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Worldwide Survey and Comparison of Adult Predator and Scavenger Insect Populations Associated with Domestic Animal Manure Where Livestock Is Artificially Congregated

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Predatory and scavenger insect fauna found associated with developmental stages of muscoid Diptera breeding in the domestic animal manure that accumulates in dairies, poultry houses, and the like, are identified and their frequency and distribution compared for the summer and winter seasons of the major climatic areas in the southwestern United States. Insects were also identified under somewhat more limited conditions in the Neotropical, Palearctic, Ethiopian, and Australian regions. The Holarctic and Australian collections were similar, although the latter lacked many species. Collections made in the Ethiopian and Neotropical regions were not similar. Further search in these latter two regions might uncover additional predatory species for introduction elsewhere. Climatic similarity between the area of origin and release elsewhere appears to be indicated for successful establishment of any new species. The principal predators were found in the insect families Labiduridae, Histeridae, and Staphylinidae, although other families predominated in certain areas. Although only two California predators, *Philonthus longicornis* Stephens and *P. rectangulus* Sharp, were common in both the Ethiopian and Neotropical regions, the California and the Neotropical regions had nine species in common. The distribution of scavengers was similar. Principal predators noted for their wide distribution and high relative abundance were *Carcinops pumilio* Erichson, *C. troglodytes* Erichson, *Gnathoncus nanus* Scriba, *Philonthus sordidus* (Gravenhorst), *P. rectangulus* and *Euborellia annulipes* (Lucas). Principal scavenger species were *Alphitobius diaperinus* (Panzer) and *Aphodius lividus* (Olivier). The fauna in cattle droppings in the field was sparse, but the species found were similar to those in the accumulated manure.

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Worldwide Survey and Comparison of Adult Predator and Scavenger Insect Populations Associated with Domestic Animal Manure Where Livestock Is Artificially Congregated[1,2]

INTRODUCTION

DIPTERA THAT FEED AND DEVELOP in accumulations of domestic animal manure where man has "artificially" congregated his livestock in dairies, poultry houses, and the like, are subjected prior to pupal formation to destruction by a number of predatory arthropods. For certain groups of Diptera, it is this accumulation of manure into piles rather than its composition that usually attracts the female. Species that breed in field droppings, in contrast, do not require the same sustained high moisture for ovipositing and successful larval development.

During investigations by Legner and Olton (1968*a*) and Legner *et al.* (1967) of a group of parasitic Hymenoptera that confine their attack activities largely to mature larvae and puparia of muscoid flies, adult entomophagous and saprophagous fauna in accumulations of animal manure were collected over wide portions of both the Eastern and Western hemispheres. Such fauna, belonging principally to the insect orders Coleoptera, Dermaptera, and Hemiptera, were always found in direct association with egg deposition and larval feeding sites of Diptera.

The Macrochelidae comprise a group of predators whose distribution and destructive capabilities have been thoroughly discussed by Axtell (1963*a*, 1963*b*, 1968) and Wade and Rodriguez (1961). Predaceous Hymenoptera have been credited with significant predation by Pimentel (1955), Simmonds (1940), and Phillips (1934). Anderson and Poorbaugh (1964) and Portchinsky (1913) discussed Diptera as predators. Recently, emphasis has been given to the predatory activities of several species of Coleoptera and Hemiptera in California by Legner and Olton (1968*b*) and Peck (1968).

This paper reports on the survey of fauna in artificial accumulations of animal manure from various geographical areas around the world, including the southwestern United States. Tables and graphs are used extensively to compare species and their distribution. The *presence* of a certain species in sample localities was especially noted; research limitations precluded the establishment of its absence.

Such a glimpse into a portion of the little-discussed fauna in animal manure may serve as a guide to further explora-

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tion for natural enemies of medically important Diptera and may suggest promising species to be considered for introduction elsewhere. Subsequent reports will focus on the seasonal distribution of such fauna and their effectiveness in the reduction of Diptera populations.

METHODS AND MATERIALS

Selection of sample sites

Collection sites in the various geographical areas were restricted to animal manure that was accumulated in dairies, poultry houses, horse and hog pens, and the like, in which the muscoid species under consideration naturally breed. The sample sites were nontreated accumulations of hen, bovine, horse, and hog manure that supported eggs, larvae or pupae of one or more of the following fly species; *Musca domestica* L., *Stomoxys calcitrans* (L.), *Fannia canicularis* (L.), *F. femoralis* Stein, *F. scalaris* (F.), and species of *Muscina, Ophyra, Phormia, Sarcophaga,* and *Phaenicia.*

The most extensive sampling was conducted in the southwestern United States and particularly in southern California (fig. 1). In the southwestern states other than California, two major bioclimatic zones, the Great Basin (Upper Sonoran) and Lower Sonoran deserts, were sampled. In northern California, six distinct areas were sampled: the Sacramento Valley, the San Joaquin Valley, the western Sierra foothills, the eastern Sierra foothills (Owens Valley), the Santa Rosa Valley, and the Salinas Valley.

In southern California, four areas were sampled, primarily according to annual rainfall: the South Coast with 450 to 500 millimeters; the Inland area with 250 to 300 millimeters; the High Desert (the Mojave) with 150 to 200 millimeters; and the Low Desert (lower Colorado) with less than 125 millimeters. Elevations of the South Coast and Inland areas varied from 15 to 300 meters; the High Desert between 1,000 and 1,500 meters; and the Low Desert from 15 meters to below sea level (fig. 1). Sampling dates and number of sites sampled per year in each area are shown in table 1.

Collection sites in other portions of North America and the world included parts of southeastern Canada, the eastern United States, Mexico, Costa Rica, the West Indies, Uruguay, Chile, northern and southern Europe, Israel, Kenya, Uganda, South Africa, Australia, and some Pacific islands.

In the southwestern United States, sample sites were chosen at random in each geographic area during the summer, July *through* September, in southern California and July *and* September in other areas. The same sites were sampled once each month. Also, winter samples were taken in most southern areas from December through February.

Sampling began in 1964 and continued through early 1969, with the four areas in southern California receiving the most intensive examination during this study. Other collections were usually made during one or more summer months when fly production in manure was at its peak. During the five-year-sample duration, six south coastal poultry sites that ceased to produce undisturbed fly-breeding habitats were substituted with six new sites selected at random in 1968. Otherwise, sites in the other areas sampled remained fixed (table 1).

Extraction of fauna

At each sample site, a minimum of 30 liters of animal manure containing developing dipterous eggs, larvae, and pupae were gathered with a hand trowel, placed into a receptacle, and

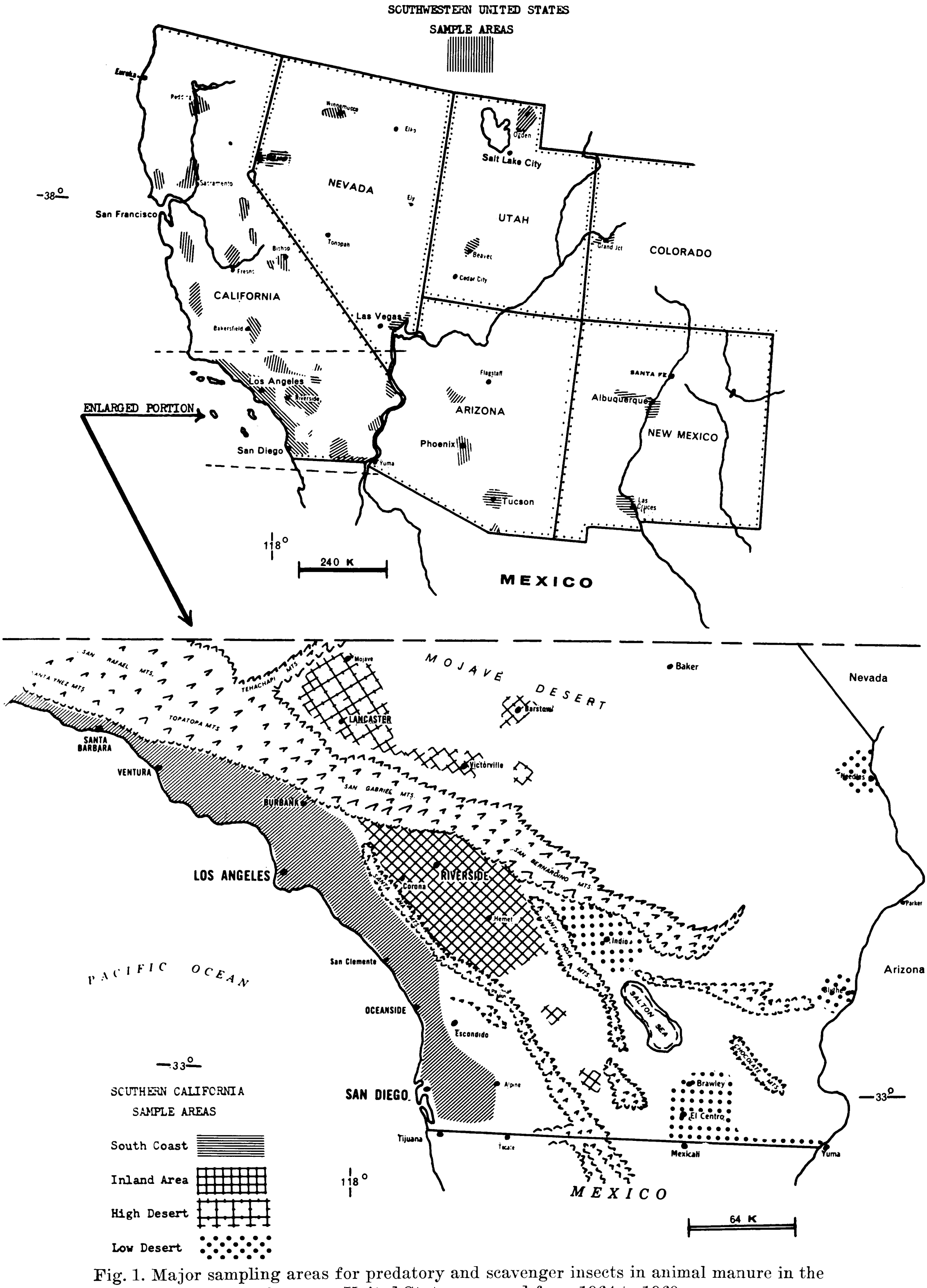

Fig. 1. Major sampling areas for predatory and scavenger insects in animal manure in the southwestern United States surveyed from 1964 to 1969.

TABLE 1

SCOPE OF SURVEY OF ADULT PREDATORY AND SCAVENGER SPECIES IN ANIMAL MANURE IN THE SOUTHWESTERN AND EASTERN UNITED STATES 1964 to 1969

Area	Manure type	Sampling period	No. sites sampled per year
Southern California			
		1964–1969	
South Coast*	hen	Jul. – Sept.	32
	hen	Dec.– Feb.	23
	bovine	Jul. – Sept.	16
	bovine	Dec.– Feb.	11
	horse	Jul. – Sept.	4
Inland	hen	Jul. – Sept.	22
	hen	Dec.– Feb.	16
	bovine	Jul. – Sept.	12
	bovine	Dec.– Feb.	6
High Desert	hen	Jul. – Sept.	5
	hen	Dec.– Feb.	9
	bovine	Jul. – Sept.	4
	bovine	Dec.– Feb.	6
Low Desert	hen	Jul. – Sept.	4
	hen	Dec.– Feb.	4
	bovine	Jul. – Sept.	10
	bovine	Dec.– Feb.	8
	horse	Jul. – Sept.	10
	horse	Dec.– Feb.	8
Northern California			
Salinas Valley	bovine	Jul. & Sept. 1967–68	6
Santa Rosa Valley	hen	Jul. 1968	2
	bovine	Jul. 1968	3
Sacramento Valley	bovine	Jul. & Sept. 1967–68	6
San Joaquin Valley	hen	Jul. & Sept. 1967–68	2
	bovine	Jul. & Sept. 1967–68	4
Sierra Western Foothills	hen	Jul. & Sept. 1967–68	4
	hog	Jul. & Sept. 1967–68	3
High Sierra (2,600 m.)	horse	Jul. & Sept. 1967–68	6
Owens Valley	bovine	Jul. & Sept. 1967–68	5
Southwestern United States			
Great Basin Region			
Central Nevada	bovine	Sept. 1968	5
Southern Nevada	bovine	Jan. 1969	3
Sonoran Desert			
Cottonwood, Arizona	bovine	Jul. & Sept. 1967–68	4
	bovine	Jan. 1969	3
	horse	Jul. & Sept. 1967–68	2
Phoenix, Arizona	bovine	Jul. & Sept. 1967–68	4
	bovine	Jan. 1969	5

* All sites remained the same for the five-year sampling period in southern California, except for six poultry sites substituted on the south coast in 1968.

TABLE 1—*Continued*

Area	Manure type	Sampling period	No. Sites sampled per year
Southwestern United States—*Continued*			
Tucson, Arizona	hen	Jul. & Sept. 1967–68	4
	hen	Jan. 1969	2
	bovine	Jul. & Sept. 1967–68	6
	bovine	Jan. 1969	5
Las Cruces, New Mexico	hen	Jan. 1969	2
	bovine	Jul. & Sept. 1967–68	3
	bovine	Jan. 1969	2
Albuquerque, New Mexico	bovine	Jul. & Sept. 1967–68	3
	bovine	Jan. 1969	2
	horse	Jan. 1969	2
Grand Junction, Colorado	bovine	Jul. 1968	2
Eastern United States			
Colorado Springs, Colorado	bovine	Jul. 1968	2
Central Wisconsin to Northern Illinois	bovine	Jul. & Sept. 1965 & 1968	7
N. W. South Carolina	bovine	Jul. 1968	3

wetted with water. The adult insect fauna collected, therefore, were physically associated with the developmental stages of Diptera, and could have preyed on them. The wetting of this gathered manure stimulated the adult fauna to climb the sides of the receptacle and floating debris in an effort to escape. The adults were gathered by hand with a 11.8 mesh/cm plastic screen and camel's hair brush, and were transferred to 75 per cent ethanol for later identification. Low winter temperatures required additional time for the adult insects to recover from cold-induced torpor. Therefore, winter samples were usually placed in the sunlight for one-half hour to initiate activity.

The extraction method was designed to remove adult arthropods only and did not adequately sample immatures, nor any of the Acarina. Moore (1954) described water flotation as a suitable method for removal of dung-inhabiting adult insects; the authors compared his method favorably with the Berlese extraction technique.

Reference in the text to the possible predatory value of certain species on muscoids is derived from several sources: (1) laboratory feeding trials, (2) personal communication with specialists, and (3) literature references. The first criterion, feeding trials, was probably the least useful, since predation under confined laboratory conditions is not a reliable indicator of natural field performance, especially in such a diverse animal community as is afforded by accumulated animal wastes. References that were especially useful in ascertaining the probable predatory or scavenger role of species are, Abbott (1937, 1938), Balduf (1935), Brues (1946), Clark (1895), Clausen (1962), Davis (1915), Evans (1964), Fichter (1949), Illingworth (1923), Landin (1961), Mank (1923), Mohr (1943), Portchinsky (1885), Snowball (1941–42), Voris (1934) and Xambeau (1907). Generally, histerid larvae and almost all Staphylinidae can be considered predaceous.

Identification of specimens

The Anthicidae were identified by F. G. Werner of the University of Arizona, Tucson; Blattidae and Dermaptera by A. B. Gurney; Carabidae by R. Gordon; Coccinellidae by E. A. Chapin; Cleridae by G. B. Vogt; Colydiidae, Cryptophagidae, Dermestidae, Mycetophagidae, Ptilidae, Rhizophagidae, and Scydmaenidae by J. M. Kingsolver; Cucujidae, Ptinidae, and Tenebrionidae by T. J. Spilman; Curculionidae by R. E. Warner; Formicidae by M. R. Smith; Hemiptera by J. L. Herring; Lathridiidae by L. M. Walkley; Nitidulidae by W. A. Connell; and Scarabaeidae by O. L. Cartwright, U. S. Department of Agriculture. I. Moore, Division of Biological Control, University of California, Riverside, identified the Staphylinidae; R. L. Wenzel, Field Museum of Natural History, Chicago, determined the Histeridae of the Western Hemisphere; and J. Therond, Nimes, France, identified the Histeridae of the Eastern Hemisphere. These determinations we gratefully acknowledge.

Statistical analyses

Quantitation was generally not possible in the random sampling of animal manure for adult insects in all geographical areas. At most sites, other than in the southwestern United States the mere presence of a species was the only reliable data obtained; sampling did not assure a species' absence. In the southwestern United States, and especially in southern California, sampling was more thorough; therefore, the absence of species had more significance. Also, in the Southwest the relative abundance of the given species found during a sample period was significant.

In southern California where the sampling was most intensive, the abundance of any given species was converted to a percentage by dividing its numbers by the total number of individuals of all species collected per sample site. These percentages were subsequently transformed to the arc sin $\sqrt{\%}$ to reduce errors caused by varying sample size and by extremely high and low percentages. The use of this transformation is discussed by Steel and Torrie (1960).

The standard error of the mean $s_{\bar{x}}$ was calculated among these transformed percentages with the formula:

$$\frac{ZX_i - X^2../n}{(n-1)n}$$

Confidence limits around the derived transformed means were calculated with the formula:

$$\bar{x} \pm (t_{05}\, s_{\bar{x}}), \text{ where } df = n - 1$$

The means and confidence limits were retransformed to the original percentage values for the tables and discussion. No values were given to a species' absence; that is, zero values were not considered in the analyses.

RESULTS AND DISCUSSION

Distribution of species in southern California

The distribution of adult insects in hen, bovine, and horse manures that were sampled during summer (July–September) and winter (December–February) in southern California is shown in figures 2 through 6 in four major sample areas. All species that occurred at over 30 per cent of all collection sites in one or more areas are listed as predominant; species that occurred at fewer than 30 per cent of the sites are listed as infrequent.

There were differences between winter and summer collections, as well as among the four areas, and differences in the number and kinds of species collected among the three manure types.

The greatest total number of species,

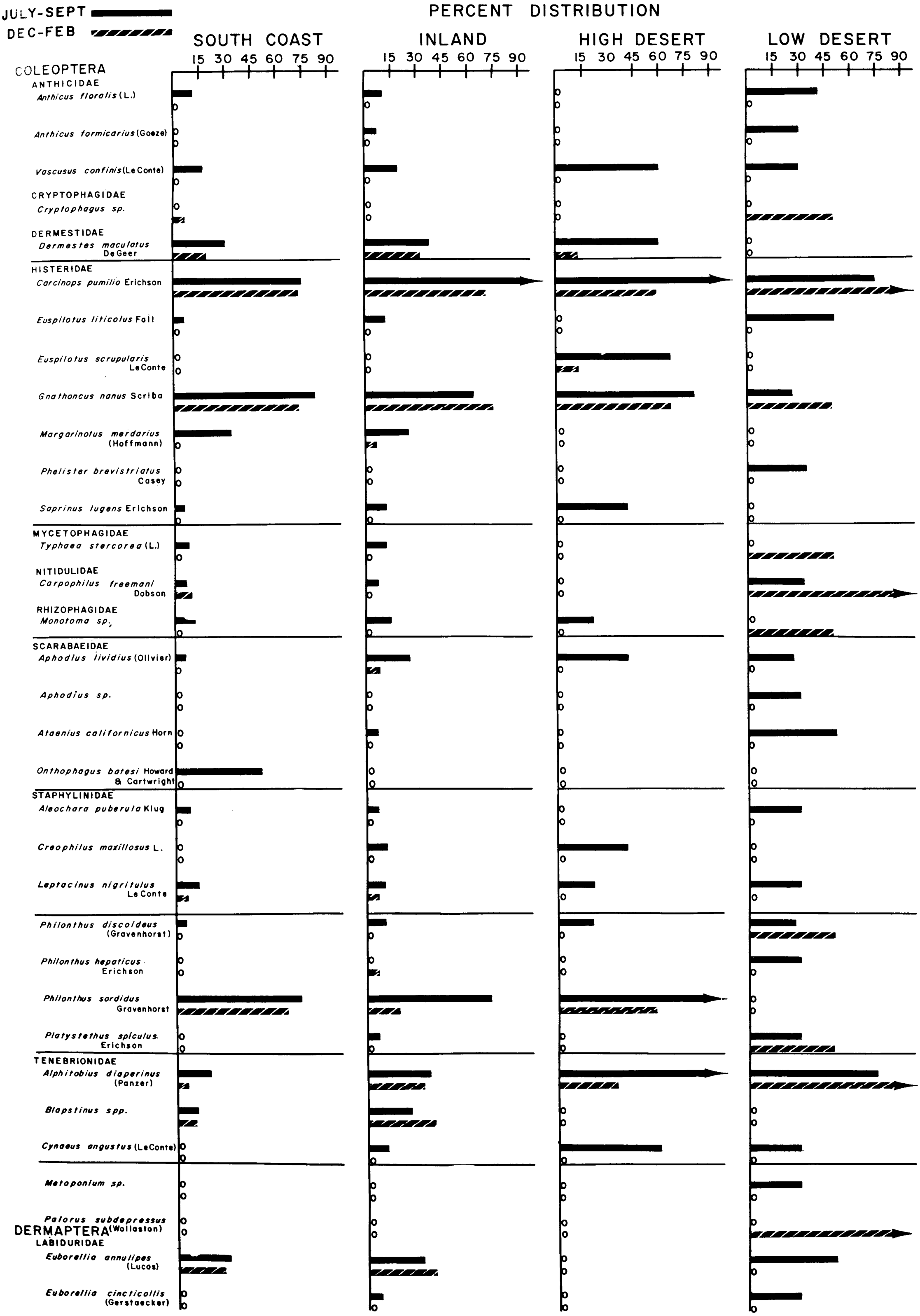

Fig. 2. Distribution of predominant predatory and scavenger insects found at over 30 per cent of collection sites in accumulated hen manure in southern California (1964 to 1969).

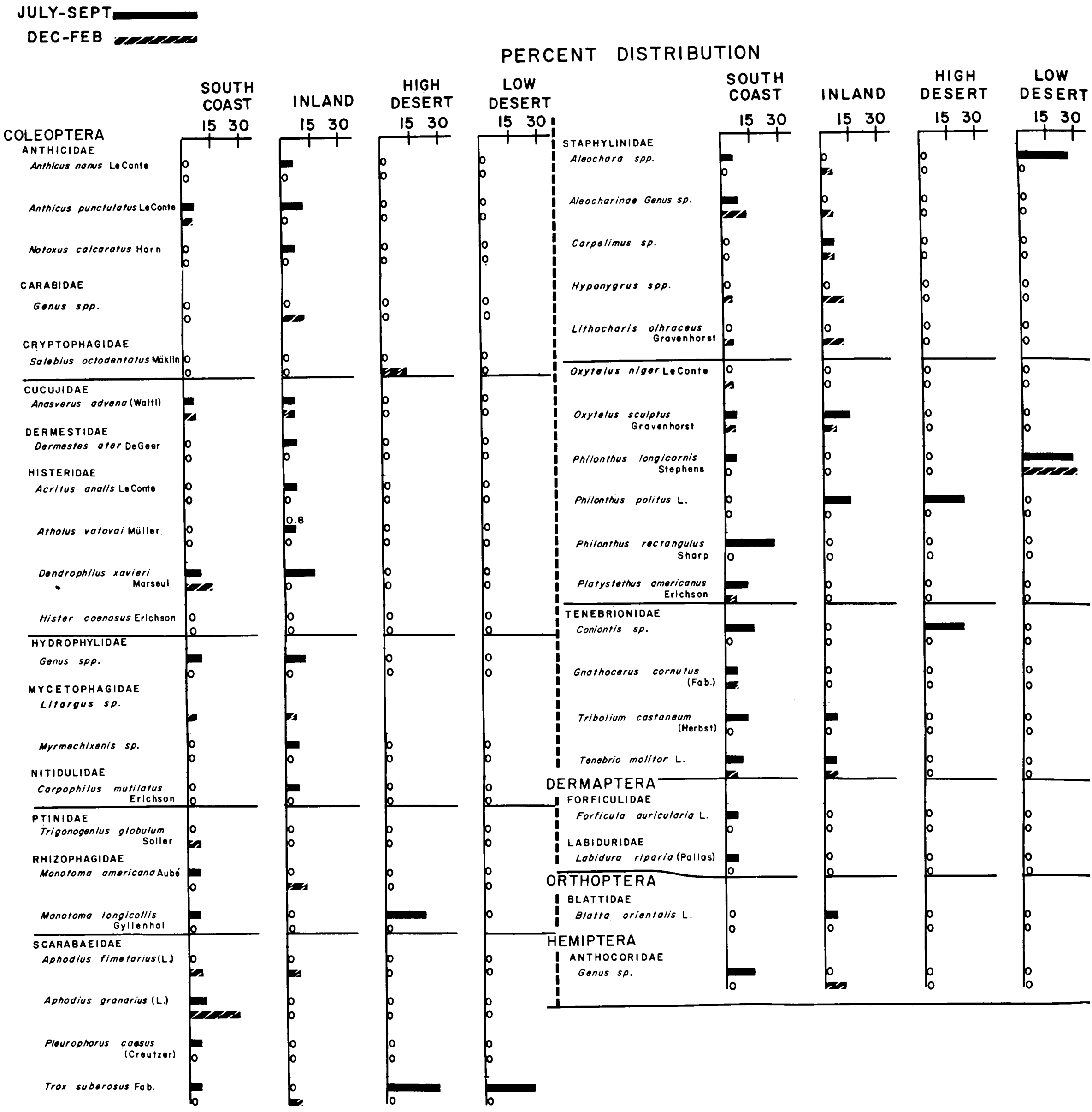

Fig. 3. Distribution of infrequent predatory and scavenger insects found at less than 30 per cent of collection sites in accumulated hen manure in southern California (1964 to 1969).

74, was collected in hen manure, the majority being infrequently found (in less than 30 per cent of sample sites). Of these, 42 species were collected on the South Coast during summer, while the winter sampling interval yielded only 24 species (genus species counted as one). In the Inland area, summer collections yielded 43 species, but only 25 species were found in winter. High Desert collections produced 18 species in summer and only seven species in winter. In the Low Desert, 23 species were collected in summer samples, and 11 species were collected in the winter (figs. 2 and 3).

Bovine manure yielded only 60 species, most of which were infrequently found (figs. 4 and 5). Summer samples on the South Coast revealed 40 species, while only 21 species were found in winter. In the Inland area, 20 species were collected in summer and only five in winter. The High Desert had 12 species present during summer collections and six species in winter. In the Low Desert, 26 species were present in summer and only 10 in winter (figs. 4 and 5).

Horse manure was not sampled in winter on the South Coast nor at anytime in the Inland area and High Desert due to the scarcity of breeding flies. This scarcity may have been caused by the general use of insecticidal sprays. The data, however, indicate that horse manure possessed the fewest number of species (33) of any manure sampled (fig. 6). Of these, 10 were collected on the South Coast during summer surveys. The Low Desert yielded 30 species during summer and only eight during winter.

Predominant species in southern California

Few of the species listed in figures 2 to 6 were predominant, not being widely distributed among collection sites. Of those species that showed widest distribution, some such as the Anthicidae, Dermestidae, Scarabaeidae and Tenebrionidae, were probably only facultative in predatory value. Their habits might be partially or wholly necrophilous or saprophagous, although their value for manure decomposition and as facultative predators should not be underestimated.

Key species that were widespread and which were known to be predaceous on muscoid eggs and young larvae (authors' unpublished data; Peck, 1968) are *Carcinops pumilio* Erichson, *Euspilotus liticolus* Fall, *E. scrupularis* LeConte, *Gnathoncus nanus* Scriba, *Margarinotus merdarius* (Hoffmann), *Aleochara puberula* Klug, *Leptacinus nigritulus* LeConte, *Philonthus sordidus* (Gravenhorst), *P. longicornis* Stephens, *Platystethus americanus* Erichson, *P. spiculus* Erichson and *Euborellia annulipes* (Lucas).

A few of these species were primarily restricted to one particular kind of manure. *Euspilotus scrupularis* and *Platystethus americanus* were absent in bovine manure. The latter was poorly distributed in hen manure, but occurred at 50 percent of collection sites in horse manure on the South Coast. No Histeridae were collected from horse manure on the South Coast from July through September. *Carcinops pumilio* was widely distributed in hen manure. *Euspilotus liticolus, Platystethus spiculus* and *Aleochara puberula* were best distributed in bovine and horse manures. *Philonthus sordidus* was well distributed in hen manure in all sample areas except the Low Desert, but was somewhat more restricted in its distribution in bovine and horse manures (figs. 2 to 6). *Philonthus longicornis* had its greatest distribution in bovine manure.

Effects of climate on manure type in the four respective sample areas was apparently a decisive factor in limiting the distribution of some species. Environmental conditions during the July to September sampling interval were generally more favorable to a wide distribution of most species. Exceptions to this were noted in hen manure in the Low Desert where species such as *Carcinops pumilio, Gnathoncus nanus, Philonthus discoideus* (Gravenhorst), and *Platystethus spiculus* were dispersed over a wider area during the winter sampling interval. In the comparatively more exposed bovine and horse manures, only *Platystethus spiculus* was prevalent under winter conditions. *Margarinotus merdarius* was apparently unable to tolerate manure conditions found in the high and low

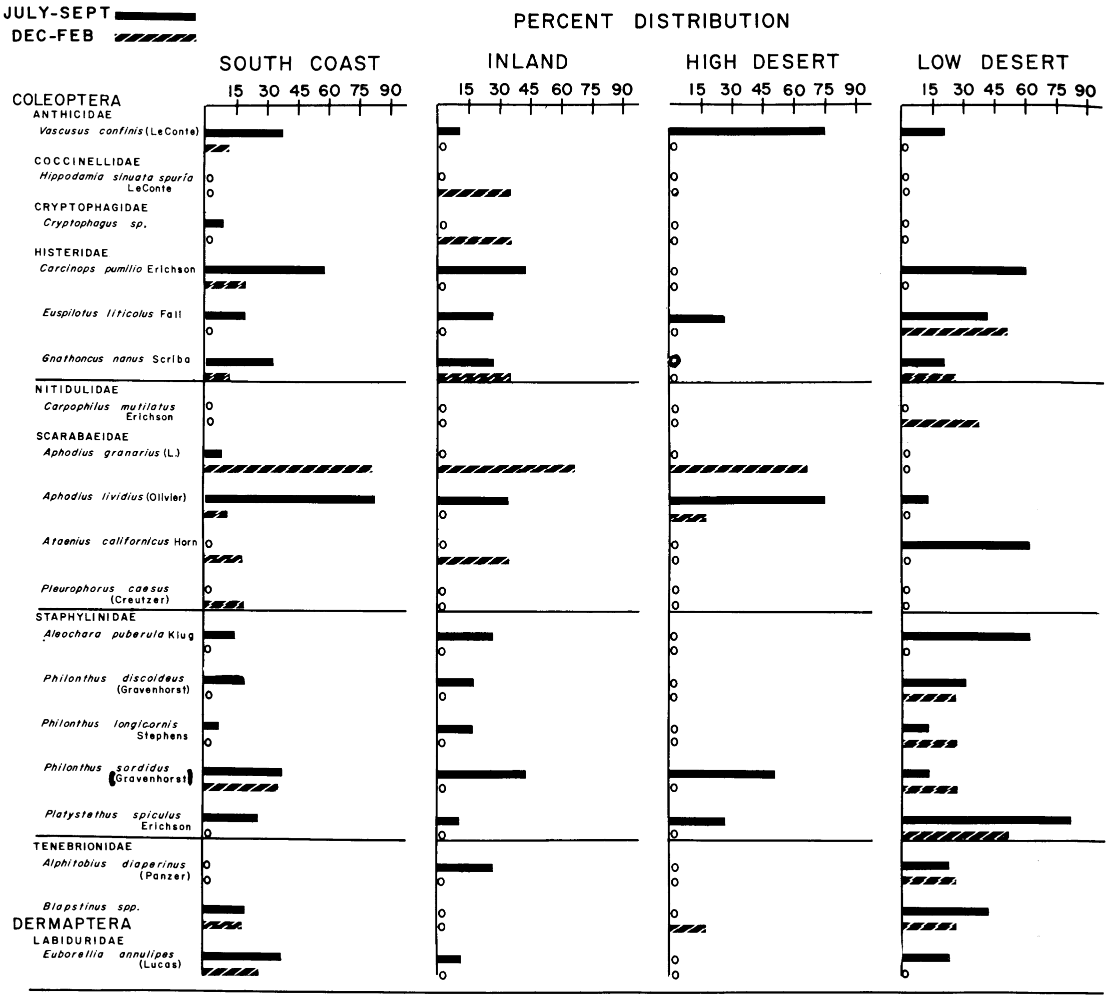

Fig. 4. Distribution of predominant predatory and scavenger insects found at over 30 per cent of collection sites in accumulated bovine manure in southern California (1964 to 1969).

desert sampling areas. It showed a definitely greater distribution on the coast.

Potential predatory species with very low distribution were the histerids *Acritus analis* LeConte, *Atholus vatovai* Muller, *Dendrophilus xavieri* Marseul, *Hister coenosus* Erichson, *Peranus bimaculatus* L., *Phelister brevistriatus* Casey, *Saprinus lugens* Erichson, *Xerosaprinus lubricus* LeConte and *X. orbiculatus* Marseul; the staphylinids *Atheta sordida* (Marsham), *Carpelimus* sp., *Creophilus maxillosus* (L.), *Hyponygrus* spp., *Lithocharis ochraceus* (Gravenhorst), *Neobisnius paederoides* (LeConte), *Oxytelus niger* LeConte, *O. sculptus* (Gravenhorst), *Philonthus hepaticus* Erichson, *P. rectangulus* Sharp, and *Rugilus oregonus* (Casey); the dermapteran species *Euborellia cincticollis* (Gerstaecker) and *Labidura riparia* (Pallas); and the hemipteran anthocorids *Lyctocoris campestris* (F.), *Xylocoris californicus* Reuter, *X. galactinus* (Fieber), and *X. vicarius* (Reu-

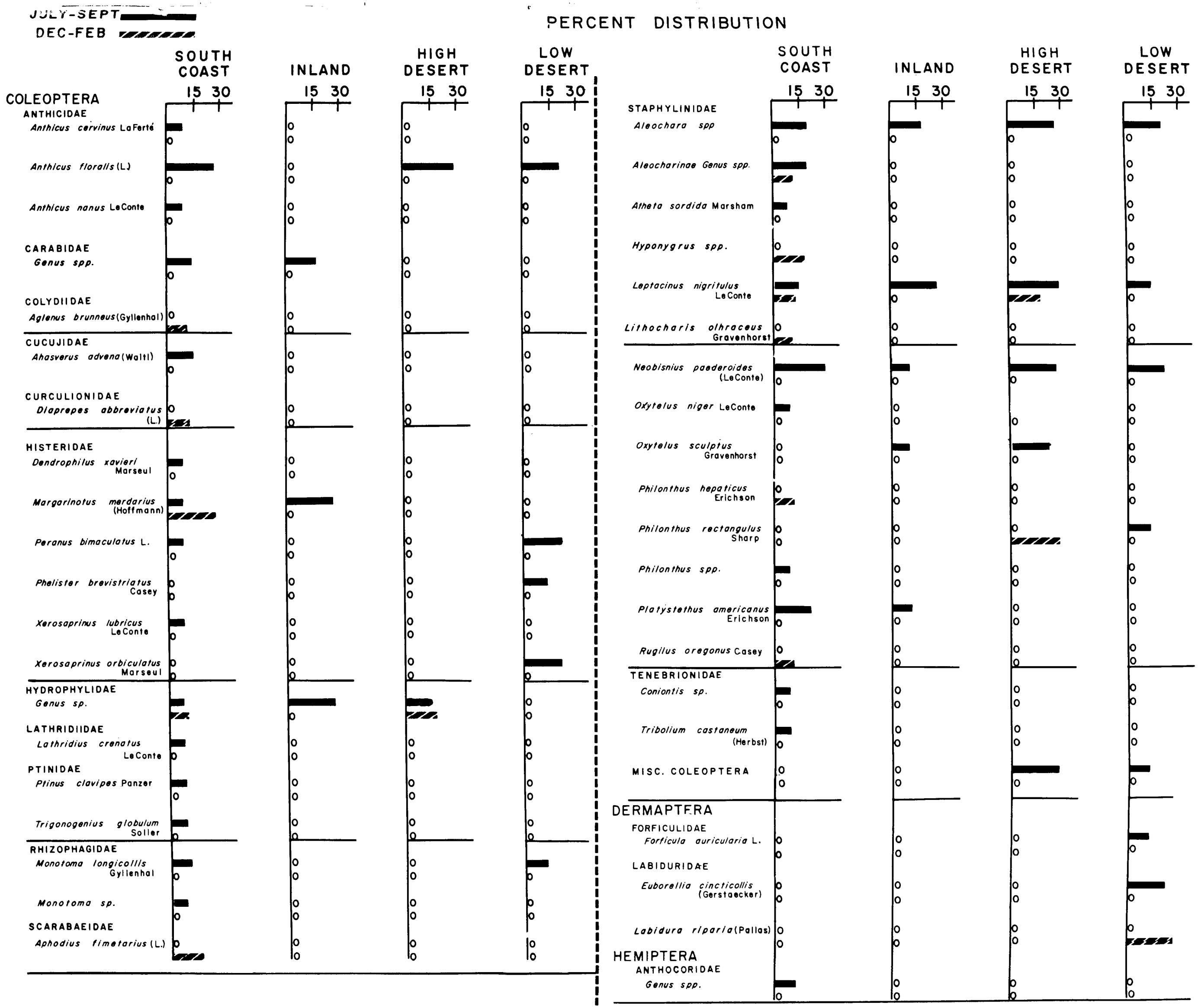

Fig. 5. Distribution of infrequent predatory and scavenger insects found at less than 30 per cent of collection sites in accumulated bovine manure in southern California (1964 to 1969).

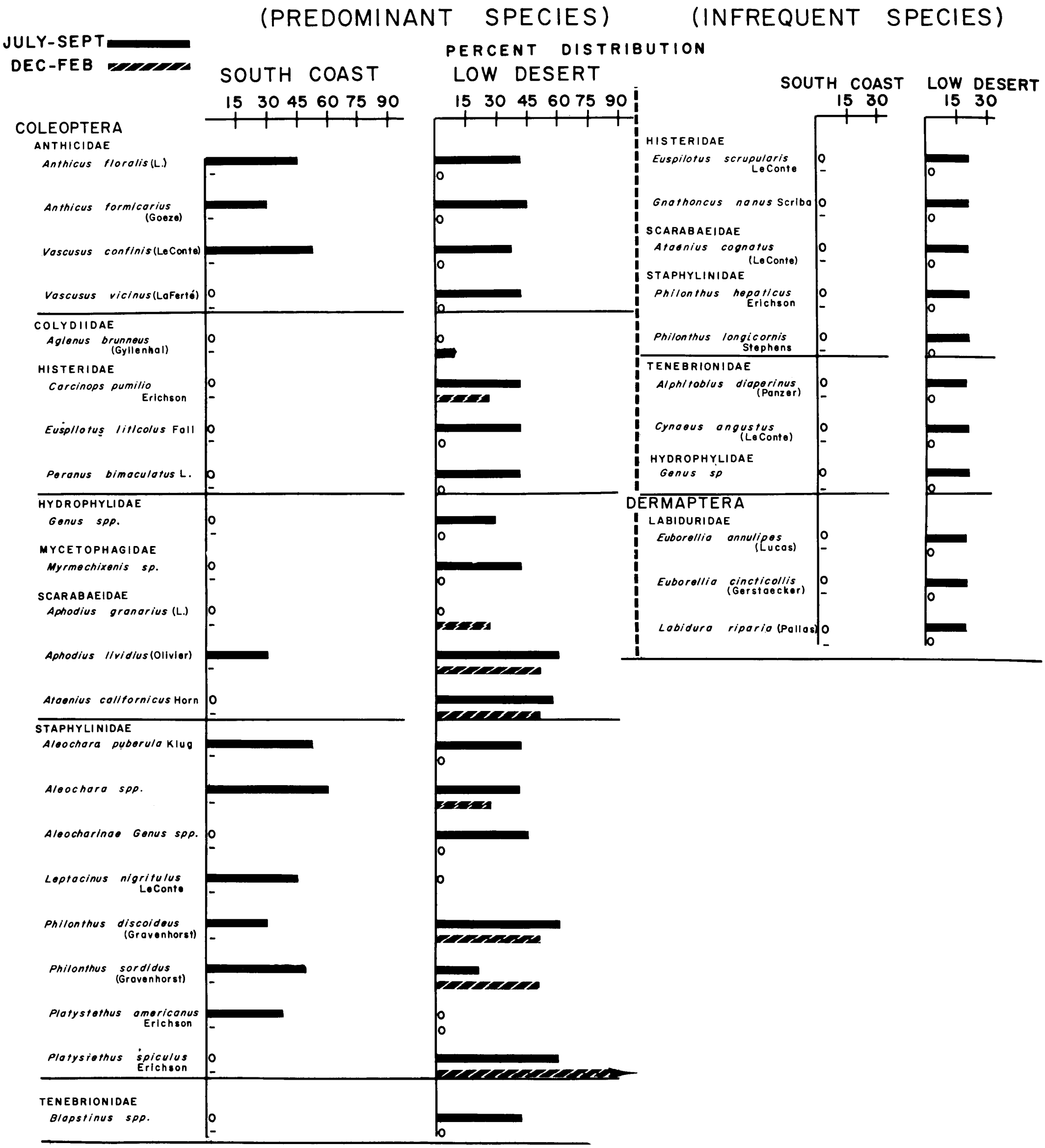

Fig. 6. Distribution of all predatory and scavenger insects in accumulated horse manure in southern California (1964 to 1969).

ter). Of extremely rare occurrence were the lygaeids, *Cryphula parallelogramma* Stal and *Geocoris bullatus* Say, and the dipsocorid *Ceratocombus vagans* McAtee & Malloch.

Widespread scavenger species that were not established in California as predators of muscoid eggs or larvae were *Vacusus confinis* (LeConte), *Dermestes maculatus* DeGeer, *Carpophilus freemani* Dobson, *Monotoma* sp., *Aphodius granarius* (L), *A. lividus* (Olivier), *Ataenius californicus* Horn, *Alphitobius diaperinus* (Panzer), *Blapstinus* spp., and *Cynaeus angustus* (LeConte).

Relative abundance of species in southern California

The relative abundance in southern California of insects inhabiting sites where Diptera were developing is shown in table 2. The average values for any given species accompanied by the 95 per cent confidence limits are estimates of relative abundance among inhabited sites. These percentages show more significant differences in the value of certain predatory species than might be inferred from distribution data alone.

Considering only documented predatory species, the percentage of Carabidae was found to be high wherever they occurred in bovine manure, although their distribution among all collection sites was very low (figs. 2 to 6, table 2). *Carcinops pumilio, Gnathoncus nanus* and *Margarinotus merdarius* were the most prominent histerids which, coupled with their wide distribution, would place them as prominent predators throughout much of southern California. *Euspilotus liticolus* was especially numerous in bovine manure.

The Hydrophylidae, although quite narrowly distributed in southern California (figs. 2 to 6), were usually well represented when they occurred in bovine manure (table 2).

Among the Staphylinidae, *Aleochara* species were especially prominent in the bovine manure habitat. *Philonthus sordidus, P. discoideus* and *Platystethus spiculus* were also prominent species in the collections.

Of the Dermaptera, only *Euborellia annulipes* was abundant (table 2).

Although the anthocorids, *Lyctocoris campestris* and *Xylocoris californicus* and other Hemiptera, were very narrowly distributed, they were very prominent where they occurred.

Among the scavengers, certain species were comparatively more abundant in their range of distribution than others. The anthicids, *Anthicus floralis* and *Vacusus confinis,* were especially prominent in collections from bovine manure. Other abundant scavenger species were the cucujid, *Ahasverus advena* (Waltl); the dermestid, *Dermestes maculatus;* the nitidulids, *Carpophilus freemani* Dobson and *Trigonogenius globulum* Solier; the scarabaeids, *Aphodius fimetarius* (L.), *A. lividus, A. granarius, Ataenius californicus, Pleurophorus caesus* (Creutzer); the tenebrionids, *Alphitobius diaperinus* (Panzer), *Blapstinus* spp. and *Tenebrio molitor* L. (table 2).

Distribution and relative abundance of species in northern California

The most accurate distribution and abundance records of insect predators from accumulated poultry manure in northern California were made by Peck (1968) in a few coastal counties. Although over 20 species of possible predators were found, only seven were abundant or showed any predatory significance in carefully executed feeding experiments. These were histerids, *Carcinops pumilio, Gnathoncus nanus, Margarinotus merdarius;* the staphylinids, *Philonthus politus* (L.), *P. sordidus, Staphylinus* (=*Creophilus*) *maxillosus villosus* Gravenhorst; and the predaceous dipteran, *Ophyra leucostoma* (Weidemann). Predatory species that were not sufficiently abundant to warrant careful study were some unidentified Hydrophylidae; the staphylinids *Atheta* sp., *Baryodma* (=*Aleochara*) *langunosa* Gravenhorst, *Megalinus linearis* (Olivier), *M. picipenne* (LeConte), *Omalium rivulare* Paykull and some unidentified Anthocoridae.

For the present study, the species of adult insects collected from animal manure in northern California during July and September, 1967, are listed in table 3. The data show the average abundance of a species among all collection sites in each area, but do not show within-area distribution because of limited sample size.

TABLE 2

SOUTHERN CALIFORNIA: AVERAGE PERCENTAGE OF ADULT PREDATORY AND SCAVENGER INSECTS THAT EMERGED THROUGH WATER FLOTATION FROM ANIMAL MANURE ACCUMULATIONS (1964 to 1968)

Insect	Manure type	Collection area and sampling period							
		South coast		Inland		High desert		Low desert	
		July–Sept.	Dec.–Feb.	July–Sept.	Dec.–Feb.	July–Sept.	Dec.–Feb.	July–Sept.	Dec.–Feb.
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
		(95% confidence limits in parentheses; . . . = not sampled)							
COLEOPTERA									
Anthicidae									
Anthicus cervinus LaFerté	hen	0	0	0	0	0	0	0	0
	bovine	7.7	0	0	0	0	0	0	0
	horse	0	. .	. .	. .	. .	. .	0	0
Anthicus floralis (L.)	hen	5.5 (2.4–9.8)	0	1.4 (1.3–1.5)	0	0	0	1.2 (0.1–5.2)	0
	bovine	12.9 (0.6–37.5)	0	0	0	9.1 (0.1–37.2)	0	1.8 (0.3–4.5)	0
	horse	4.7	. .	. .	. .	. .	. .	1.9 (0.1–7.6)	0
Anthicus formicarius (Goeze)	hen	0	0	0.5	0	0	0	5.2	0
	bovine	0	0	0	0	0	0	0	0
	horse	4.7	. .	. .	. .	. .	. .	0.8 (0.1–2.6)	0
Anthicus nanus LeConte	hen	0	0	0.9	0	0	0	0	0
	bovine	9.1	0	0	0	0	0	0	0
	horse	0	. .	. .	. .	. .	. .	0	0
Anthicus punctulatus LeConte	hen	2.9	7.4	1.6 (0.3–2.8)	0	0	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	0	. .	. .	. .	. .	. .	0	0
Notoxus calcaratus Horn	hen	0	0	0.9	0	0	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	. .	. .	. .	. .	. .	. .	0	0
Vacusus confinis (LeConte)	hen	4.6 (2.0,8–2)	0	2.3 (0.3–6.1)	0	4.0 (0.1–15.0)	0	2.6	0
	bovine	10.9 (1.5–27.4)	5.8	6.7	0	11.9 (0.1–45.0)	0	3.6 (0.5–9.0)	0
	horse	9.5	. .	. .	. .	. .	. .	2.7 (0.8–5.9)	0
Vacusus vicinus (LaFerté)	hen	0	0	0	0	0	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	0						1.2 (0.1–7.4)	0

Carabidae									
Genus spp.	hen	0	0	0	2.4(0.1–10.5)	0	0	0	0
	bovine	12.5(11.9–13.2)	0	74.6(5.7–88.2)	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
Coccinellidae									
Hippodamia sinuata spuria LeConte	hen	0	0	0	0	0	0	0	0
	bovine	0	0	0	10.0	0	0	0	0
	horse	..	..	..	..	..	..	0	0
Colydiidae									
Aglenus brunneus (Gyllenhal)	hen	0	0	0	0	0	0	0	0
	bovine	0	11.8	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	2.5
Crytophagidae									
Cryptophagus sp.	hen	0	4.4	0	0	0	0	0	5.9
	bovine	3.8	0	0	10.0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
Salebius octodentatus Mäklin	hen	0	0	0	0	0	16.7	0	0
	bovine	0	..	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0
Cucujidae									
Ahasverus advena (Waltl)	hen	1.2	5.5	3.9	50.0	0	0	0	0
	bovine	11.1(0.1–48.9)	0	0	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
Curculionidae									
Diaprepes abbreviatus (L.)	hen	0	0	0	0	0	0	0	0
	bovine	0	12.5	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0
Dermestidae									
Dermestes ater DeGeer	hen	0	0	1.4	0	0	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0
Dermestes maculatus DeGeer	hen	12.3(2.0–29.6)	12.4(0.1–44.7)	4.5(1.2–9.7)	19.0(8.9–31.7)	11.6(0.1–52.9)	5.0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
Histeridae									
Acritus analis LeConte	hen	0	0	2.7	0	0	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0
Atholus vatovai Müller	hen	0	0	0.8	0	0	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0
Carcinops pumilio Erichson	hen	49.6(32.7–66.5)	31.3(18.4–45.8)	54.8(36.6–72.3)	37.7(14.6–64.2)	25.6(16.9–35.5)	16.4(4.0–35.0)	6.4(0.6–18.4)	14.3(0.1–82.9)
	bovine	21.9(9.3–38.1)	21.6(0.2–72.5)	48.6(9.1–89.2)	0	0	0	22.1(1.3–57.8)	0
	horse	0	..	..	..	..	..	2.0	2.7
Dendrophilus xavieri Marseul	hen	8.0(0.1–32.8)	4.2(3.7–4.6)	4.5(0.1–21.7)	0	0	0	0	0
	bovine	7.7	0	0	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0

TABLE 2—*Continued*

Insect	Manure type	Collection area and sampling period							
		South coast		Inland		High desert		Low desert	
		July–Sept.	Dec.–Feb.	July–Sept.	Dec.–Feb.	July–Sept.	Dec–.Feb.	July–Sept.	Dec.–Feb.
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
		(95% confidence limits in parentheses; ... = not sampled)							
Histeridae—*continued*									
Euspilotus liticolus Fall	hen	0.4	0	2 2(0.1–7.6)	0	0	0	6.2(0.1–35.0)	0
	bovine	5.1(0.1–23.4)	0	20.7(0.1–99.6)	0	50.0	0	2.2(0.7–4.3)	41.5(18.3–67.0)
	horse	0	..	..	..	..	..	13.6(0.2–42.6)	0
Euspilotus scrupularis LeConte	hen	0	0	0	0	4.6(0.8–11.4)	9.1	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	..	..	..	..	..	..	1.1	0
Gnathoncus nanus Scriba	hen	30.9(21.4–41.2)	35.3(25.4–45.8)	17.8(7.3–31.8)	50.2(33.0–67.4)	26.3(1.2–67.9)	59.2(34-1–82.0)	11.1	1.9
	bovine	14.1(6.9–16.4)	6.7	8.8(0.9–21.8)	25.0	0	0	3.3(0.1–21.3)	7.1
	horse	0	..	..	..	..	..	1.1	0
Hister coenosus Erichson	hen	1.2	0	0	0	0	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0
Margarinotus merdarius (Hoffman)	hen	11.0(4.8–19.3)	0	6.6(0.1–25.5)	1.0	0	0	0	0
	bovine	8.7	15.2(7.6–24.8)	13.6(0.1–56.7)	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
Peranus bimaculatus L.	hen	0	0	0	0	0	0	0	0
	bovine	1.4	0	0	0	0	0	1.4(1.3–1.6)	0
	horse	..	..	..	..	..	..	1.1(0.9–1.2)	0
Phelister brevistriatus Casey	hen	0	0	0	0	0	0	5.2	0
	bovine	0	0	0	0	0	0	2.0	0
	horse	..	..	..	..	..	..	0	0
Saprinus lugens Erichson	hen	0.4	0	0.9(0.1–3.9)	0	3.6(0.1–24.2)	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
Xerosaprinus lubricus LeConte	hen	0	0	0	0	0	0	0	0
	bovine	25.0	0	0	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
Xerosaprinus orbiculatus Marseul	hen	0	0	0	0	0	0	0	0
	bovine	0	0	0	0	0	0	4.6	0
	horse	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Hydrophylidae									
Genus sp.	hen	2.2(0.5–47.7)	0	1.6(1.4–1.9)	0	0	0	0	0
	bovine	2.8	20.0	21.6(9.1–37.5)	0	21.3(1.6–54.8)	50.0	0	0
	horse	0	..	..	..	..	..	0.8	0
Lathridiidae									
Lathridius crenatus LeConte	hen	0	0	0	0	0	0	0	0
	bovine	5.6	0	0	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
Mycetophagidae									
Litargus sp.	hen	0	23.1	0	5.9	0	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0
Myrmechixenis sp.	hen	0	0	0.5	0	0	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	..	..	..	..	..	..	2.3(2.1–2.5)	0
Typhaea stercorea (L.)	hen	2.6(1.5–3.8)	0	2.2(0.3–5.8)	0	0	0	0	5.9
	bovine	0	0	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0
Nitidulidae									
Carpophilus freemani Dobson	hen	7.7	8.8(5.6–12.6)	0.5	0	0	0	14.3	4.8(2.1–8.5)
	bovine	0	0	0	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
Carpophilus mutilatus Erichson	hen	0	0	7.1	0	0	0	0	0
	bovine	0	0	0	0	0	0	0	12.5
	horse	..	..	..	..	..	..	0	0
Ptinidae									
Ptinus clavipes Panzer	hen	0	0	0	0	0	0	0	0
	bovine	11.6	0	0	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
Trigonogenius globulum Solier	hen	0	8.2	0	0	0	0	0	0
	bovine	23.1	0	0	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
Rhizophagidae									
Monotoma americana Aube	hen	3.6	0	0	5.0(0.1–32.5)	0	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
Monotoma longicollis Gyllenhal	hen	3.1	0	0	0	1.3	0	0	0
	bovine	2.2	0	0	0	0	0	2.8	0
	horse	0	..	..	..	..	..	0	0
Monotoma sp.	hen	2.6(0.5–6.3)	0	3.8(0.1–14.3)	0	2.3	0	0	5.9
	bovine	4.4	0	0	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
Scarabaeidae									
Aphodius fimetarius (L.)	hen	0	12.5	0	6.3	0	0	0	0
	bovine	0	34.8(0.1–98.3)	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0

TABLE 2—*Continued*

Insect	Manure type	South coast July–Sept.	South coast Dec.–Feb.	Inland July–Sept.	Inland Dec.–Feb.	High desert July–Sept.	High desert Dec.–Feb.	Low desert July–Sept.	Low desert Dec.–Feb.
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
		(95% confidence limits in parentheses; . . . = not sampled)							
Scarabaeidae—*continued*									
Aphodius lividius (Olivier)	hen	3.3(0.1–36.9)	0	1.4(0.2–3.9)	10.0	1.5(0.1–20.2)	0	2.6	0
	bovine	15.3(8.8–23.3)	14.3	25.5(6.3–51.9)	0	32.1(9.7–60.3)	14.3	1.9	0
	horse	75.0	..	..	..	..	..	2.8(0.1–13.5)	9.4(0.9–25.3)
Aphodius granarius (L.)	hen	1.1(0.1–17.3)	23.9(0.4–66.6)	0	0	0	0	0	0
	bovine	25.0	29.4(16.9–43.6)	0	53.0(0.1–98.3)	0	85.9(11.5–98.9)	0	0
	horse	..	..	..	..	..	..	0	22.2
Aphodius sp.	hen	0	0	0	0	0	0	2.6	0
	bovine	0	0	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0
Ataenius californicus Horn	hen	0	0	0.9	0	0	0	6.6(2.0–13.6)	0
	bovine	0	33.5(10.4–62.0)	0	50.0	0	0	39.5(8.2–77.1)	0
	horse	0	..	..	..	..	..	55.6(20.4–87.8)	6.8(0.1–39.9)
Ataenius cognatus (LeConte)	hen	0	0	0	0	0	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	0	0	..	..	..	..	2.2	0
Onthophagus batesi Howard & Cartwright	hen	2.2(0.2–5.8)	0	0	0	0	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0
Pleurophorus caesus (Creutzer)	hen	0.4	0	0	0	0	0	0	0
	bovine	0	37.1(6.4–75.5)	0	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
Trox suberosus (F.)	hen	3.6	0	0	9.1	2.5(1.8–3.4)	0	11.1	0
	bovine	0	0	0	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
Staphylinidae									
Aleochara puberula Klug	hen	8.4(0.1–69.4)	0	1.4	0	0	0	7.8	0
	bovine	11.4(0.1–68.5)	0	22.5(0.1–72.0)	0	0	0	3.7(2.7–4.7)	0
	horse	8.2(0.4–31.3)	..	..	..	..	..	0.8(0.1–2.7)	0
Aleochara spp.	hen	0.5	0	0	1.0	0	0	11.1	0
	bovine	7.1(0.5–47.1)	0	17.9(0.1–87.3)	0	5.0	0	7.2(0.1–28.9)	0

Aleocharinae sp.	hen	1.2	47.5(0.1–95.8)	0	1.0	0	0	0	0
	bovine	5.9(0.1–20.0)	33.3	0	0	0	0	0	0
	horse	0	..	..	..	..	..	1.5(0.1–5.1)	0
Atheta sordida (Marsham)	hen	0	0	0	0	0	0	0	0
	bovine	8.3	0	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0
Carpelimus sp.	hen	0	0	0.5	7.2	0	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0
Creophilus maxillosus (L.)	hen	0	0	3.6(0.1–25.9)	0	2.5(2.3–2.7)	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0
Hyponygrus spp.	hen	0	17.6	0	5.1(2.0–9.5)	0	0	0	0
	bovine	0	10.7(6.1–16.4)	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0
Leptacinus nigritulus LeConte	hen	6.6(1.2–16.0)	4.0	2.1(0.1–7.1)	2.1	1.3	0	5.2	0
	bovine	7.0(0.1–36.0)	13.3	11.7(5.6–19.8)	0	6.9(0.8–18.2)	28.6	1.3	0
	horse	4.7	..	..	..	..	..	0	0
Lithocharis ochracea (Gravenhorst)	hen	0	7.7	0	2.5(1.4–3.9)	0	0	0	0
	bovine	0	60.0	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0
Neobisnius paederoides (LeConte)	hen	0	0	0	0	0	0	0	0
	bovine	6.9(1.4–16.0)	0	12.5	0	5.0	0	4.9(0.1–44.3)	0
	horse	..	..	..	..	..	..	0	0
Oxytelus niger LeConte	hen	0	29.4	0	0	0	0	0	0
	bovine	10.2	0	0	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
Oxytelus sculptus (Gravenhorst)	hen	1.9	9.1	43.2(0.1–98.0)	14.3	0	0	0	0
	bovine	0	0	4.8	0	14.3	0	0	0
	horse	0	..	..	..	..	..	0	0
Philonthus discoideus (Gravenhorst)	hen	4.7	0	1.0(0.1–4.7)	0	2.3	0	23.6	11.8
	bovine	8.6(1.7–20.3)	0	14.7(0.1–66.7)	0	0	0	3.7(2.6–5.9)	7.1
	horse	4.7	..	..	..	..	..	9.1(0.1–45.3)	9.4(0.9–25.3)
Philonthus hepaticus Erichson	hen	0	0	0	1.1	0	0	2.6	0
	bovine	0	33.3	0	0	0	0	0	0
	horse	0	..	..	..	..	..	1.1	0
Philonthus longicornis Stephens	hen	10.0	0	0	0	0	0	11.1	1.9
	bovine	1.4	0	4.0(0.1–17.0)	0	0	0	2.3	33.3
	horse	0	..	..	..	..	..	1.0	0
Philonthus politus (L.)	hen	0	0	1.4(0.2–4.0)	0	6.9	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0

TABLE 2—*Continued*

Insect	Manure type	South coast July–Sept.	South coast Dec.–Feb.	Inland July–Sept.	Inland Dec.–Feb.	High desert July–Sept.	High desert Dec.–Feb.	Low desert July–Sept.	Low desert Dec.–Feb.
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
		(95% confidence limits in parentheses; . . . = not sampled)							
Aleocharinae—*continued*									
Philonthus rectangulus Sharp	hen	2.0	0	3.2	0	0	0	0	0
	bovine	0	0	0	0	0	30.7(0.3–86.3)	1.1	0
	horse	. .	. .	. .	. .	. .	. .	0	0
Philonthus sordidus (Gravenhorst)	hen	12.6(7.2–19.3)	28.6(12.6–48.1)	13.4(6.6–22.2)	6.0(3.8–8.7)	21.5(1.6–55.3)	41.5(9.0–79.0)	0	0
	bovine	11.1(3.9–21.4)	20.8(11.1–32.7)	18.5(1.8–46.9)	0	17.8(0.1–69.9)	0	1.3	16.7
	horse	57.1	. .	. .	. .	. .	. .	1.4	17.8(0.1–96.9)
Philonthus spp.	hen	0	0	0	0	0	0	0	0
	bovine	3.8	0	0	0	0	0	0	0
	horse	0	. .	. .	. .	. .	. .	0	0
Platystethus americanus Erichson	hen	2.0(0.1–30.3)	31.2	0	0	0	0	0	0
	bovine	5.6(1.5–12.0)	0	6.7	0	0	0	0	0
	horse	4.7	. .	. .	. .	. .	. .	0	0
Platystethus spiculus Erichson	hen	0	0	0.5	0	0	0	23.6	11.8
	bovine	29.9(0.1–87.9)	0	10.9	0	5.0	0	49.2(13.8–85.0)	20.7(9.6–34.6)
	horse	23.3(0.1–80.8)	. .	. .	. .	. .	. .	15.0(0.1–49.9)	69.7(18.0–99.8)
Rugilus oregonus (Casey)	hen	0	0	0	0	0	0	0	0
	bovine	0	6.7	0	0	0	0	0	0
	horse	. .	. .	. .	. .	. .	. .	0	0
Tenebrionidae									
Alphitobius diaperinus (Panzer)	hen	11.8(0.3–36.8)	5.9	5.2(2.5–8.9)	12.0(3.8–23.9)	4.5(2.1–7.6)	51.1(0.1–98.8)	59.8(9.0–98.8)	43.5(0.1–98.8)
	bovine	0	0	30.0(0.1–98.5)	0	0	0	4.2(0.1–27.7)	12.5
	horse	0	. .	. .	. .	. .	. .	0.5	0
Blapstinus spp.	hen	10.4(3.8–17.0)	42.3(0.1–98.7)	11.2(1.9–26.7)	12.5(5.7–21.4)	0	0	0	0
	bovine	9.8(0.5–28.2)	49.6(1.5–98.3)	0	0	0	40.0	4.7(0.1–21.4)	85.7
	horse	0	. .	. .	. .	. .	. .	8.8(4.2–14.9)	0
Coniotis sp.	hen	9.9(3.1–20.1)	0	0	0	2.3	0	0	0
	bovine	8.3	0	0	0	0	0	0	0
	horse	. .	. .	0	0	0	0	0	0
Cynaeus angustus (LeConte)	hen	0	0	1.6(0.7–3.1)	0	1.9(0.8–3.7)	0	3.8	0
	bovine	0	0	0	0	0	0	0	0
	horse	0	0	0	0	0	0	0	0

Gnathocerus cornutus (F.)	hen	9.2	3.2	0	0	0	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
Metaponium sp.	hen	0	0	0	0	0	0	14.3	0
	bovine	0	0	0	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
Palorus subdepressus (Wollaston)	hen	0	0	0	0	0	0	0	5.8(0.1–28.8)
	bovine	0	0	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0
Tenebrio molitor L.	hen	3.1(0.9–10.0)	26.1	1.4	14.3	0	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
Tribolium castaneum (Herbst)	hen	1.3(0.1–7.0)	0	0.5	0	0	0	0	0
	bovine	9.1	0	0	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0
DERMAPTERA									
Forficulidae									
Forficula auricularia L.	hen	14.7	0	0	0	0	0	0	0
	bovine	0	0	0	0	0	0	3.1	0
	horse	0	..	..	..	..	..	0	0
Labiduridae									
Euborellia annulipes (Lucas)	hen	6.8(3.4–11.2)	14.8(5.0–28.7)	6.8(2.2–13.7)	9.1(1.9–21.0)	0	0	9.1(0.1–63.4)	0
	bovine	20.5(2.1–51.2)	14.7(4.8–28.7)	14.3	0	0	0	2.1(0.1–7.6)	0
	horse	0	..	..	..	..	..	2.2	0
Euborellia cincticollis (Gerstaecker)	hen	0	0	0.9	0	0	0	2.6	0
	bovine	0	0	0	0	0	0	1.4(1.3–1.6)	0
	horse	0	..	..	..	..	..	1.1	0
Labidura riparia (Pallas)	hen	2.9	0	0	0	0	0	0	0
	bovine	0	0	0	0	0	0	0	1.0
	horse	0	..	..	..	..	..	0.5	0
ORTHOPTERA									
Blattidae									
Blatta orientalis L.	hen	0	0	0.5	0	0	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0
HEMIPTERA									
Anthocoridae, Lygaeidae, and Dipsocoridae	hen	5.8(0.5–16.3)	0	0	33.8(0.1–98.8)	0	0	0	0
(*Ceratocombus* sp., *Lyctocoris* spp., *Xylocoris* spp., *Geocoris* sp., *Cryphula* sp.)	bovine	9.2(0.6–26.4)	0	0	0	0	0	0	0
	horse	..	..	..	..	..	..	0	0
Pseudoscorpionida	hen	2.9	0	0	0	0	0	0	0
	bovine	0	0	0	0	0	0	0	0
	horse	0	..	..	..	..	..	0	0

TABLE 3

NORTHERN CALIFORNIA: AVERAGE PERCENTAGE OF ADULT PREDATORY AND SCAVENGER INSECTS THAT EMERGED THROUGH WATER FLOTATION FROM ANIMAL MANURE ACCUMULATIONS

(July to September, 1967)

Insect	Collection area and manure type									
	Salinas Valley	Santa Rosa Valley		Sacramento Valley	San Joaquin Valley		Sierra Western Foothills		High Sierra (8000 ft.)	Owens Valley
	Bovine	Bovine	Hen	Bovine	Bovine	Hen	Hen	Hog	Horse	Bovine
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
COLEOPTERA										
Anthicidae										
Anthicus cervinus LaFerté	0	0	0	0.4	0	0	0	0	0	0
Anthicus floralis (L.)	5.1	0	0	0	4.0	0	0	0	0	0
Anthicus punctulatus LeConte	0	0	0	0.4	0	0	0	0	0	0
Carabidae										
Pteroszichus sp.	0	0	0	0	0	0	0	0	21.4	0
Stenolophus sp.	0	0	0	0.4	0	0	0	0	0	0
Curculionidae										
Listrocleres costrirostris (Klug)	2.5	26.7	0	0	4.0	0	0	0	0	0
Histeridae										
Carcinops pumilio Erichson	7.6	6.7	2.7	0.4	24.0	0	6.3	1.7	0	20.0
Dendrophilus xavieri Marseul	3.7	0	0	0	0	0	0	0	0	0
Gnathoncus nanus Scriba	13.9	0	8.7	0	0	0	87.5	0	0	10.0
Margarinotus merdarius (Hoffmann)	17.7	0	2.0	0	0	0	0	0	0	0
Peranus bimaculatus L.	0	0	0	2.2	0	0	0	0.8	0	0
Saprinus lugens Erichson	0	0	0	0	0	0	6.3	0	0	0
Saprinus oregonensis LeConte	0	0	0	0	0	0	0	0.8	0	0
Saprinus subnitescens Bickhardt	0	0	0	0.4	0	0	0	0	0	0
Hydrophylidae										
Genus spp. (5+)	6.3	13.3	3.3	16.9	0	0	0	23.1	0	0

Aphodius lividius (Olivier)	0	0	6.7	8.0	0	0	0	0	0	0
Staphylinidae										
Hyponygrus spp.	10.1	0	0	0	0	0	0	0	0	0
Oxytelus sculptus Gravenhorst	1.3	13.3	48.7	12.0	20.0	0	0	5.0	0	0
Oxytelus sp.	0	0	0	0	0	0	0	5.8	0	0
Philonthus discoideus (Gravenhorst)	1.2	0	0	3.1	0	0	0	0	0	0
Philonthus longicornis Stephens	2.5	0	0	4.0	0	0	0	2.5	0	0
Philonthus politus L.	2.5	0	0	0	0	0	0	0	0	0
Philonthus rectangulus Sharp	2.5	0	0	8.0	0	0	0	15.7	0	0
Philonthus sordidus Gravenhorst	7.6	20.0	16.7	3.1	0	25.0	0	0.8	0	0
Philonthus sp.	0	0	0.7	0	0	0	0	0.8	28.6	0
Platystethus americanus Erichson	0	0	2.0	5.3	8.0	0	0	15.7	0	20.0
Platystethus sp.	0	0	0	0	0	0	0	0	7.1	0
Quedius sp.	0	0	0	0	0	0	0	0	7.1	0
Creophilus maxillosus (L.)	0	0	0	0	0	50.0	0	0	0	0
Xantholininae Genus sp.	0	6.7	0.7	1.8	0	0	0	0.8	35.7	10.0
Genus spp.	6.3	6.7	8.0	24.0	36.0	0	0	4.1	0	20.0
Tenebrionidae										
Alphitobius diaperinus (Panzer)	0	0	0	0.8	0	0	0	0	0	0
Alphitophagus bifasciatus (Say)	0	0	0	0	0	25.0	0	0	0	0
Amphidora littoralis Eschscholtz	1.3	0	0	0	0	0	0	0	0	0
Cyaneius angustus (LeConte)	1.2	0	0	0.8	4.0	0	0	0	0	0
Tenebrio obscurus F.	0	0	0	0.4	0	0	0	0	0	0
DERMAPTERA										
Labiduridae										
Euborellia annulipes (Lucas)	0	0	0	3.1	0	0	0	13.2	0	0
Labidura riparia (Pallas)	1.2	0	0	0	0	0	0	0	0	0

Of 41 species collected, at least 30 were suspected predators of muscoid Diptera. They were the carabids, *Pterosszichus* sp. and *Stenolophus* sp.; the histerids, *Carcinops pumilio, Dendrophilus xavieri, Gnathoncus nanus, Margarinotus merdarius, Peranus bimaculatus, Saprinus lugens, S. oregonensis* LeConte, *S. subnitescens* Bickhardt; two unidentified species of Hydrophylidae; the staphylinids, *Hyponygrus* spp., *Oxytelus sculptus, Oxytelus sp. Philonthus discoideus, P. longicornis, P. politus, P. rectangulus, P. sordidus, Philonthus* sp., *Platystethus americanus, Platystethus* sp., *Quedius* sp. *Creophilus maxillosis,* an unidentified species of Xantholininae, and two unidentified species in subfamilies of Staphylinidae; and the dermapterans, *Euborellia annulipes* and *Labidura riparia.*

The relative abundance of these predators varied according to the different sample areas, which represented several diverse climatic zones. The coldest areas in the Sierra Nevada and Owens Valley contained the fewest number of species (table 3). Also, species common at the lower elevations were not found in horse manure in the Sierra, this area possessing some unique species. Samples taken in the Salinas Valley, the Sacramento Valley and the western Sierra foothills yielded the greatest diversity of species.

With few exceptions, the most numerous predatory species of the north were also well represented in the south (tables 2 and 3). Exceptions could be found in the higher incidence of unidentified species of Staphylinidae in the north (table 3), and the presence of *Creophilus maxillosus.* Only two known northern histerid species, *Saprinus oregonensis* and *S. subnitescens,* were not found in southern California. Several of the unidentified Hydrophylidae apparently were also absent in the south.

The data indicate that southern California possesses a richer predatory fauna than the northern part (tables 2 and 3), which supports Peck's (1968) intensive study. Before the magnitude of this difference can be determined, however, more extensive surveys will have to be conducted in the north. A degree of certainty occurs only with the highly abundant species. Since the December-through-February surveys in southern California did not produce any additional prominent species, it may be assumed that the same relation would probably be true in the north.

The diversity of scavenger species was considerably less in northern than in southern California. However, one curculionid, *Listrocleres costrirostris* (Klug); and three tenebrionids, *Alphitophagus bifasciatus* (Say), *Amphidora littoralis* Eschscholtz and *Tenebrio obscurus* F. were found only in northern California. However, the abundance of most scavengers relative to predators was generally much lower than that recorded in southern California (tables 2 and 3).

Distribution and relative abundance of species in other portions of the southwestern states and eastern North America

Of the more than 76 species of adult insects collected in manure accumulations in other southwestern states and in eastern North America (tables 4 and 5), 50 are probably predatory. Among these were 10 carabids, 15 histerids, at least 4 hydrophylids, 17 staphylinids, 4 Dermaptera, and 2 anthocorids (tables 4 and 5).

In contrast to the California fauna shown in table 4, the Carabidae were very conspicuous, although their relative abundance was not great.

Among the Histeridae, only five comparatively scarce southwestern species, *Euspilotus mormonellus* Casey, *Hister abbreviatus* F., *Spilodiscus quadratulus*

Casey, *Xerosaprinus fimbriatus* LeConte and *X. vitiosus* LeConte; and one southeastern Canadian species, *Atholus americanus* Paykull, were absent in California collections. One eastern staphylinid, *Philonthus umbratilis* (Gravenhorst), was found, but this species did not extend to the Southwest. The few collection localities in eastern North America produced several predatory species that were also abundant in California, such as the histerids, *Carcinops pumilio, Gnathoncus nanus* and *Hister coenosus;* and the staphylinids *Oxytelus sculptus, Philonthus longicornis, P. politus, P. rectangulus, P. sordidus* and *Platystethus americanus.*

As in California, four predators, *Carcinops pumilio, Gnathoncus nanus, Philonthus sordidus* and *P. rectangulus,* were probably the most widely distributed and relatively abundant. The California collections included these as well as other prominent species (tables 2 and 3).

In the Southwest, *Euspilotus liticolus* figured prominently in the collections from the warm and dry areas.

Most unidentified Staphylinidae collected in the Southwest were probably well represented in California. However, positive identifications of some species of *Philonthus* and Xantholininae were not obtained. With the possible exception of one unidentified species of Anthocoridae in Arizona, additional predatory species were not found.

Among the scavenger species found throughout the Southwest and eastern survey areas, there was also a great deal of similarity with those of California, the relative numbers of these species being greater in the warmer climatic areas. Outside of southern California, very few additional scavenger species were encountered—with the exception of the nitidulid *Glischrochilus quadrisiqnatus* (Say) in the east (tables 4 and 5).

Adult insects collected in other parts of America and the Eastern Hemisphere

At least 147 species were collected in other localities during this survey, of which more than 90 species are probably predators and, therefore, potentially capable of muscoid egg or larval predation (table 5). Collection efforts in this portion of the investigation were devoted to the identity of species; therefore, data are not available on the relative abundance of the different species. The presence or absence of a species is presented in each respective collection area (table 5).

The histerid genera *Abraeus* and *Chaetabraeus* were not encountered in North America. Table 5 shows collections of additional Staphylinidae: the genera, *Apocellus, Belonuchus, Diochus, Falagria, Hesperus, Cilea, Lithocharis, Medon, Neobisnius, Piestinas, Rugilus, Scopaeus, Stenus, Sunius,* and *Tachyphorus.* Additional genera of Dermaptera, *Nesogaster,* and *Lygaeidae, Geocoris,* were encountered as well as species of Dipsocoridae, Nabidae, and Formicidae and some new additions in the Blattidae (table 5).

Among genera that were already represented in surveys of North America, many additional species were found in the Neotropical and Ethiopian regions. Considerable similarity occurred among Palearctic, Nearctic and Australian collections (tables 2 to 5). Completely distinct species were found in elephant manure, although this habitat did not yield any of the key muscoid species under consideration (table 5). The Formicidae appeared to be active only in manure collected in tropical areas.

Only two California predators were common to both the Ethiopian and Neotropical regions; these were *Philonthus longicornis* and *P. rectangulus* (a new record for Latin America). Other California predators that appeared in the

TABLE 4

SOUTHWESTERN AND EASTERN UNITED STATES: AVERAGE PERCENTAGE OF ADULT PREDATORY AND SCAVENGER INSECTS THAT EMERGED THROUGH WATER FLOTATION FROM ANIMAL MANURE ACCUMULATIONS

Insect	July to September, 1967 and 1968												January, 1969								
	Central Nevada	Arizona					New Mexico		Colorado		Cent. Wisc. to No. Ill.	N. W. S. Carolina	So. Nevada	Arizona				New Mexico			
		Cottonwood		Phoenix	Tucson		Las Cruces	Albu-querque	Grand Jct.	Colo. Spgs.				Cotton-wood	Phoenix	Tucson		Las Cruces		Albuquerque	
	Bov.	Bov.	Hor.	Bov.	Bov.	Hen	Bov.	Bov.	Bov.	Bov.	Bov.	Bov.	Bov.	Bov.	Bov.	Bov.	Hen	Bov.	Hen	Bov.	Hor.
	Per cent	*Per cent*					*Per cent*		*Per cent*		*Per cent*	*Per cent*	*Per cent*	*Per cent*				*Per cent*			
COLEOPTERA																					
Anthicidae																					
Anthicus floralis (L.)	0	0	0	0	2.8	0	0	3.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Anthicus formicarius (Goeze)	0	0	0	0	8.3	1.7	2.5	3.5	0	0	0	0	0	0	0	0	0	6.3	0	0	0
Anthicus sp.	12.3	0	0	0	0.9	1.7	0	1.7	0	0	0	7.7	0	0	0	0	0	0	0	0	0
Vacuscus confinis (LeConte)	0	0	0	0	1.8	0	2.5	0	0	0	0	0	0	0	0	0	0	3.6	0	0	0
Carabidae																					
Amara blanchardi Hayward	0	0	0	0	0	0	0	3.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Amara californica Dejean	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Amara sp.	0	0	0	0	0	0	0	1.7	0	0	3.1	0	0	0	0	0	0	0	0	0	0
Apristus laticollis Lec.	0	0	0	0	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bembidion quadrimaculatum (L.)	0	0	0	0	0	0	0	0	0	0	3.1	0	0	0	0	0	0	0	0	0	0
Bembidion sp.	0	0	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0
Euryderus grossus	0	0	0	0	0	0	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Harpalus sp.	0	0	0	0	3.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stenolophus sp.	0	0	0	0	0	0	0	3.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Genus spp.	1.2	0	0	0	0	0	0	0	0	10.0	0	2.6	0	0	0	0	3.6	0	0	0	0
Coccinellidae																					
Hippodamia convergens Guérin-Méneville	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cucujidae																					
Ahasverus advena (Waltl.)	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dermestidae																					
Dermestes ater DeGeer	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dermestes maculatus DeGeer	0	0	0	0	0	5.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Histeridae																					
Acritus analis LeConte	0	0	0	0	0	0	2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Carcinops pumilio Erichson	11.1	30.8	0	49.1	3.7	0	22.5	43.8	0	0	0	2.6	0	15.4	4.1	1.8	0	18.7	7.1	11.8	0
Euspilotus liticolus Fall	0	28.8	0	0	0.9	0	2.5	0	0	0	0	0	4.3	0	0	0	0	0	0	0	0
Euspilotus scrupularis LeConte	0	1.9	0	0	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Euspilotus mormonellus Casey	0	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gnathoncus nanus Scriba	3.7	15.4	0	0	3.7	0	2.5	0	0	0	0	0	0	3.8	2.0	0	0	0	42.8	0	0
Hister abbreviatus F.	2.5	3.8	3.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hister coenosus Erichson	0	0	0	0	0	0	0	0	0	0	0	2.6	0	0	0	0	0	0	0	0	0
Peranus bimaculatus L.	0	1.9	0	0	0	0	2.5	0	0	0	0	0	0	0	0	0	0	37.5	0	0	0
Saprinus lugens Erichson	0	0	0	0	0	1.7	7.5	5.3	0	0	0	0	0	0	0	0	0	0	0	0	0
Saprinus subnitescens Bickhardt	0	0	0	0	0	0	0	0	15.0	0	0	0	0	0	0	0	0	0	0	0	0
Spilodiscus quadratulus Casey	0	0	0	0	0	0	0	3.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Xerosaprinus fimbriatus LeConte	0	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Xerosaprinus vitiosus LeConte	0	5.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrophylidae																					
Genus spp.	1.2	0	7.6	0.9	0	0	0	0	0	0	0	5.1	0	0	2.0	0	0	0	0	0	0
Mycetophagidae																					
Litargus sp.	0	0	0	0	0	5.3	0	0	0	0	0	0	0	0	0	0	1.8	0	14.3	0	0
Typhaea stercorea (L.)	0	0	0	0	0	8.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitidulidae																					
Carpophilus freemani Dobson	0	0	0	0	0	21.1	0	0	0	0	0	0	0	0	0	0	0	0	7.1	0	0
Carpophilus hemipterus L.	0	0	0	0	0	0	0	0	0	0	0	7.7	0	0	0	0	0	0	0	0	0
Carpophilus marginellus Motscholsky	0	0	0	0	0	1.7	0	0	0	0	0	2.6	0	0	0	0	0	0	0	0	0
Glischrochilus quadrisignatus (Say)	0	0	0	0	0	0	0	0	0	0	28.3	0	0	0	0	0	0	0	0	0	0
Scarabaeidae																					
Aphodius fimetarius (L.)	0	0	5.7	0	0	0	0	0	0	0	0	0	0	0	0	3.6	0	0	0	0	0
Aphodius granarius (L.)	18.5	0	3.8	17.5	5.5	0	0	3.5	28.3	0	0	10.3	4.3	80.8	0	37.5	0	0	0	0	20.0
Aphodius lividius (Olivier)	0	3.8	0	0	4.6	0	7.5	0	0	0	0	30.8	0	0	0	1.8	0	6.3	0	0	0
Serica sp.	0	0	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0
Staphylinidae																					
Aleochara spp.	0	11.5	13.5	6.1	24.8	15.8	2.5	0	8.3	0	2.1	0	0	0	4.1	1.8	0	0	7.1	0	0
Aleocharinae Genus sp.	0	0	3.8	0	0	3.5	5.0	0	0	0	10.3	0	0	0	0	1.8	0	0	0	0	0
Hyponygrus fracticornis (Müller)	0	0	0	0	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0	0
Hyponygrus spp.	0	0	0	0	4.6	1.7	0	12.3	0	0	6.3	0	0	0	0	1.8	0	18.7	0	0	20.0
Oxytelus sculptus (Gravenhorst)	1.2	0	0	0	0	0	0	0	0	0	3.1	0	0	0	0	0	0	0	0	0	0
Oxytelus sp.	0	0	0	0.9	0	0	2.5	1.7	0	0	8.3	12.8	0	0	0	0	0	0	0	0	0
Philonthus discoideus (Gravenhorst)	4.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Philonthus longicornis Stephens	0	0	0	0	4.6	1.7	0	0	0	0	0	0	0	0	0	1.8	0	0	0	0	0
Philonthus politus (L.)	0	0	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0
Philonthus rectangulus Sharp	0	1.9	0	0	0	1.7	5.0	0	15.7	0	3.1	2.6	0	0	0	0	0	0	0	0	11.8
Philonthus sordidus (Gravenhorst)	4.9	1.9	3.8	0	2.8	5.3	0	0	6.7	0	2.5	0	0	0	0	0	0	6.3	0	5.9	0
Philonthus umbratilis (Gravenhorst)	0	0	0	0	0	0	0	0	5.0	30.0	0	0	0	0	0	0	0	0	0	0	0
Philonthus sp.	6.2	1.9	38.5	0.9	5.5	1.7	0	0	23.3	0	13.6	0	4.3	0	0	0	0	14.3	0	11.8	0

Neotropical collections were *Carcinops pumilio, Hister coenosus, Euspilotus liticolus, Peranus bimaculatus, Oxytelus sculptus, Philonthus discoideus, Platystethus spiculus, Euborellia annulipes,* and *Labidura riparia* (table 5). Species found also in the Ethiopian Region were *Atholus vatovai* and *Philonthus sordidus* (table 5).

These data suggest that California predators are more closely associated to the Neotropical Region than to the Ethiopian. Other data from North America revealed no further similarities with species in the Ethiopian and Neotropical collections (tables 4 and 5).

A comparison of the various scavenger species collected in the different regions shows a pattern similar to that of the predator species: similar fauna were collected in Nearctic, Palearctic, and Australian regions. Collections in the Ethiopian Region had only one species common to other regions, the widespread *Aphodius lividus* (table 5).

Although the distribution of some California scavengers extended into Neotropical collections, this region possessed many additional, apparently native species (table 5), especially among the Scarabaeidae.

Some entire families known elsewhere were absent in some regional collections. The Anthicidae and Curculionidae were not found in accumulations of manure in the Palearctic nor Ethiopian regions; while the Nabidae and Scydmaenidae appeared only in the Ethiopian Region. The Australian Region was generally poor in numbers of species and families of both scavengers and predators (table 5).

Cattle droppings in the fields *vs.* artificial accumulations of manure

A thorough study of the insect community associated with cattle manure dropped naturally in the field was conducted by Poorbaugh (1966) in northern California. He recognized the differences in physical conditions between undisturbed manure in the field and that which was accumulated "artificially" into piles, and especially emphasized that different species of Diptera were capable of breeding in either situation. Poorbaugh (1966) listed many species of Diptera that were either attracted to or reared from undisturbed cattle droppings. Of the 27 predatory and eight scavenger coleopterous species that he found, all scarabaeids, *Aphodius fimetarius, A. granarius, A. lividus,* and *A. vittatus,* were also well represented in accumulated manure in other sections of California (tables 2 and 3).

Other species that were identified so that comparisons could be made were the staphylinids, *Lithocharis ochracea, Philonthus longicornis, P. politus, P. rectangulus, P. sordidus,* and *Platystethus americanus.* All these species were also found in hen manure (table 2) with *P. politus* restricted to hen manure in southern California. Additional predators that were well represented in field droppings of cattle were five species of Hydrophylidae (Poorbaugh, 1966).

None of the staphylinids and only a few of the scarabaeids were developed in field droppings, their presence due apparently to attraction alone. It is suspected, although evidence is lacking, that many species in the manure-accumulation habitat do not develop there as immatures, but are also attracted in the adult stage. Many of the insect families that were common in accumulations of manure were absent in the field droppings; and among those families that occurred in both habitats, the accumulations of manure had a greater number of species present. It is apparent, therefore, that although some species, especially staphylinids, were unique in field droppings, the adult insect community in manure accumulations was much richer in species.

Other earlier studies in Europe and Mexico by Koebele (Swezey, 1925; Pemberton, 1948) and Hammer (1941), and in Australia and Java by Handschin

TAB

TYPES OF ANIMAL MANURE FROM WORLDWID
AND THE PREDATORY AND SAPROPHAGO

Insect	Western Hemisphere										
	New Brunswick, Canada (9/2/65–9/6/65)	Southern Mexico (5/3/65–5/9/65)		Costa Rica (4/14/54–5/9/65)		Jamaica (1/17/64–3/17/64)	Puerto Rico (4/10/63–9/16/63)	Trinidad (8/2/63–9/12/63)	Chile (1965)		Uruguay
		SE	SW	Low-lands	High-lands				Central (3/25–5/5)	Southern (3/4–3/8)	
	Hen manure (H); bovine manure										
COLEOPTERA											
Anthicidae											
Anthicus floralis (L.)	P	..	B	..	..	..	..	..	H & B	..	[illegible]
Anthicus formicarius (Goeze)	P	..	B	..	..	..	..	..	H & B	..	[illegible]
Vacusus vicinus (LaFerté)	..	..	..	B	..	..	..	..	..	..	..
Vacusus vulgaris Werner	..	..	..	..	..	..	..	..	..	..	[illegible]
Cleridae											
Opetiopalpus sp.	..	..	..	..	..	..	..	..	..	..	..
Cucujidae											
Ahasverus advena (Waltl)	..	..	..	..	..	..	..	..	..	..	..
Curculionidae											
Diaprepes abbreviatus (L.)	..	..	..	..	..	..	B	..	..	..	..
Metamasius sp.	..	..	..	..	..	..	B	..	..	..	..
Dermestidae											
Dermestes ater DeGeer	..	..	..	..	..	..	..	..	..	..	..
Dermestes frischii Kugelann	..	..	..	..	..	..	..	..	..	..	..
Dermestes maculatus DeGeer	..	..	..	..	..	..	..	..	H	..	B
Histeridae											
Abraeus curtulus Fahzaeus	..	..	..	..	..	..	..	..	..	..	..
Atholus americanus Paykull	P	..	..	..	..	..	..	..	..	..	..
Atholus geminus Erichson	..	..	..	..	..	..	..	..	..	..	..
Atholus graueri Graueri & Muller	..	..	..	..	..	..	..	..	..	..	..
Atholus rothkirchi Bickhardt	..	..	..	..	..	..	..	..	..	..	..
Atholus vatovai Muller	..	..	..	..	..	..	..	..	..	..	..
Carcinops pumilio Erichson	P	..	..	..	..	..	..	..	H & B	..	..
Carcinops troglodytes Erichson	..	..	..	..	B	..	B	..	..	..	..
Chaetabraeus alluadi Muller	..	..	..	..	..	..	..	..	..	..	..
Euspilotus liticolus Fall	..	..	B	..	..	..	..	..	..	..	..
Euspilotus sp.	..	B	..	..	..	..	..	..	..	..	..
Epierus nov. sp.	..	..	..	..	..	..	B	..	..	..	..
Gnathoncus nannetensis Marseul	..	..	..	..	..	..	..	..	..	..	..
Gnathoncus nanus Scriba	P	B	..	..	..	..	..	..	..	..	..
Gnathoncus punctator Reitter	..	..	..	..	..	..	..	..	..	..	..
Hesperosaprinus sp.	..	..	..	..	B	..	..	..	..	..	..
Hister coenosus Erichson	..	..	..	B	B	..	..	..	..	..	..
Hister litus Marseul	..	..	B	..	..	..	..	..	..	..	..
Hister loandas Marseul	..	..	..	..	..	..	..	..	..	..	..
Hister nigrinus Fahzaeus	..	..	..	..	..	..	..	..	..	..	..
Hister punctifer Paykull	..	..	..	..	..	..	B	..	..	..	[illegible]
Peranus bimaculatus L.	..	B	..	..	..	..	..	..	..	..	[illegible]
Peranus confinis Erichson	..	..	..	..	..	..	B	H & B	..	..	..
Phelister affinis LeConte	..	B	B	..	..	..	..	..	..	..	..
Phelister brevistriatus Casey	..	..	..	B	..	..	..	..	..	..	..
Phelister cumanensis Marseul	..	B	B	..	..	..	..	..	..	..	..
Phelister haemorrhous Marseul	..	..	..	B	..	B	..	H	B	..	[illegible]
Phelister panamensis LeConte	..	B	B	B	..	..	..	..	..	..	..
Phelister pumilus Erichson	..	..	..	..	..	..	..	..	..	..	[illegible]
Phelister pusio Erichson	..	..	..	B	..	..	..	..	..	..	..
Phelister rouzeti Marseul	..	..	..	B	..	..	..	..	..	..	[illegible]
Phelister stercoricola Bickhardt	..	..	..	..	..	..	..	..	..	..	..
Hydrophylidae											
Genus spp.	P (4 spp.)	B	B	B	B	..	..	..	..	B	B (4 sp
Mycetophagidae											
Litargus balteatus LeConte	..	..	..	..	..	..	..	..	H & B	..	..
Litargus sp.	..	..	..	..	..	..	..	..	..	..	..
Typhaea stercorea (L.)	..	..	..	..	..	..	..	..	..	..	..
Nitidulidae											
Carpophilus humeralis (F.)	..	..	..	..	..	..	..	..	..	..	..
Carpophilus lugubris Murray	..	..	B	..	..	..	..	..	..	..	..

…LLECTION SITES (WITH SAMPLING PERIODS)
…SECTS THEY CONTAINED, 1963 TO 1967

Eastern Hemisphere										Pacific Area				
…Ireland (9/16/66–9/21/66)	Southern Norway (9/23/66–9/25/66)	Denmark (9/26/66)	Central W. Germany (9/28/66–10/8/66)	Eastern Austria (10/12/66)	Rome and Naples, Italy (10/13/66–10/26/66)	Northern Israel (10/27/66–11/23/66)	Tsavo-Nairobi, Kenya (11/24/66–12/15/66)	Kampala, Uganda (12/28/66–1/2/67)	Johannesburg, S. Africa (1/27/67)	Sydney and Melbourne, Australia (2/5/67–2/22/67)	New Zealand (1967)		American Samoa (3/12/67)	Oahu, Hawaii (3/15/67–3/17/67)
											Christ-church (2/22)	Auck-land (3/4–3/10)		
…manure (P); elephant manure (E); rabbit manure (R)														
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B (…pp.)	B (2 spp.)	P	B (3 spp.)	..	B (2 spp.)	H & B (2 spp.)	H & B (3 spp.)	B (2 spp.)	..	..	B	H	..	B
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Insect	Western Hemisphere									
	New Brunswick, Canada (9/2/65–9/6/65)	Southern Mexico (5/3/65–5/9/65)		Costa Rica (4/14/54–5/9/65)		Jamaica (1/17/64–3/17/64)	Puerto Rico (4/10/63–9/16/63)	Trinidad (8/2/63–9/12/63)	Chile (1965)	
		SE	SW	Low-lands	High-lands				Central (3/25–5/5)	Southern (3/4–3/8)
	Hen manure (H); bovine manu									
COLEOPTERA—*continued*										
Nitidulidae—*continued*										
Carpophilus mutilatus Erichson	..	..	..	..	..	..	..	..	..	..
Carpophilus pilosellus Motschulsky	..	..	..	..	..	..	..	..	..	..
Ptilidae										
Genus sp.	..	..	..	..	..	B	..	..	..	..
Rhizophagidae										
Genus sp.	..	..	..	..	..	..	..	..	..	..
Monotoma sp.	..	..	..	..	..	..	..	..	..	..
Scarabaeidae										
Aphodius cuniculus Chevrolat	..	..	..	..	..	..	B	H	..	..
Aphodius fimetarius (L.)	..	..	..	..	..	..	..	..	..	..
Aphodius lividus (Olivier)	..	B	B	B	B	..	B	..	H & B	..
Aphodius sallei Harold	..	..	..	B	B	..	..	..	..	..
Aphodius vittatus (Say)	..	..	B	..	..	..	..	..	..	..
Aphodius spp.	..	..	..	..	B	..	..	..	B	..
Ataenius duplopunctatus Lea	..	..	..	..	..	..	B	..	..	..
Ataenius frater Arrow	..	..	..	..	..	..	B	..	..	..
Ataenius gracilis (Melsheimer)	..	..	B	B	..	..	..	..	..	..
Ataenius picinus Harold	..	..	..	..	..	..	B	..	..	..
Ataenius platensis (Blanchard)	..	..	..	..	..	..	..	..	..	..
Ataenius steinheili Harold	..	..	..	..	..	..	..	H	..	..
Ataenius strigicauda Bates	..	..	..	..	..	..	B	..	..	..
Ataenius spp.	..	B	B	B	B	..	..	..	..	..
Cyclocephala sp.	..	..	..	..	..	..	..	..	..	..
Diplotaxis sp.	..	..	B	B	..	..	..	..	..	..
Liatongus sp.	..	..	..	..	..	..	..	..	..	..
Onthophagus batesi Howard & Cartwright	..	B	B	..	..	..	..	..	..	..
Onthophagus landolti texanus Schaeffer	..	..	B	..	..	..	..	..	..	..
Onthophagus sp.	..	..	..	..	..	..	..	..	..	..
Genus sp.	..	..	..	..	..	..	..	..	..	..
Scydmaenidae										
Genus spp.	..	..	..	..	..	..	..	..	..	..
Staphylinidae										
Aleochara spp.	..	B	B	B	B	..	..	..	..	B
Aleocharinae spp.	P	B	..	B	B	..	..	..	B	..
Apocellus sp.	..	..	..	B	..	..	..	..	..	..
Belonuchus sp.	..	..	..	B	..	..	..	..	..	..
Carpelimus aeolus Blackwelder	..	..	..	..	..	..	B	..	..	..
Carpelimus correctus Blackwelder	..	..	..	..	..	..	B	..	..	..
Creophilus sp.	..	..	..	B	..	..	..	..	B	..
Diochus nanus Erichson	..	..	..	..	..	..	B	..	..	..
Falagria sp.	..	..	..	B	..	..	..	..	..	..
Hesperus sp.	..	..	..	B	..	..	..	..	..	..
Hyponygrus humeralis (Erichson)	..	B	..	..	..	..	B	H	..	..
Hyponygrus spp.	..	..	..	..	..	..	..	..	..	..
Leptacinus sp.	..	..	..	..	..	..	..	..	..	B
Cilea silphoides (L.)	..	..	..	..	..	..	..	..	..	..
Lithocharis ochracea (Gravenhorst)	..	..	..	..	..	B	..	..	..	..
Medon sp.	..	..	..	B	..	..	..	..	..	..
Neobisnius sp.	..	..	..	B	B	..	..	..	..	..
Oxytelus incisus Motschoulsky	..	..	..	..	..	B	B	..	..	..
Oxytelus sculptus (Gravenhorst)	..	..	..	..	..	..	..	..	..	B
Oxytelus spp.	P	B	B	B	B	..	..	..	..	..

ontinued

	Eastern Hemisphere									Pacific Area				
Southwest Ireland (9/16/66–9/21/66)	Southern Norway (9/23/66–9/25/66)	Denmark (9/26/66)	Central W. Germany (9/28/66–10/8/66)	Eastern Austria (10/12/66)	Rome and Naples, Italy (10/13/66–10/26/66)	Northern Israel (10/27/66–11/23/66)	Tzavo-Nairobi, Kenya (11/24/66–12/15/66)	Kampala, Uganda (12/28/66–1/2/67)	Johannesburg, S. Africa (1/27/67)	Sydney and Melbourne, Australia (2/5/67–2/22/67)	New Zealand (1967) Christ-church (2/22)	New Zealand (1967) Auck-land (3/4–3/10)	American Samoa (3/12/67)	Oahu, Hawaii (3/15/67–3/17/67)
g manure (P); elephant manure (E); rabbit manure (R)														
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B	..	P	B	..	B	..	..	B	..	..	..	..	..	..
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..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	H	..	..	..	..	B	..	..	..
B	B	P	B	B	..	..	H	B & R (3 spp.)	..	..	..	..	..	..

Insect	Western Hemisphere										
	New Brunswick, Canada (9/2/65–9/6/65)	Southern Mexico (5/3/65–5/9/65)		Costa Rica (4/14/54–5/9/65)		Jamaica (1/17/64–3/17/64)	Puerto Rico (4/10/63–9/16/63)	Trinidad (8/2/63–9/12/63)	Chile (1965)		Uruguay
		SE	SW	Low-lands	High-lands				Central (3/25–5/5)	Southern (3/4–3/8)	
	Hen manure (H); bovine manure										
COLEOPTERA—*continued*											
Staphylinidae—*continued*											
Oxytelinae sp	..	..	..	..	..	..	B	H	..	..	..
Philonthus discoideus (Gravenhorst)	..	..	..	..	..	..	B	..	..	..	..
Philonthus flavolimbatus Erichson	..	..	..	B	..	..	..	..	..	..	..
Philonthus hepaticus Erichson	..	..	..	..	..	B	..	H	..	..	..
Philonthus longicornis Stephens	P	..	..	B	..	..	..	H	..	..	..
Philonthus politus (L.)	P	..	..	..	..	..	..	..	..	..	..
Philonthus rectangulus Sharp	P	B	..	B	B	..	..	..	..	..	[illegible]
Philonthus sordidus (Gravenhorst)	P	..	..	..	..	..	..	..	..	..	..
Philonthus spp.	P	B	B	B	B	..	..	..	H & B (3)	B (2)	[illegible] (2
Piestinas sp.	..	..	..	B	..	..	..	..	..	..	..
Platystethus spiculus Erichson	..	B	B	..	..	..	B	..	..	..	..
Platystethus sp.	..	..	..	..	..	..	..	..	..	..	..
Rugilus sp.	..	..	..	..	..	..	..	..	..	..	[illegible]
Scopaeus sp.	..	..	..	..	..	..	..	..	..	..	[illegible]
Staphylinus sp.	..	..	..	..	..	..	..	..	..	..	..
Stenus sp.	..	..	..	..	..	..	..	..	..	..	..
Sunius sp.	..	B	..	..	..	..	..	..	..	..	..
Tachyphorus sp.	..	..	..	..	..	..	..	..	..	..	B
Xantholinae spp.	P	B	..	B	B	..	..	..	..	..	B
Tenebrionidae											
Alphitobius diaperinus (Panzer)	..	..	..	..	..	..	B	..	..	..	..
Alphitobius laevigatus (F.)	..	..	..	..	..	..	..	..	..	..	..
Alphitophagus bifasciatus (Say)	..	..	..	..	..	..	..	..	..	..	..
Cynaeus angustus (LeConte)	..	..	..	..	..	..	..	..	H & B	..	..
Eutochia pulla Erichson	..	..	..	..	..	..	..	..	..	..	..
Opatrinus sp.	..	..	..	..	..	..	B	..	..	..	..
Palorus subdepressus (Wollaston)	..	..	..	..	..	..	..	..	..	..	..
Tribolium castaneum (Herbst)	..	..	..	..	..	..	..	..	..	..	..
Trox suberosus (F.)	..	..	..	..	..	..	B	..	..	..	..
DERMAPTERA											
Labiduridae											
Euborellia annulipes (Lucas)	..	..	..	B	..	..	B	..	..	..	[illegible]
Euborellia stali (Dohrn)	..	..	..	..	..	B	B	H	..	..	..
Labidura riparia (Pallas)	..	..	..	..	..	..	B	..	..	..	[illegible]
Labiidae											
Labia minor (L.)	P	..	..	..	..	..	..	..	..	..	[illegible]
Labia sp.	..	..	..	..	..	..	B	..	..	..	..
Nesogaster sp.	..	..	..	..	..	..	..	..	..	..	..
HEMIPTERA											
Anthocoridae											
Xylocoris spp.	..	..	..	..	..	..	..	..	H & B	..	[illegible]
Dipsocoridae											
Ceratocombus vagans McAtee & Malloch	..	..	..	B	..	..	..	..	..	..	..
Lygaeidae											
Geocoris uliginosus (Say)	..	..	..	..	..	..	..	..	..	..	..
Polycrates consutus (Germar)	..	..	..	..	..	..	..	..	..	..	..
Megalonotini Genus sp	..	..	..	..	..	..	..	..	..	..	..
Nabidae											
Phorticus sp.	..	..	..	..	..	..	..	..	..	..	..
HYMENOPTERA											
Formicidae											
Dorylus spp.	..	..	..	..	..	..	..	..	..	..	..

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	Eastern Hemisphere									Pacific Area				
…(9/16/66–9/21/66)	Southern Norway (9/23/66–9/25/66)	Denmark (9/26/66)	Central W. Germany (9/28/66–10/8/66)	Eastern Austria (10/12/66)	Rome and Naples, Italy (10/13/66–10/26/66)	Northern Israel (10/27/66–11/23/66)	Tzavo-Nairobi, Kenya (11/24/66–12/15/66)	Kampala, Uganda (12/28/66–1/2/67)	Johannesburg, S. Africa (1/27/67)	Sydney and Melbourne, Australia (2/5/67–2/22/67)	New Zealand (1967) Christ-church (2/22)	New Zealand (1967) Auck-land (3/4–3/10)	American Samoa (3/12/67)	Oahu, Hawaii (3/15/67–3/17/67)
manure (P); elephant manure (E); rabbit manure (R)														
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	E	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
B	..	P	B	..	B	H & B	B	B	..	..	B	H	..	B
..	..	..	B	..	B	..	..	..	..	..	..	H	..	..
B	..	..	B	..	B	..	B	..	B	..	..	H	..	B
B	..	..	B	..	..	H & B	B	..	..	..	..	..	..	..
..	B	..	B	B (3 spp.)	..	H & B	B & E (6 spp.)	B & R (5 spp.)	B (2 spp.)	B	..	H (3 spp.)	..	B (2 spp.)
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	B	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	H & B	..	..	..	..	..	..	..	..
..	..	..	..	B	..	..	B	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	B	..	..	..	..	..	..	..	..	..	..	..
B	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	B	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
B	..	..	B	B	..	..	H & B (3 spp.)	..	B	..	B	H	..	..
..	..	..	..	..	..	H & B	..	..	..	..	..	..	H & P	..
	..	..	..	..	..	H	..	..	..	..	..	..	..	..
..	..	..	..	..	..	H & B	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	B	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	H	..	..	..	..	..	..	..	..
..	..	..	..	..	..	H	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	H & B	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	H	..	..	..	..	..	..	..	..
B	..	..	B	..	B	H	..	B	..	..	B	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	B	..	H	..	..
	..	..	..	..	..	H & B	B	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	H	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	E	..	..	..	..	..	..	..
	..	..	..	..	..	H	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	B	..	..	..	..	..	..
	..	..	..	..	..	H & B	..	B	..	..	..	..	..	..

TABLE 5

Insect	Western Hemisphere										
	New Brunswick, Canada (9/2/65–9/6/65)	Southern Mexico (5/3/65–5/9/65)		Costa Rica (4/14/54–5/9/65)		Jamaica (1/17/64–3/17/64)	Puerto Rico (4/10/63–9/16/63)	Trinidad (8/2/63–9/12/63)	Chile (1965)		Uruguay
		SE	SW	Low-lands	High-lands				Central (3/25–5/5)	Southern (3/4–3/8)	
	Hen manure (H); bovine manure (										
HYMENOPTERA—*continued*											
Formicidae—*continued*											
Monomorium sp.	..	..	..	..	..	..	..	..	..	..	..
Pheidole sp.	..	..	..	..	..	..	..	..	..	..	..
Ponera opaciceps Mayr	..	..	..	..	..	..	..	H	..	..	..
Ponera sp.	..	..	..	..	..	..	B	H	..	..	..
Solenopsis geminata (F.)	..	..	..	..	..	B	B	..	..	..	..
Tetramorium guinense (F.)	..	..	..	..	..	..	B	..	..	..	..
ORTHOPTERA											
Blattidae											
Blatella sp.	..	..	..	..	..	..	..	..	..	..	..
Ischnoptera sp.	..	..	..	..	..	..	..	H	..	..	..
Periplaneta sp.	..	..	..	..	..	..	..	..	..	..	..
Pycnoscelus surinamensis (L.)	..	..	..	..	..	..	B	..	..	..	..
Genus sp.	..	..	..	..	..	..	..	..	..	..	..

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	Eastern Hemisphere										Pacific Area				
												New Zealand (1967)			
(9/1?/66–9/21/66)	Southern Norway (9/23/66–9/25/66)	Denmark (9/26/66)	Central W. Germany (9/28/66–10/8/66)	Eastern Austria (10/12/66)	Rome and Naples, Italy (10/13/66–10/26/66)	Northern Israel (10/27/66–11/23/66)	Tzavo-Nairobi, Kenya (11/24/66–12/15/66)	Kampala, Uganda (12/28/66–1/2/67)	Johannesburg, S. Africa (1/27/67)	Sydney and Melbourne, Australia (2/5/67–2/22/67)	Christ-church (2/22)	Auck-land (3/4–3/10)	American Samoa (3/12/67)	Oahu, Hawaii (3/15/67–3/17/67)
manure (P); elephant manure (E); rabbit manure (R)														
.	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	B	. .	. .	. .
.	. .	. .	. .	. .	. .	. .	. .	B	. .	. .	. .	. .	. .	. .
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	. .	. .	. .	. .	. .	. .	. .	B	. .	. .	. .	. .	. .	. .
	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	. .	. .	. .	. .	. .	H	. .	. .	. .	. .	. .	. .	. .	. .
	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	. .	. .	. .	. .	. .	. .	H	. .	. .	. .	. .	. .	. .	. .

(1932) reported species for the field manure habitat different than those encountered in this study. Koebele did, however, report activity of one scarab, *Aphodius fimetarius,* in European pasture manure that was also found in California (Poorbaugh, 1966, and tables 2 to 5). Other species in their studies that may have been common to ours could not be ascertained because descriptions of species which they found were not exact. Further references to the field dropping habitat are Mohr (1943), Sanders and Dobson (1966), and Snowball (1941–42).

CONCLUSIONS

True predators are unable to survive where their prey populations drop to very low densities (Huffaker, 1958). The heterogeneous distribution of many predatory species recorded in the present study probably resulted from considerable dispersal activity and local increased reproduction as a numerical response to increased prey density (Holling, 1959, 1961). The effects of such predation on the dipterous species developing in animal manure cannot be judged, however, merely by their existence at a breeding site. Their predatory actions may involve various combinations of functional (Holling, 1959, 1961) and compensatory responses (Ricker, 1954; Errington, 1946, 1963). Further detailed studies are necessary to elucidate the role of these predators in population regulation. Already, our preliminary studies have shown that the problems are complex. Cannibalism is a factor, for instance, as is predation of other predator and scavenger larvae and other invertebrate fauna.

The samples taken in areas outside California were not extensive enough to warrant a critical discussion of regional differences. The data do suggest, however, a great similarity of species in the Holarctic and Australian regions, and a corresponding dissimilarity of the Ethiopian and Neotropical regions. The addition of many Holarctic species to the Australian area might increase local predatory complexes there. A further search in the Ethiopian and Neotropical regions for additional predatory species might prove fruitful in light of evidence from the restricted samples presented here. Many distinct genera could be considered for study and possible introduction.

Some predators such as *Epierus* sp., apparently were not normal inhabitants of animal manure. Almost all species of this genus occur under the bark of trees where the larvae prey on other insects (R. L. Wenzel, personal communication). Also, the species of *Neosaprinus* are generally associated with ants or with bat guano. Previous association alone, however, is not sufficient to exclude a consideration of potential candidates for introduction. *Gnathoncus nanus,* for example, has adapted to a rather wide variety of situations, although most species of the genus are associated with either bird or small-animal dung (R. L. Wenzel, personal communication; Blatchley, 1910; Hicks, 1959; McGrath and Hatch, 1941; Schaufuss, 1909).

To successfully establish a species outside its area of origin, it would seem important to seek a climate similar to the one where the species was found. For instance, it is not likely that many tropical species could adapt to the rigorous climates in the temperate zone. Their natural dispersion would have already occurred if this were possible. Often a species such as *Carcinops troglodytes* Erichson, which exists in the tropics, has a vicarious counterpart, such as *C. pumilio,* in both northern and southern temperate areas (R. L. Wenzel, personal communication, and table 5). However, *Peranus bimaculatus,* which has a similar distribution to *C. pumilio* does not have such a vicarious counterpart in tropical latitudes.

Philonthus rectangulus, of apparently Asiatic origin, is considered to be in an active state of dispersion. This staphylinid has recently spread throughout Europe, the United States, and Latin America (I. Moore, personal communication).

Species considered to have been already spread by man are the histerids, *Carcinops pumilio, C. troglodytes, Gnathoncus nanus, Margarinotus merdarius* and *Peranus bimaculatus* (R. L. Wenzel, personal communication), and probably the staphylinids, *Lithocharis ochracea, Oxytelus sculptus, Philonthus discoideus, P. longicornis,* and *P. sordidus.*

The fact that morphological variation among most species appears to be discontinuous, would rather suggest randomness of movement and little chance of clinal configuration. Of course, if their dispersal is fairly recent, as suspected, future population patterns are yet to be set. Further studies, therefore, would increase understanding of the evolutionary changes in animal populations.

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