However, one rearing record from coconuts suggests that under certain conditions these may be an important source of *M. sorbens* populations.

[5] Considerable information on the biology and disease carrying ability of the former has been published recently in China by Chow (10), Jettmar (51), Tao (126), and Meng and Winfield (81-89).

[6] Patton (98, 99) and Meng and Winfield (81-89) have published most of what little has been recorded about *Musca sorbens.*

M. vicina, largely because it was not nearly as abundant as *M. sorbens,* we consider of lesser importance on Guam. However, large populations have been seen on other island groups (the Palaus for instance), where it may be the more important species.

It is obvious from our studies on Guam that many species usually considered innocuous must spread disease to some extent. *Atherigona orientalis,* for example, although not common in houses, was the commonest fly on Guam and fed on or bred in almost every type of decaying substance on the island. Another example is the phorid *Megaselia scalaris,* which was abundant indoors and was able to reach excrement and human food where larger flies were excluded. It was even seen several times on food in refrigerators.

We found that life history work with scavenging flies was not difficult and that immature stages of all species were readily distinguished. With the present knowledge, accurate identifications of larvae and pupae of most species on Guam should be possible without further rearing. However, when time and conditions permit, rearing of all material should be undertaken.

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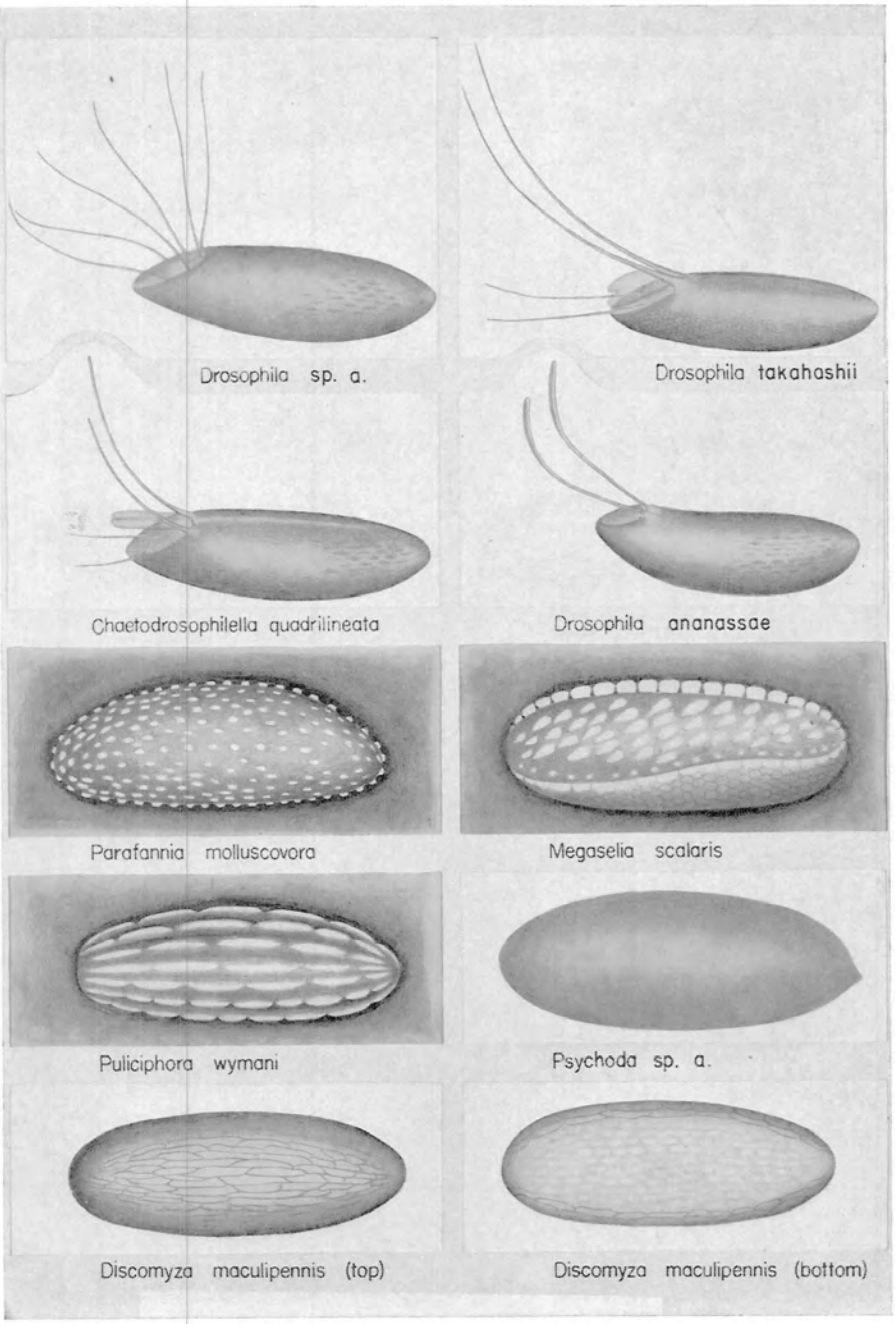
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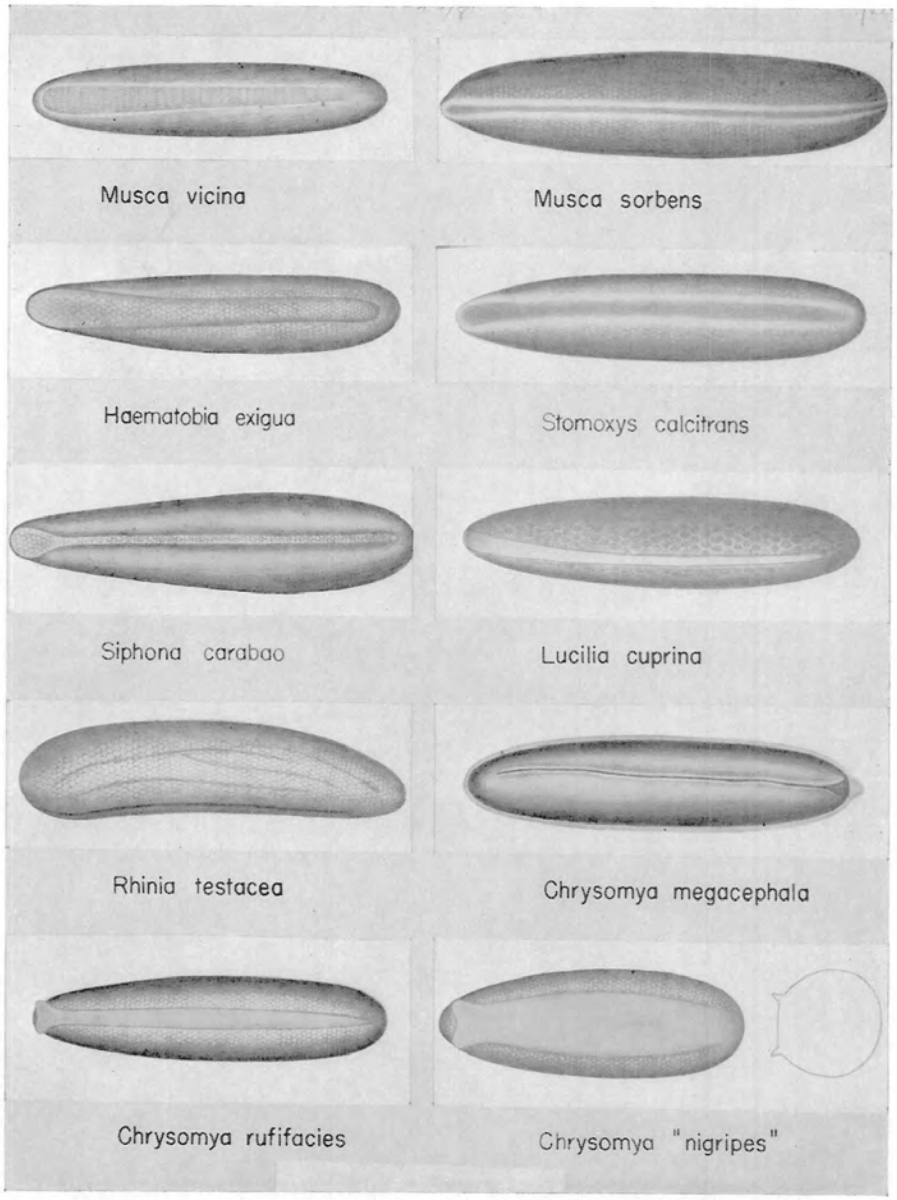
Discomyza maculipennis (bottom)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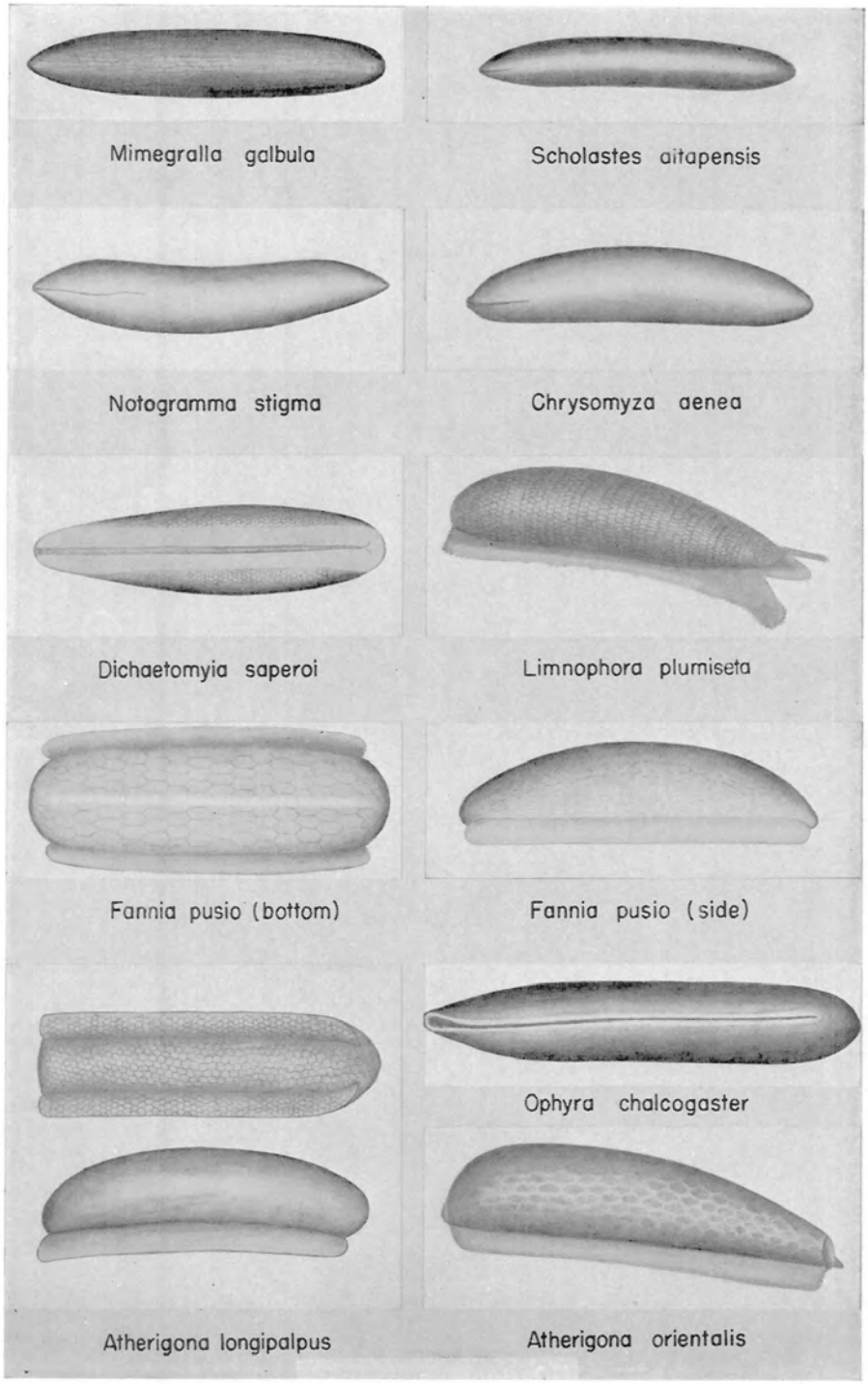
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Fannia pusio (side)
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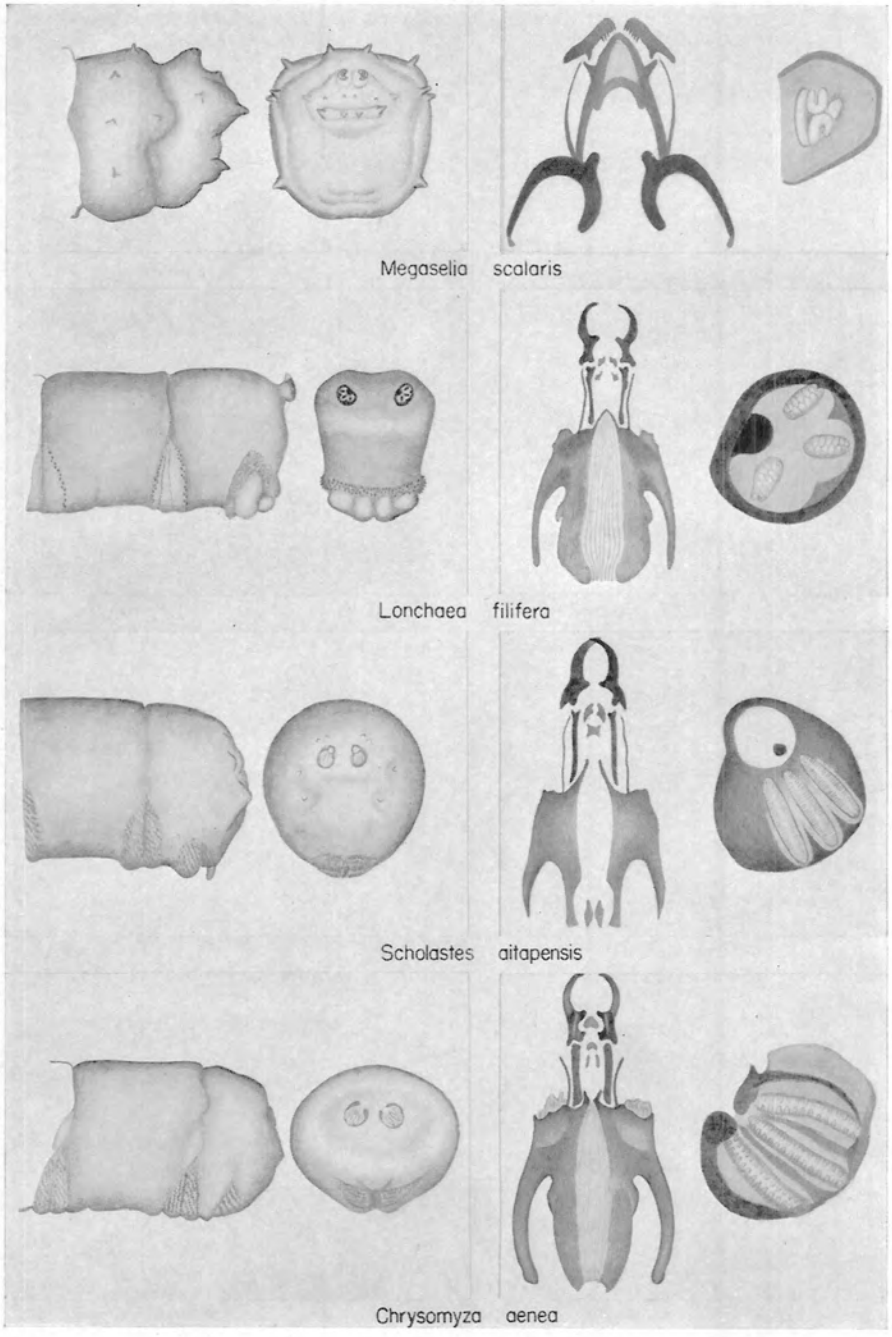
Atherigona orientalis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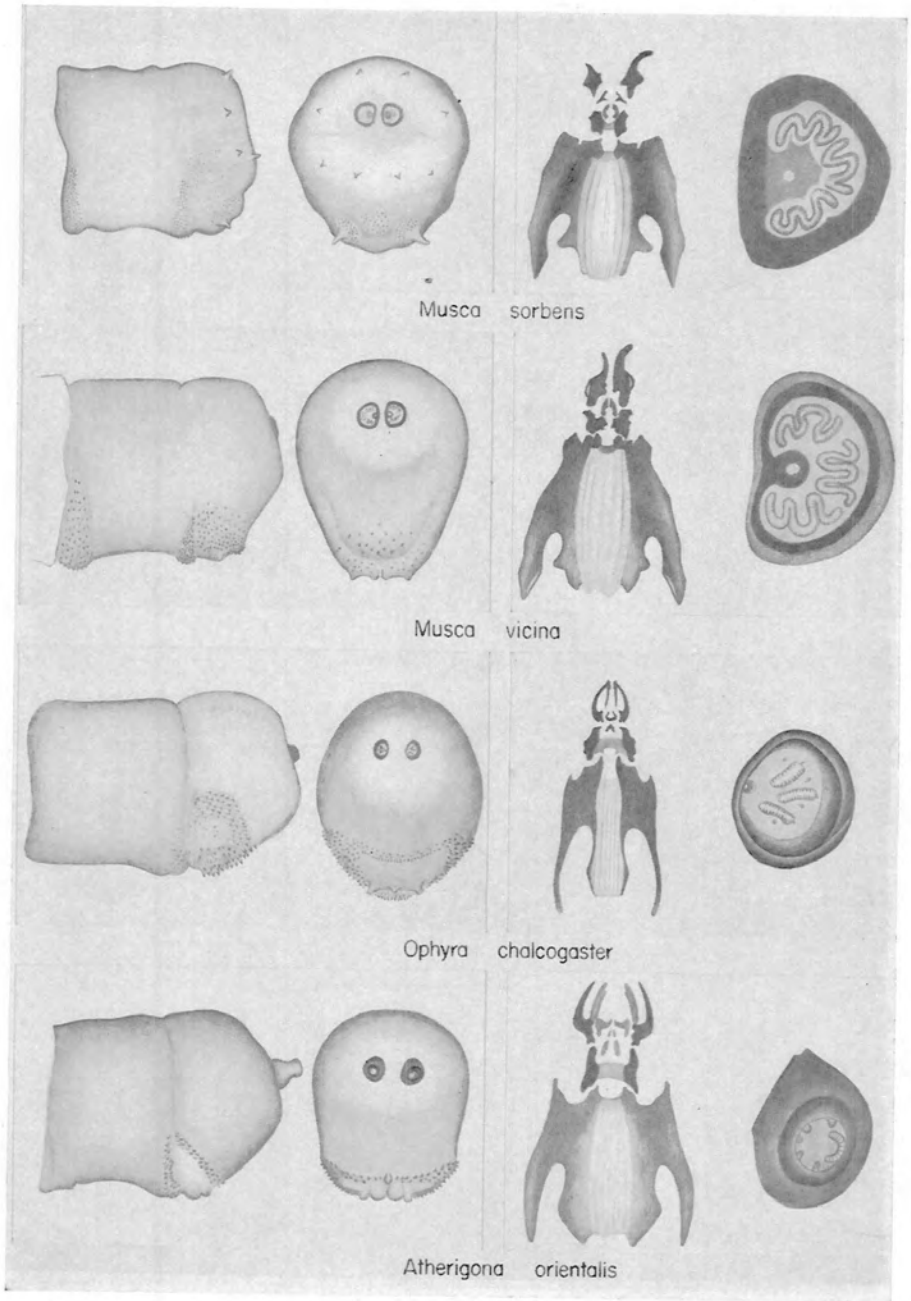
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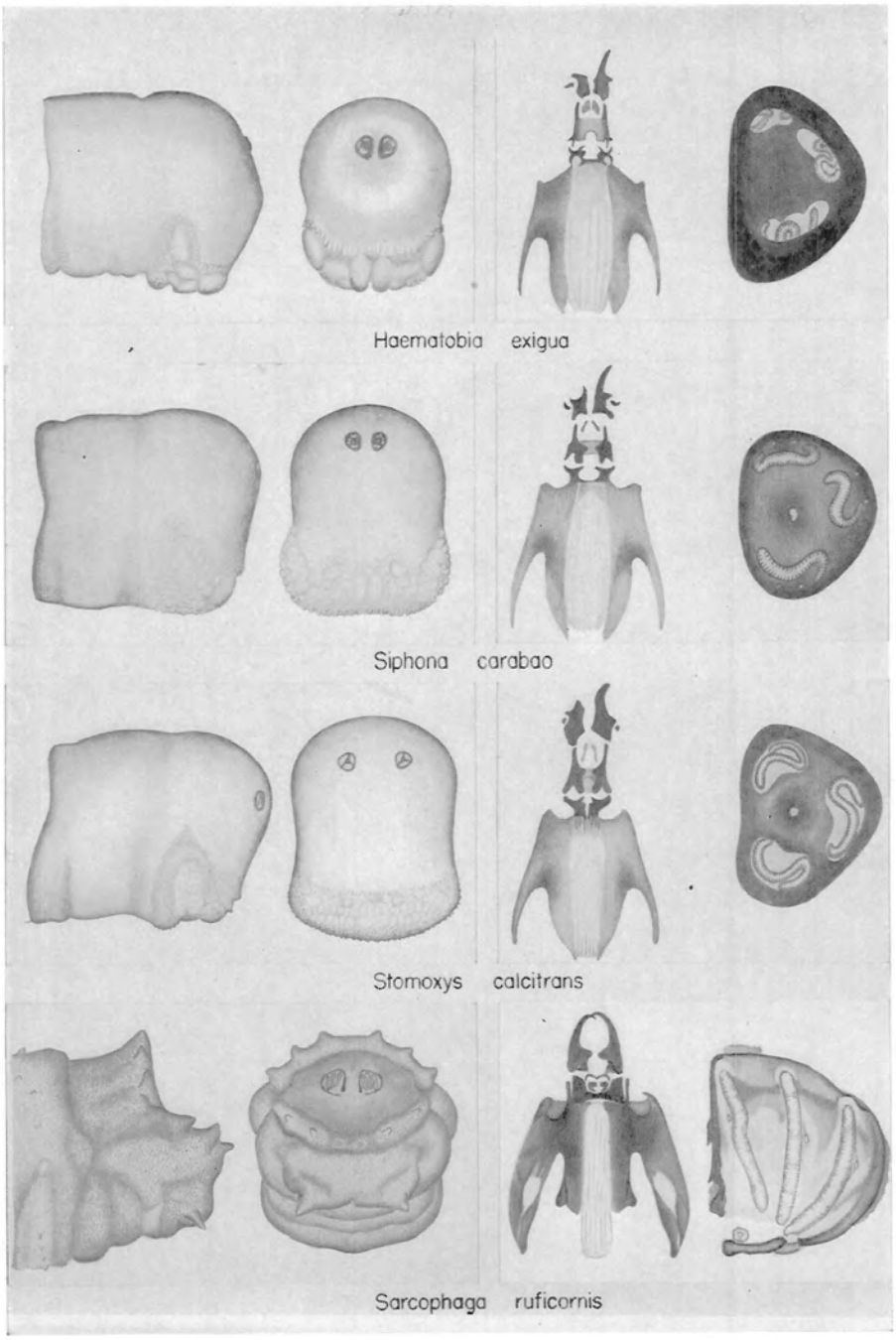
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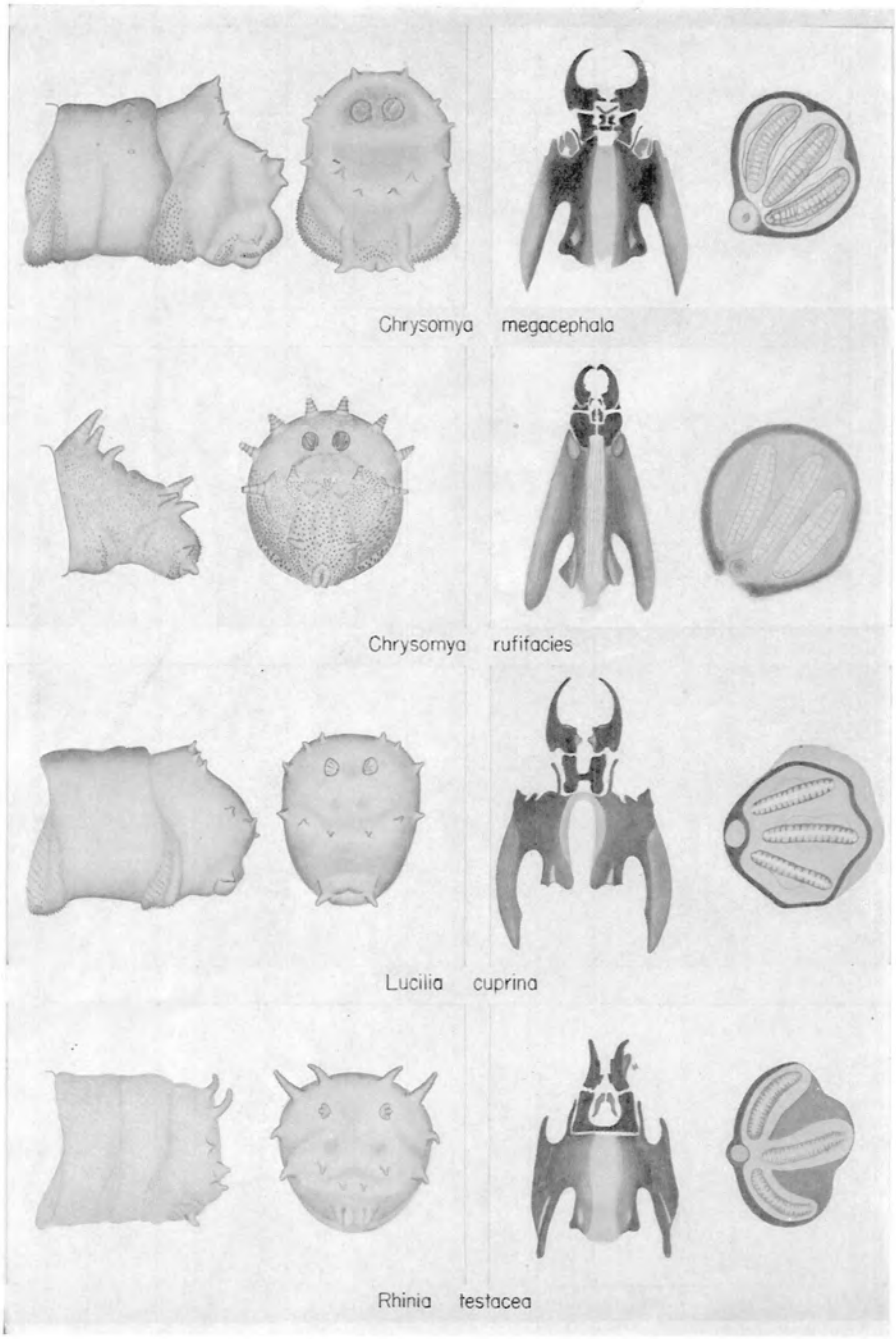
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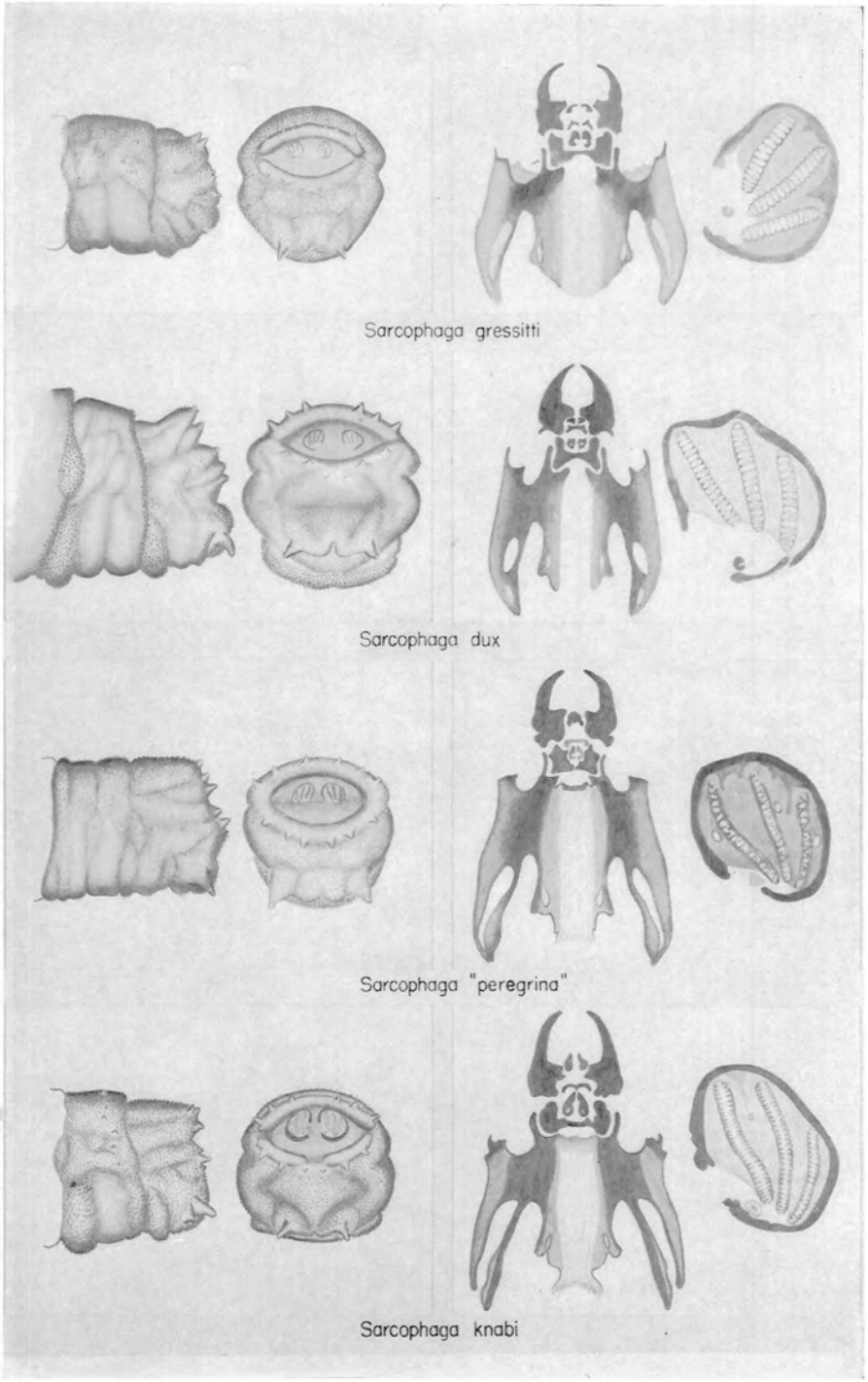
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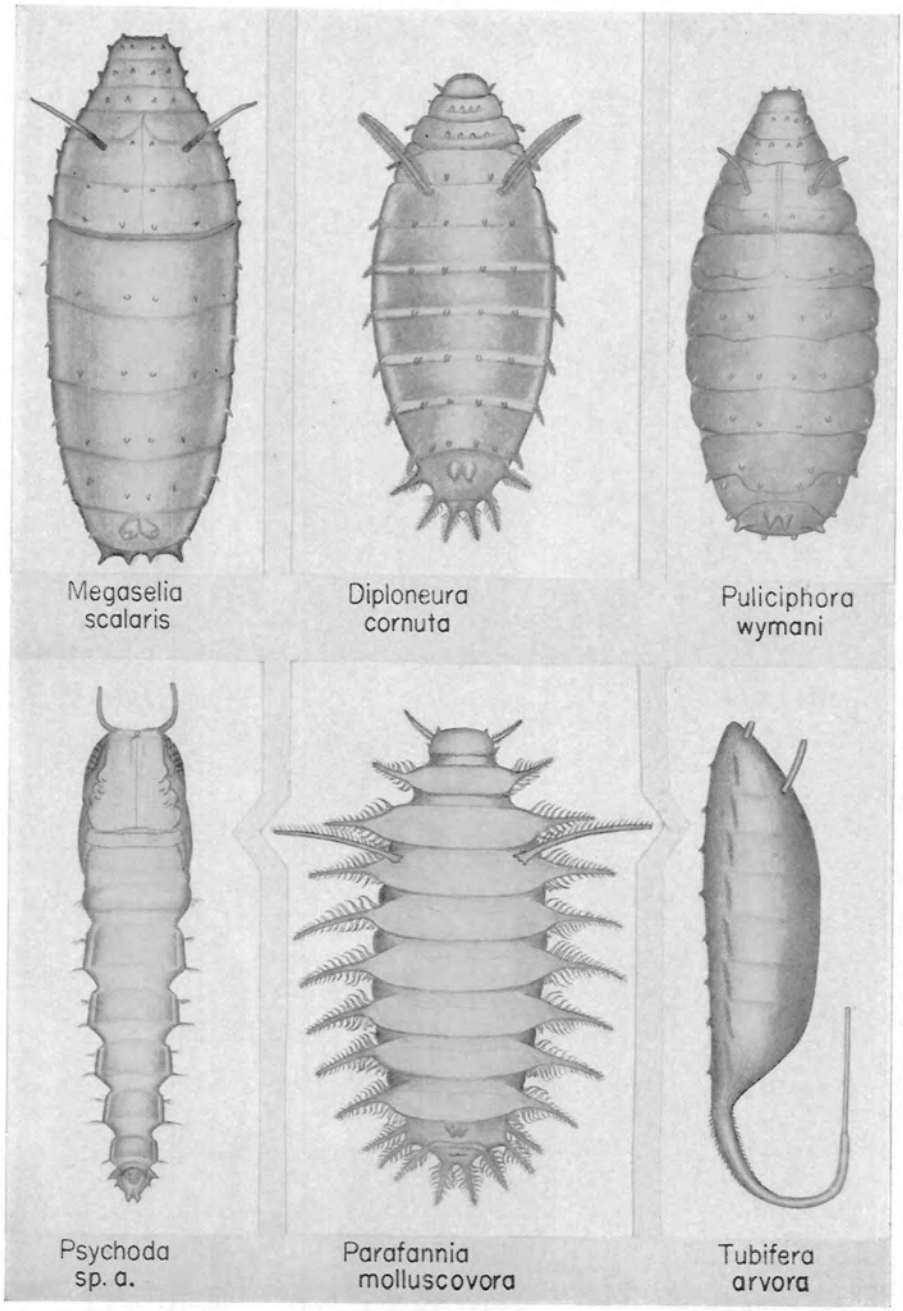
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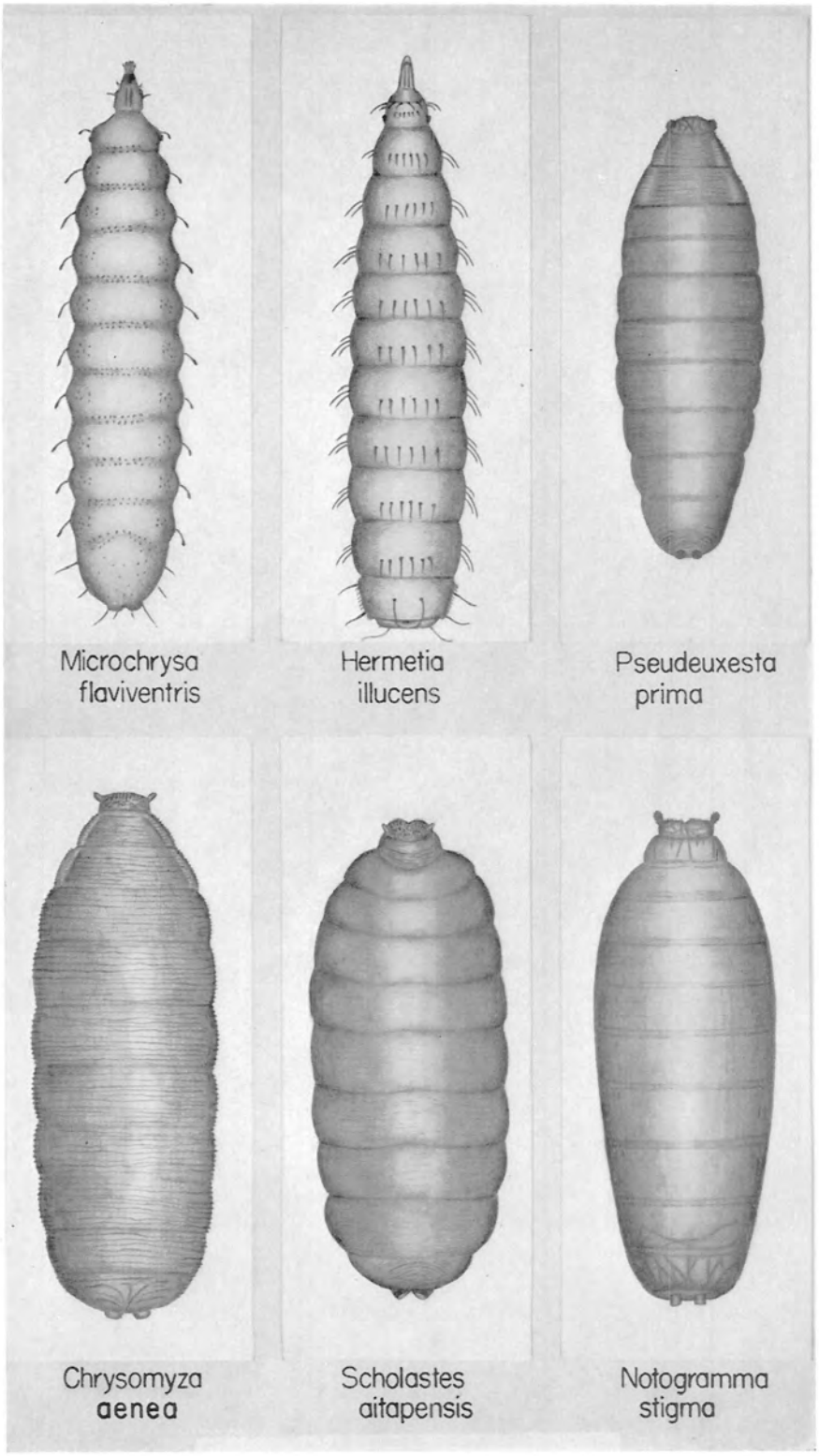
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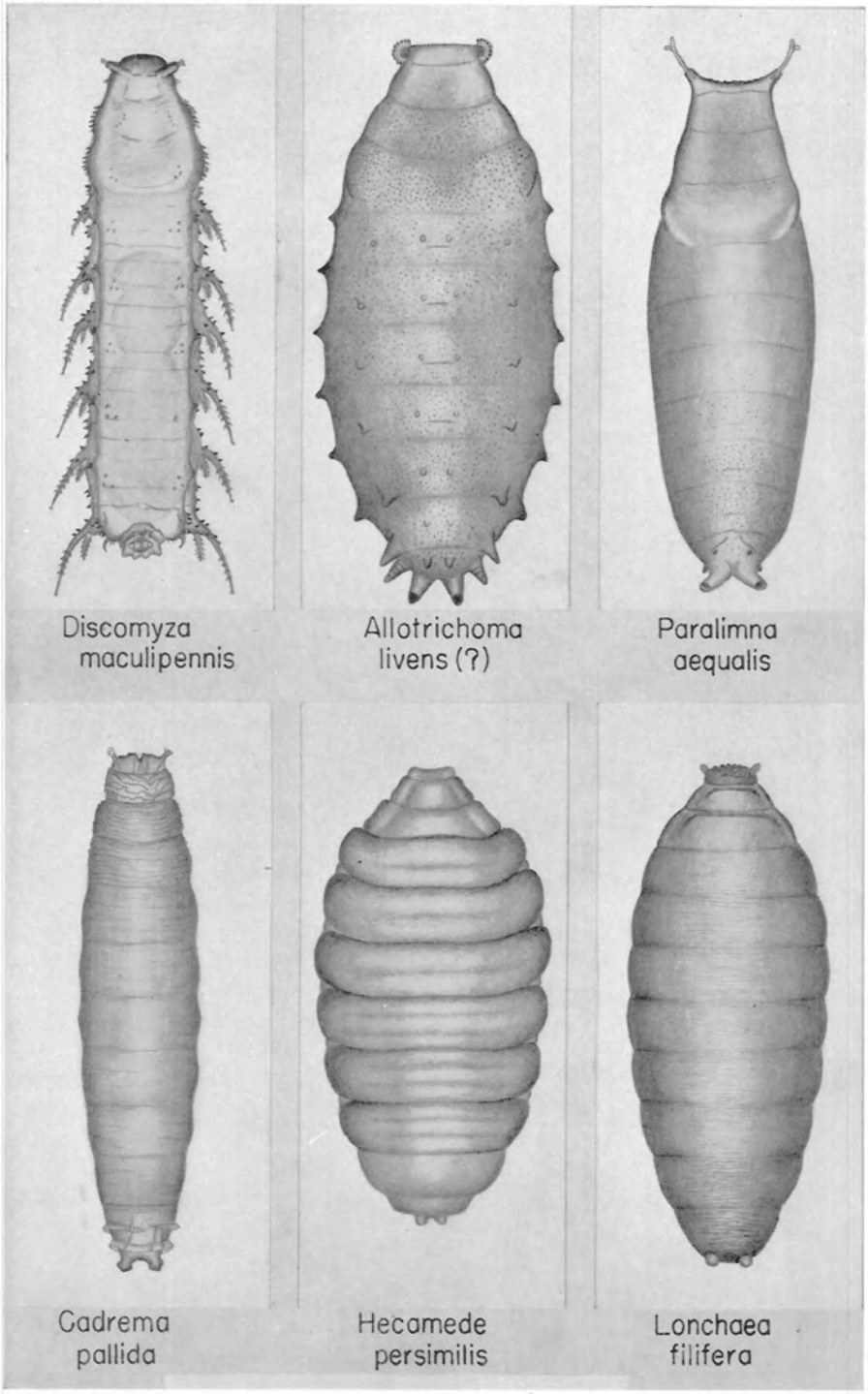
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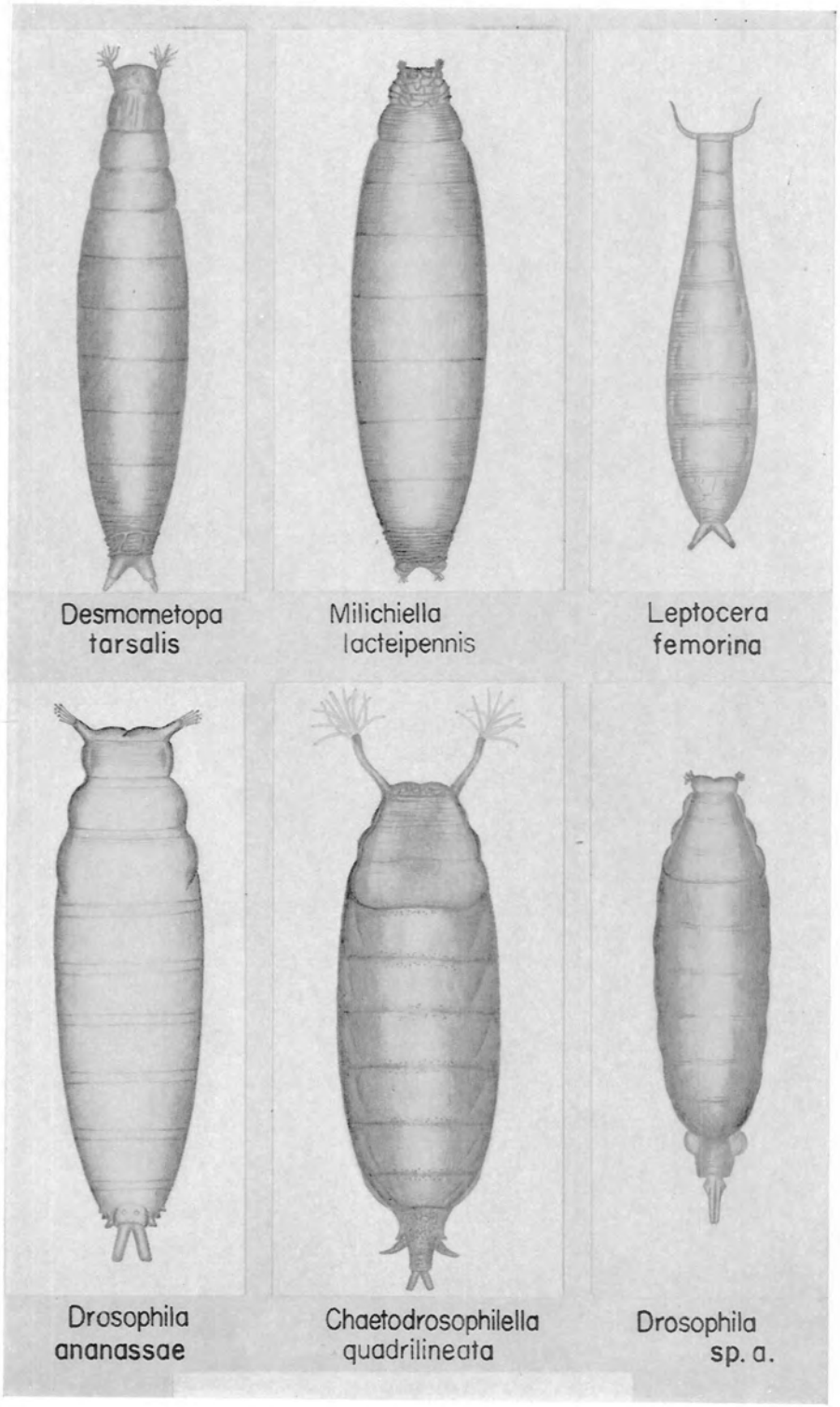
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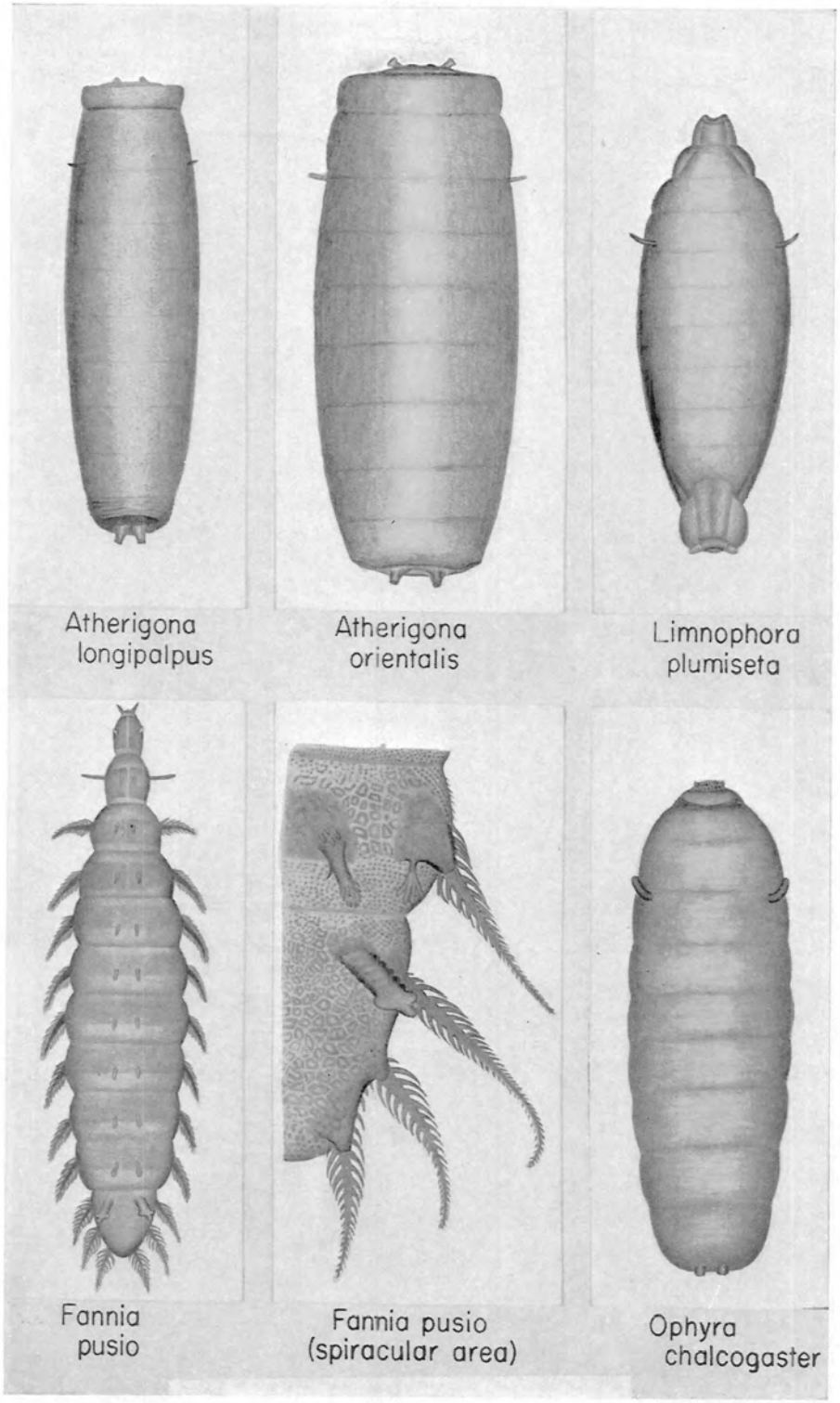
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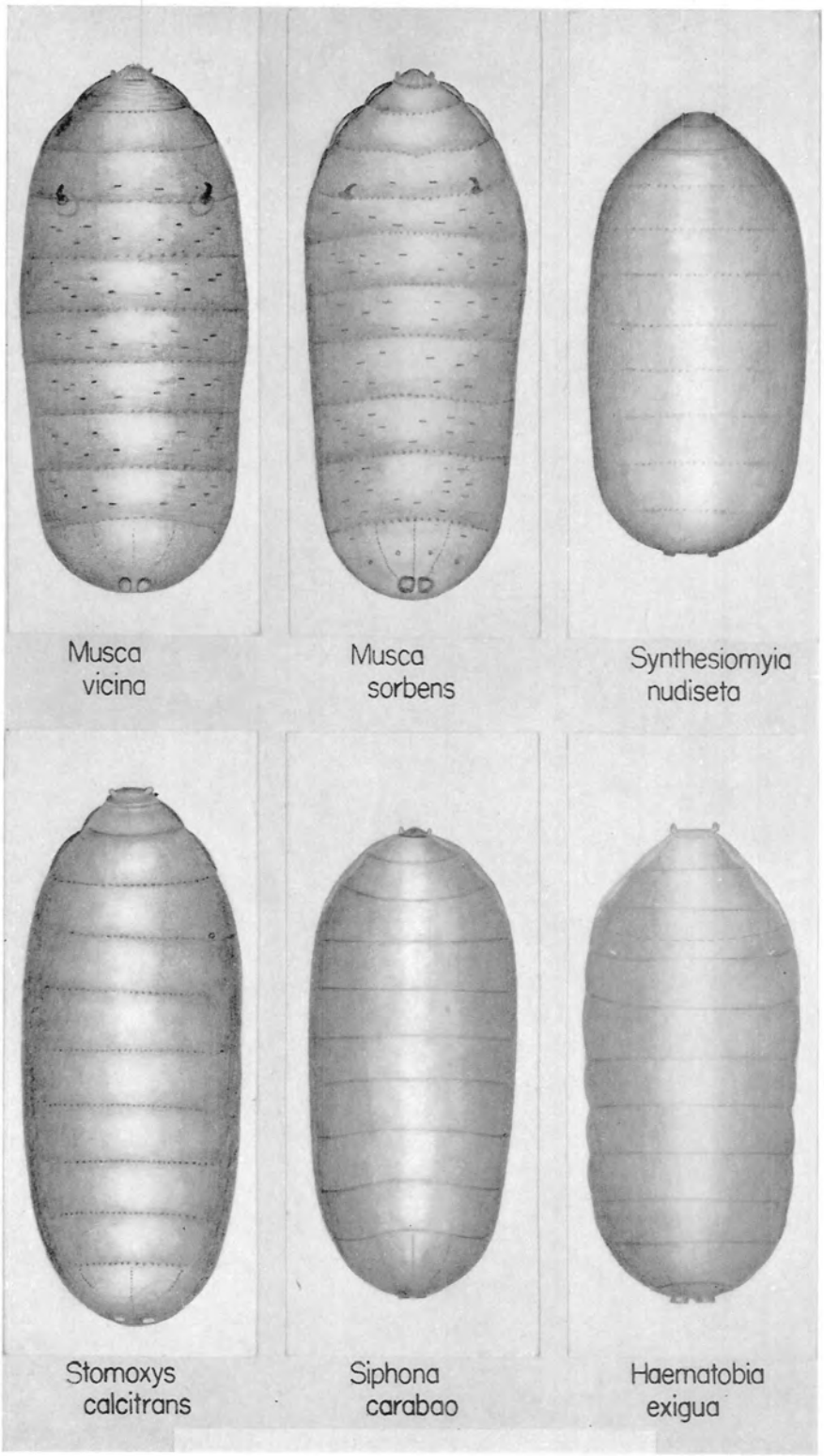
Ophyra chalcogaster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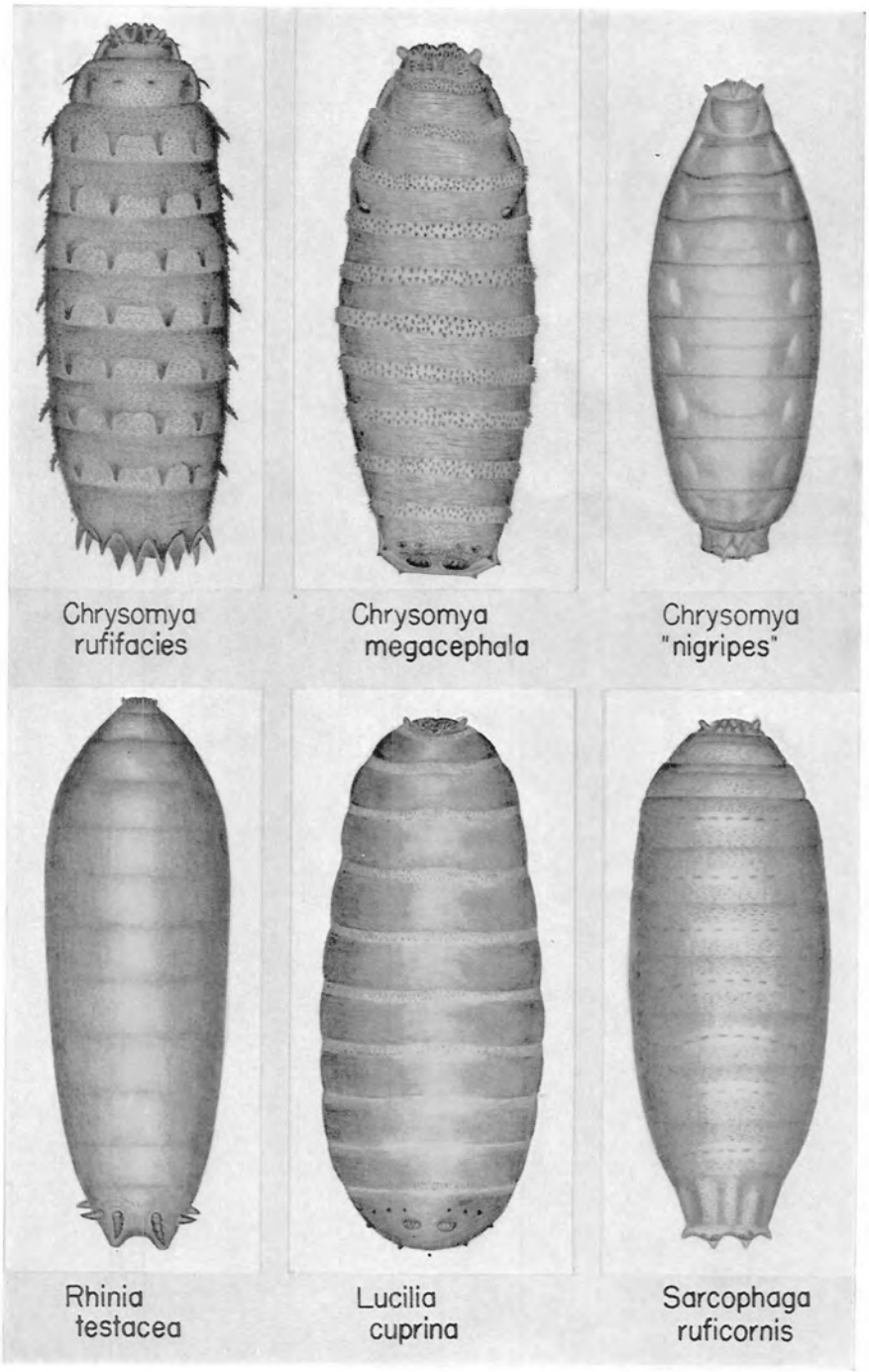
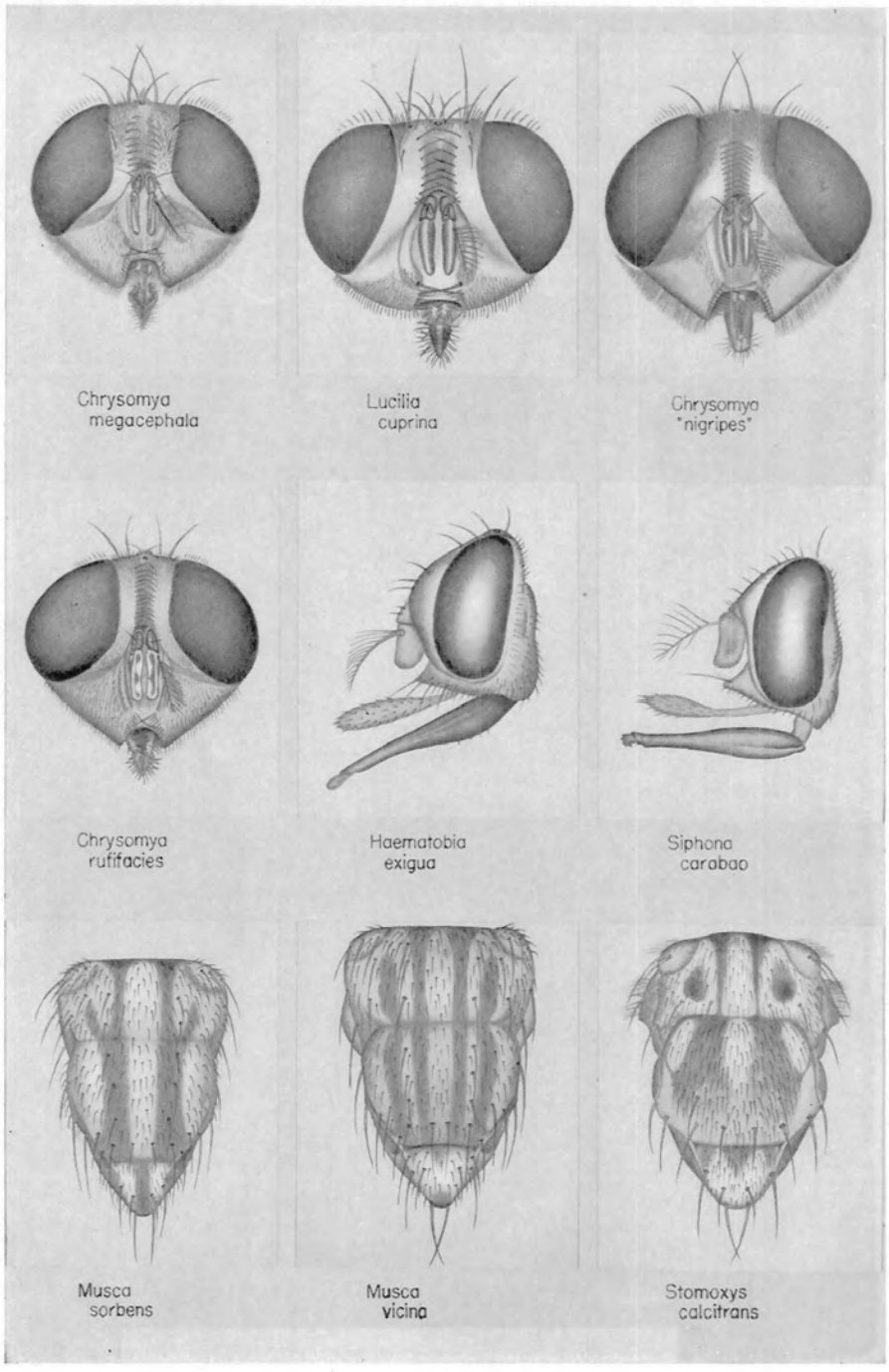
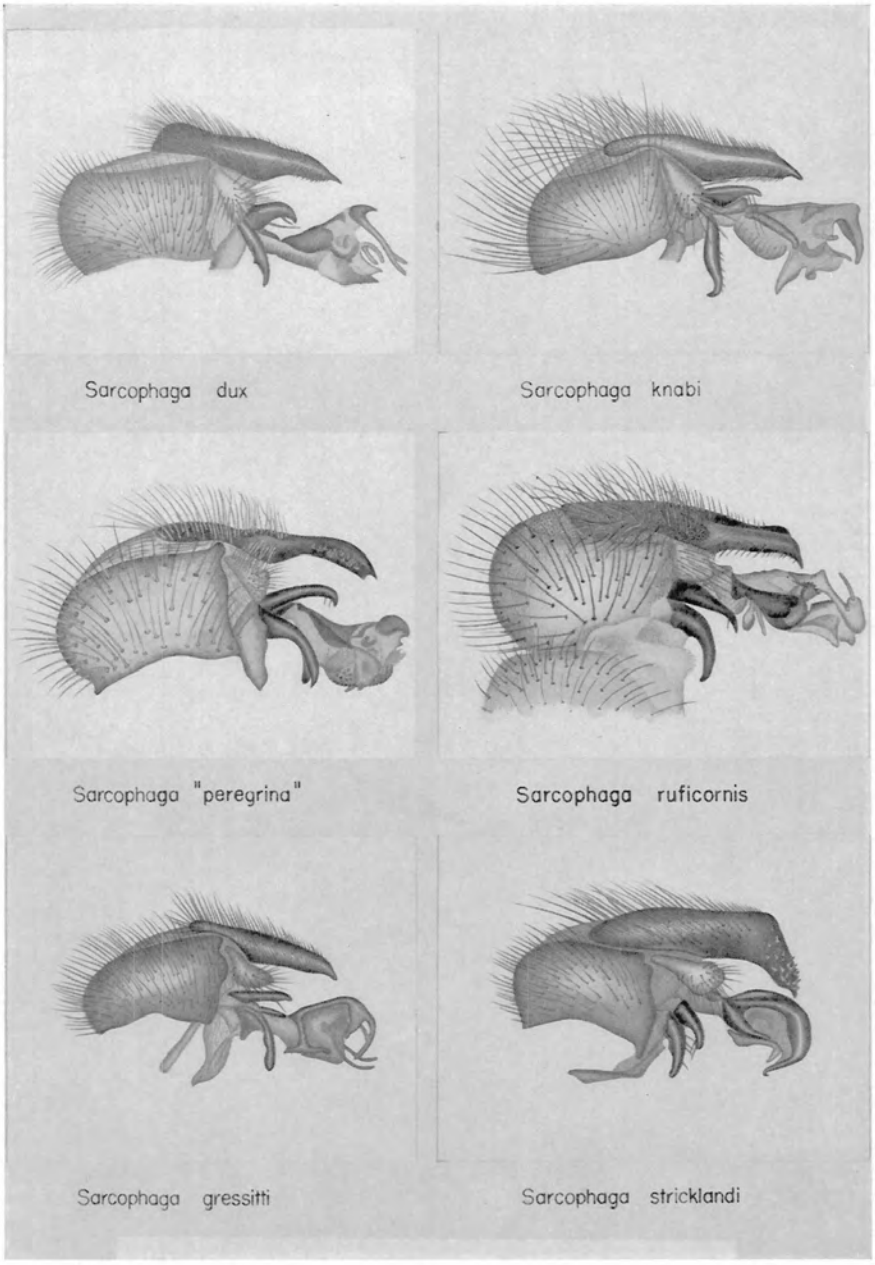

Chrysomya rufifacies
Chrysomya megacephala
Chrysomya "nigripes"
Rhinia testacea
Lucilia cuprina
Sarcophaga ruficornis


Chrysomya megacephala
Lucilia cuprina
Chrysomya "nigripes"
Chrysomya rufifacies
Haematobia exigua
Siphona carabao
Musca sorbens
Musca vicina
Stomoxys calcitrans


Sarcophaga dux
Sarcophaga knabi
Sarcophaga "peregrina"
Sarcophaga ruficornis
Sarcophaga gressitti
Sarcophaga stricklandi