Legner, 1963

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2. Excessive numbers of chironomid midges were found to be a nuisance to residents of a subdivision adjacent to the lake. Midges were especially abundant during July and August. During periods of peak abundance the onshore midge population consisted primarily of a single species, *Paralauterborniella subcincta*.

3. It is believed that light trapping gives a rather good indication of the prevalence of various species of midges emerging from the lake. The maximum number of midges collected by this method was estimated at 97,000 for a one-week period. On this occasion the catch consisted of approximately 88% *P. subcincta*.

4. *P. subcincta* larvae were observed living attached to the submerged leaves and stems of pondweed. These larvae were seldom collected by dredging. Quantitative sampling procedures for plant-inhabiting larvae must be developed before it will be possible to study the abundance and distribution of the aquatic stages of such midges.

5. Midges whose larvae are primarily benthic, including *Chironomus* and *Procladius*, were collected consistently by dredging. However, these genera did not appear to constitute a major nuisance at Laguna Lake.

6. Techniques ordinarily employed for the control of benthic midge larvae may not succeed in lakes where the offending species are associated with aquatic vegetation.

Acknowledgment

We greatly appreciate the advice of Dr. Ernest C. Bay, with whom we consulted frequently during this study.

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ATTRACTION OF *HIPPELATES* EYE GNATS AND OTHER MINUTE DIPTERA TO BAITS AND MAN WITH CONSIDERATIONS ON COMPETITIVE DISPLACEMENT BY EXOTIC NON-PROBLEM SPECIES[1]

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The principle of competitive displacement whereby one species of organism outcompetes or replaces another has been reviewed recently by DeBach (1966), Flanders (1966), and Turnbull (1967). The phenomenon was first demonstrated by Gause (1934) for protozoans, while DeBach and Sundby (1963) illustrated its action with certain species of parasitoid insects attacking citrus scale insects. Turnbull (1967) emphasized that in order for displacement to occur, the competing organisms must necessarily be very closely related. DeBach (1964), discussing the employment of the competitive displacement principle as a biological control tool, suggested that closely related but nonproblematic species of *Hippelates* might be introduced into areas where noxious species occur, with the purpose of reducing the latter through coexistence or eliminating them by displacement.

Earlier efforts at biological control of *Hippelates* have stressed the importation of exotic natural enemies (Bay and Legner, 1963; Legner and Bay, 1965; Legner, 1967; Legner et al., 1966). Coincident with foreign explorations particular attention was paid to the habits of local *Hippelates* species in the various exploration sites. Preliminary findings (Legner and Bay, 1965) showed that various degrees of aggressiveness and activity existed within a single species, some forms of which were even reproductively isolated from others suggesting that they were siblings or even separate species. The present discussion describes some of the charateristics of certain predominant *Hippelates* and associated species over widely separated Eastern and Western Hemispheric sites, their relative abundance being determined from egg bait and net collections, and presents the possibilities for their introduction in California for competitive displacement or coexistence with noxious species. The principal target species under consideration are *Hippelates collusor* (Townsend), *H. robertsoni* Sabrosky, and *H. impressus* Becker (Mulla and March, 1959).

Methods and Materials

The principal survey tool was the bait trap (Fig. 1) which was armed with two size 000 (10 x 25 mm) gelatin capsules containing powdered egg, and a plug of cellucotton to anchor the capsules to the bottom of the trap. These traps were suspended randomly throughout the survey areas in the shade from bushes and trees, and they were activated by the addition of 200 ml H_2O. Insects were most strongly attracted from the third through the sixth days after activation when temperatures ranged from 22-32°C. Predation of trap contents by ants was precluded by the addition of axle grease to the branch from which it was suspended. Attracted insects entered the trap openings through differential screens of 16 mesh/in. made their way upwards through an inverted funnel and into the collection receptacle at the top (Fig. 1).

Other survey methods to determine the existence of additional species included collections made from the windshield of automobiles in which rotting egg baits had been

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placed (Legner and Bay, 1965), net sweeps of the ground vegetation, and directly from the air immediately surrounding the head of humans. In the latter case, the author, his wife, and daughter participated in all areas, and references to attraction intensity include observations on all three individuals.

Collected specimens were stored in 75% ethanol. Identifications of Agromyzidae, Anthomyzidae, Chloropidae, Chyromyidae, Dolichopodidae, Milichiidae, Muscidae, Sepsidae, Sphaeroceridae, and Trixoscelididae were made by C.W. Sabrosky; of Drosophilidae, Ephydridae, Ceratopogonidae, and Phoridae by W.W. Wirth; of Empididae, Otitidae, and Thyreophoridae by G. Steyskal; and of Sciaridae by A. Stone of the U.S. Department of Agriculture, U.S. National Museum. I am grateful for this assistance.

Surveys were conducted during the summer months in each locality, unless otherwise indicated. Checks with local scientists generally indicated that the survey intervals were at the time of maximum *Hippelates* abundance in the respective areas, which generally corresponded to mid- or late summer. Areas covered included diverse sites in North, Central, and South America, the West Indies, Europe, the Middle East, and Africa.

Results

Relative Numbers of Species Trapped and Distribution - The relative attraction of insect species in the size range of *Hippelates* to rotting egg bait traps at the various foreign collection sites are presented in Table 1. Species collected throughout southern California are shown in Table 2.

It is apparent that Chloropidae were generally the most numerous species trapped in both Western and Eastern Hemispheric sites, with *Hippelates* in the west and *Oscinella* and *Elachiptera* in the east being most prominent. *Hippelates* was absent from the Eastern Hemisphere, which bore out previous conclusions by Sabrosky (1941 and 1951).

The most widely distributed species in America were *Hippelates pusio*, *H. dorsalis*, *H. pernanus*, and *Milichiella lacteipennis*; while *Oscinella frit* predominated in Europe and the Middle East, and *O. dimidiofrit* Becker in E. Africa (Tables 1 and 2).

There were more *Hippelates* species trapped in the West Indies than in any other region. As one proceeded north or south of this region, other genera of Chloropidae replaced *Hippelates*, although none of them was as strongly attracted to rotting egg as *Hippelates* themselves. Some distinct species prevailed in South America (Table 1).

Samples gathered by net sweeps of ground vegetation often produced greater proportions of certain species than the bait traps, enabling some estimation of weak or strong attraction to the baits. Some species were so scarce that only the most casual relationship to the traps was indicated (e.g., Ceratopogonidae, Muscidae, Otitidae, etc.).

Attraction to Man - For the most part, only *Hippelates* species were strongly attracted to the vicinity of the human head. A very slight attraction was shown by unidentified

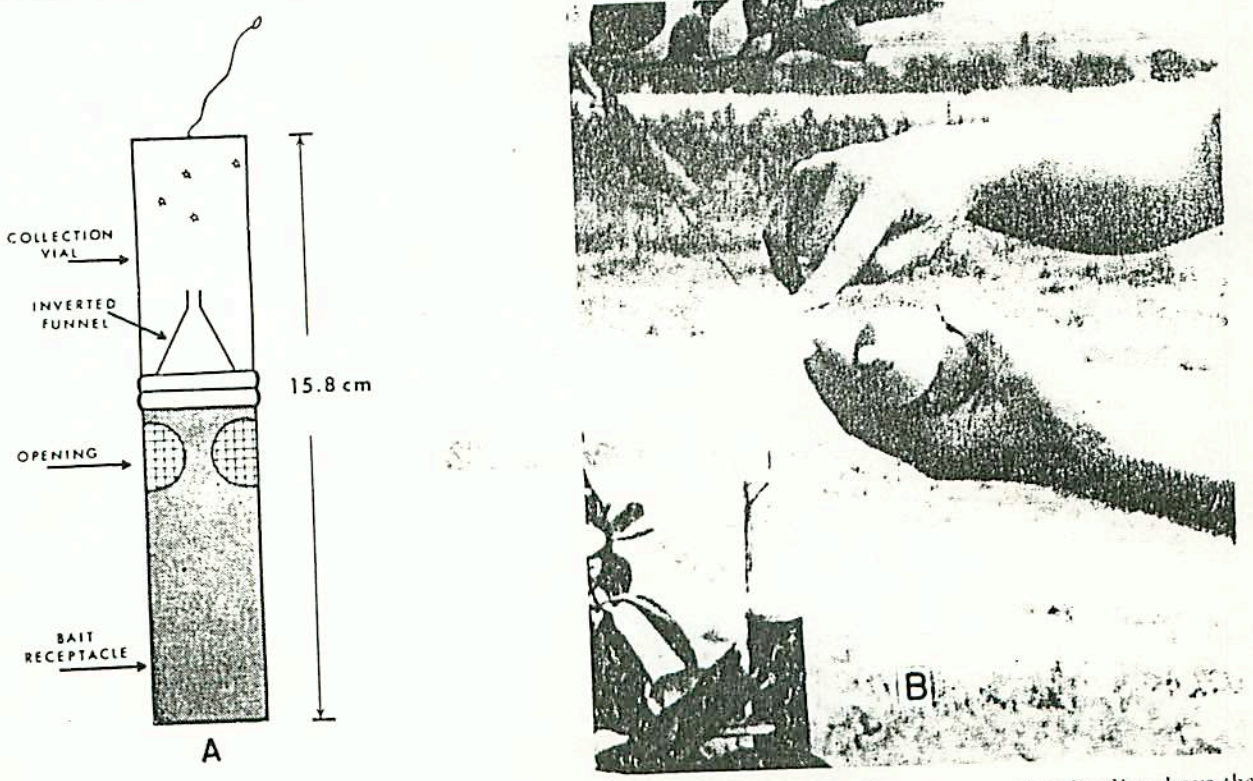

Figure 1. Bait trap used in survey for *Hippelates* species: (a) basic design, (b) application of grease to ant barrier disc above the trap located in tree foliage.

species of *Conioscinella* at several American sites, and a moderate attraction was shown by *Oscinella aharonii* Duda in the Middle East. There was no observed attraction to man of any of the other species trapped in portions of the Eastern Hemisphere (Table 1).

Two species which stand out as being very strongly attracted to humans are *Hippelates collusor* in the Southwestern United States and *Hippelates pusio* in Bermuda. Other West Indian and American forms of *H. pusio* did not demonstrate the same degree of aggressiveness (Legner and Bay 1965) (Tables 1 and 2). Of moderate concern were *H. flavipes* in the West Indies, *H. parviseta* (Mall.) in Uruguay, *H. australis* Sabrosky in Chile, and *H. dorsalis* and *H. robertsoni* in California. Other species listed in Tables 1 and 2 were at the most only very weakly attracted to humans.

Behavioral Peculiarities of Some Hippelates and Chloropid Species - The *Hippelates* species that I have observed in North America and the West Indies were many times more aggressive than any found in South and Central America, or chloropids in Europe and Africa. From conversations with local residents in the respective collection sites of South and Central America, I learned that only occasionally do "gnats" congregate about the eyes and ears, although some areas in northern Peru and the Mato Grosso Region of Brazil apparently harbor localized noxious species.

The Chilean *Hippelates australis* was perhaps the most interesting of all species encountered. It is very strongly attracted to rotting egg bait and foodstuffs, but demonstrates only a weak attraction to mucous areas of the head. The density of *H. australis* seems to increase as one proceeds south of Santiago, until around Valdivia with 80+ in of rainfall. This is the only chloropid species that was ever observed to imbibe rotten egg bait directly. If a droplet were placed on a flat surface, scores of individuals would form a ring around it, extending a rather long proboscis that measured about 1/3 body length. They would then proceed to sponge (or suck) the droplet dry, like so many elephants around a water trough.

The predominant Uruguayan species, *Hippelates parviseta* (Mall.), had the habit of settling on one's arms and legs in small numbers not exceeding five individuals, but rarely reached the vicinity of the head. This species appears to be extremely tolerant of wind, and could be collected from the arms and legs and around rotting egg bait during brief intervals between wind gusts exceeding 15 mph. The attraction to rotting egg appeared to be quite passive, and there was no noticeable feeding on it.

In northern Uruguay and southern Brazil *Diplotoxa glabricollis* (Thomas) and *Hippelates annulatus* Enderlein had the curious habit of collecting in the small hollows of hoofprints made by wild pigs and range livestock around river banks. The region is characteristically swept by a light breeze that forces many small insects to seek refuge. Such was probably the case with these species that, in spite of the protection afforded by the hoofprint craters, still found it

Table 1. Diptera under 4 mm long attracted to rotten egg baits at diverse sites in the Americas, the Mediterranean area, and East Africa.

Locality & Sample Period	Family & Species	Relative Attraction to Baits (%)	Attraction Intensity baits	Attraction Intensity man
Jamaica				
Montego Bay				
June-Sept. 1963	Chloropidae			
	Conioscinella spp.	15.6	W	W
	Hippelates apicatus Malloch	4.2	W	W
	H. dorsalis Loew	0.3	W	M
	H. flavipes Loew	2.0	W	W
	H. peruanus Becker	3.3	W	O
	H. pusio Loew	51.6	S	M
	Hippelates nov. sp.	22.1	M	W
	Milichiidae			
	Desmometopa sp.	0.3	W	O
	Otitidae			
	Acrosticta apicalis (Williston)	0.3	W	O
	Phoridae			
	Genus sp. (?)	0.3	W	O
Discovery Bay				
June-Sept. 1963	Chloropidae			
	Conioscinella spp.	75.1	W	W
	Hippelates tibialis Duda	19.5	W	O
	Otitidae			
	Euxesta nov. sp.	5.4	W	O
Spanish Town				
June-Sept. 1963	Ceratopogonidae			
	Dasyhelea sp.	0.2	W	O
	Forcipomyia sp.	0.7	W	O
	Chloropidae			
	Conioscinella spp.	0.7	W	W
	Hippelates currani Aldrich	0.5	W	O
	H. dorsalis Lw.	3.4	W	O
	H. flavipes Lw.	4.4	W	W
	H. peruanus Beck.	1.0	W	O
	H. pusio Lw.	86.0	S	M
	Hippelates nov. sp.	0.7	W	O
	Ephydridae			
	Hydrellia sp.	0.5	W	O
	Milichiidae			
	Milichiella lacteipennis (Loew)	0.7	W	O
	Otitidae			
	Acrosticta apicalis (Williston)	0.5	W	O
	Sphaeroceridae			
	Leptocera sp.	0.7	W	O
May Pen				
June-Sept. 1963	Chloropidae			
	Hippelates peruanus Becker	3.0	W	O
	H. pusio Lw.	97.0	S	M

Locality & Sample Period	Family & Species	Relative Attraction to Baits (%)	Attraction Intensity baits	man
Yallas June-Sept. 1963	Chloropidae			
	· *Hippelates currani* Ald.	0.6	W	O
	· *H. flavipes* Lw.	3.0	W	M
	· *H. peruanus* Beck.	0.6	W	O
	· *H. pusio* Lw.	66.0	S	M
	· *Hippelates* nov. sp. (?)	3.6	W	O
	Milichiidae			
	Desmometopa tarsalis Loew	21.9	W	O
	Desmometopa sp.	2.5	W	O
	Milichiella lacteipennis (Lw.)	1.8	W	O
West Kingston June-Sept. 1963	Ceratopogonidae			
	Forcipomyia sp.	0 3	W	W
	Chloropidae			
	·*Conioscinella* sp.	0.9	W	O
	·*Hippelates apicatus* Mall.	0.6	W	O
	· *H. dorsalis* Lw.	0.3	W	M
	· *H. flavipes* Lw.	2.1	W	O
	· *H. peruanus* Beck.	2.1	W	O
	· *H. pusio* Lw.	91.3	S	M
	· *Hippelates* nov. sp. (?)	1.5	W	O
	Phoridae			
	Genus sp. (?)	0.3	W	O
	Sphaeroceridae			
	Leptocera sp.	0.6	W	O
Bermuda, W.I. Sept. 1963	Chloropidae			
	· *Hippelates pusio* Lw.	100.0	S	S
Puerto Rico Aguadilla March-Sept. 1963	Chloropidae			
	· *Hippelates flavipes* Lw.	57.0	M	W
	Empididae			
	Genus sp. (?)	14.4	W	O
	Milichiidae			
	Milichiella lacteipennis (Lw.)	28.6	W	O
Isabella March-Sept. 1963	Chloropidae			
	· *Conioscinella* sp.	2.0	W	O
	· *Hippelates dorsalis* Lw.	2.0	W	W
	· *H. flavipes* Lw.	8.2	W	W
	· *H. peruanus* Beck.	52.2	M	O
	. *H. proboscideus* Will.	1.0	W	O
	· *H. pusio* Lw.	29.6	M	M
	Chyromyidae			
	Aphaniosoma sp.	2.0	W	O
	Otitidae			
	Euxesta eluta Loew	3.0	W	O
Rio Piedras March-Sept. 1963	Milichiidae			
	Milichiella lacteipennis (Loew)	100.00	W	O
Caguas March-Sept. 1963	Chloropidae			
	·*Conioscinella* sp.	61.6	W	W
	· *Hippelates flavipes* Lw.	27.0	W	W
	· *Hippelates* nov. sp.	7.7	W	O
	Milichiidae			
	Milichiella lacteipennis (Loew)	3.7	W	O
Maricao March-Sept. 1963	Chloropidae			
	· *Conioscinella* sp.	17.7	W	O
	· *Hippelates peruanus* Becker	70.5	W	O
	Milichiidae			
	Desmometopa sp.	11.8	W	O
Aibonito	Milichiidae			
	Desmometopa sp.	20.0	W	O
	Milichiella lacteipennis (Loew)	80.0	W	O
Ponce March-Sept. 1963	Chloropidae			
	· *Hippelates flavipes* Lw.	13.2	M	W
	· *H. pusio* Lw.	78.2	S	M
	Milichiidae			
	Milichiella lacteipennis (Loew)	8.6	W	O
Yauco March-Sept. 1963	Chloropidae			
	· *Hippelates flavipes* Lw.	0.9	W	W
	· *H. peruanus* Becker	10.4	W	O
	· *H. pusio* Lw.	88.6	S	M
	· *H. tibialis* Duda	0.1	W	O
Lajas March-Sept. 1963	Chloropidae			
	· *Hippelates apicatus* Mall.	3.6	W	O
	· *H. currani* Aldrich	0.4	W	O
	· *H. flavipes* Loew	4.6	W	W
	·*H. lutzi* Curran	1.7	W	O
	· *H. peruanus* Beck.	9.6	W	O
	· *H. pusio* Loew	68.7	S	M
	Milichiidae			
	Milichiella lacteipennis (Loew)	11.4	W	O

Locality & Sample Period	Family & Species	Relative Attraction to Baits (%)	Attraction Intensity baits	Attraction Intensity man
Parguera March-Sept. 1963	Chloropidae			
	· *Hippelates apicatus* Mall.	5.0	W	O
	· *Hippelates* sp. nr. *brumpti* Seguy	6.0	W	O
	· *H. currani* Ald.	2.0	W	O
	· *H. pusio* Loew	32.0	S	M
	· *Hippelates* nov. sp.	8.0	W	O
	· *Cadrema pallida* (Lw.)	9.0	W	O
	· *Conioscinella tripunctata* (Curran)	4.0	W	O
	· *Conioscinella* sp.	5.0	W	O
	· *Oscinella* sp.	1.0	W	O
	Milichiidae			
	Milichiella lacteipennis (Loew)	12.0	W	O
	Sphaeroceridae			
	Leptocera sp.	16.0	W	O
Punta Arenas March-Sept. 1963	Chloropidae			
	· *Cadrema pallida* (Lw.)	6.9	W	O
	· *Conioscinella* sp.	6.9	W	O
	· *Hippelates peruanus* Becker	31.1	M	O
	· *H. pusio* Lw.	27.7	M	W
	· *Hippelates* nov. sp.	3.4	W	O
	Chyromyidae			
	Aphaniosoma sp.	6.9	W	O
	Milichiidae			
	Milichiella lacteipennis (Loew)	4.4	W	O
	Otitidae			
	Acrosticta apicalis (Williston)	5.4	W	O
	Trixoscelididae			
	Spilochroa ornata (Johnson)	7.3	W	O
Trinidad Cocos Bay Aug. 1963	Chloropidae			
	· *Hippelates currani* Ald.	0.6	W	O
	· *Hippelates* sp. nr. *dorsalis* Loew	1.3	W	O
	· *Hippelates* sp. nr. *femoralis* Duda	2.6	W	O
	· *H. flavipes* Loew	30.6	M	W
	· *H. peruanus* Beck.	21.2	W	O
	· *H. pusio* Lw. variety	37.8	M	W
	· *Hippelates* sp.	0.6	W	O
	· *Olcella* sp.	5.3	W	O
Curepe Aug. 1963	Chloropidae			
	· *Conioscinella* sp.	4.5	W	O
	· *Eugaurax quadrilineatus* (Williston)	4.5	W	O
	· *Hippelates flavipes* Lw.	32.0	M	W
	· *H. peruanus* Beck.	41.0	M	O
	· *Olcella* sp.	4.5	W	O
Curepe Aug. 1963	Milichiidae			
	Milichiella sp.	4.5	W	O
	Sepsidae			
	Palacosepsis sp.	4.5	W	O
	Sphaeroceridae			
	Leptocera sp.	4.5	W	O
Brazil Rio de Janeiro Jan. 1965	Ceratopogonidae			
	Atrichopogon sp.	5.3	W	O
	Bezzia sp.	5.3	W	O
	Chloropidae			
	· *Conioscinella incolumis* (Becker)	6.6	W	O
	· *Hippelates annulatus* End.	11.3	W	O
	· *H. flaviceps* (Loew)	6.3	W	O
	· *H. peruanus* Beck.	22.0	W	O
	· *Oscinella* sp.	7.3	W	W
	· *Pentanotaulax pubiseta* (Becker)	7.3	W	O
	Otitidae			
	Euxesta annonae (Fab.)	23.3	W	O
	Euxesta stigmatias Lw.	5.3	W	O
Chile Puerto Varas March 1965	Chloropidae			
	· *Hippelates australis* Sabrosky	99.0	S	M
	Sphaeroceridae			
	Leptocera sp.	1.0	W	O
Valdivia March 1965	Chloropidae			
	· *Hippelates australis* Sabrosky	95.8	S	M
	· *H. nigripes* Duda	4.2	W	O
Temuco March 1965	Chloropidae			
	· *Conioscinella inconstans* (Becker)	7.5	W	O
	· *Hippelates australis* Sabrosky	92.5	S	M
Uruguay San Jacinto Jan. March 1965	Agromyzidae			
	· Genus sp. (?)	0.9	W	O
	Chloropidae			
	· *Conioscinella* sp.	2.3	W	O
	· *Diplotoxa glabricollis* (Thomson)	10.8	W	O
	· *Elachiptera sacculicornis* (Enderlein)	1.9	W	O
	· *Hippelates parviseta* (Malloch)	64.9	W	W
	· *H. peruanus* Beck.	0.9	W	O
	· *Hippelates* sp. nr. *annulatus* Enderlein	12.7	W	O

Locality & Sample Period	Family & Species	Relative Attraction to Baits (%)	Attraction Intensity baits	man
Uruguay San Jacinto Jan.-March 1965				
	Chloropidae			
	· *Oscinella* sp.	0.9	W	O
	Dolichopodidae			
	Sympycnus nov. sp.	0.5	W	O
	Genus sp. (?)	0.5	W	O
	Milichiidae			
	Desmometopa flavicoxa Hendel	0.5	W	O
	Meoneura sp.	0.5	W	O
	Milichiella lacteipennis (Loew)	0.5	W	O
	Sciaridae			
	Bradysia sp.	0.5	W	O
	Sphaeroceridae			
	Leptocera spp.	0.9	W	O
Chuy Jan.-March 1965				
	Chloropidae			
	· *Conioscinella* sp.	1.9	W	O
	· *Diplotoxa glabricollis* (Thoms.)	22.3	W	O
	· *Hippelates* sp. nr. · *annulatus* End.	7.5	W	O
	· *Hippelates* spp.	5.6	W	O
	· *Lasiopleura* sp.	1.8	W	O
	Dolichopodidae			
	Genus sp. (?)	15.0	W	O
	Ephydridae			
	Genus sp. (?)	18.0	W	O
	Sphaeroceridae			
	Leptocera spp.	27.9	W	O
Peru Machu Picchu April 1965				
	Agromyzidae			
	· *Cerodontha* sp.	7.3	W	O
	Anthomyzidae			
	Mumetopia nov. sp.	11.0	W	O
	Stenomicra nov. sp.	4.0	W	O
	Chloropidae			
	· *Conioscinella* sp. nr. · *pleuralis* (Becker)	11.0	W	O
	· *Hippelates annulatus* End.	11.1	W	W
	· *Hippelates* nov. sp. nr. · *proboscideus* Will.	11.0	W	O
	· *Oscinella orbitalis* Duda	40.6	W	W
	· *Oscinella* sp.	4.0	W	O
Argentina Iquazu March 1965				
	Chloropidae			
	· *Conioscinella soluta* (Becker)	44.0	W	O
	· *Hippelates peruanus* Becker	52.0	W	W
	Milichiidae			
	Milichiella lacteipennis (Loew)	4.0	W	O
Costa Rica San Jose April-May 1965	Chloropidae			
	· *Hippelates pusio* Lw.	0.4	W	W
	· *H. tener* Coquillett	0.4	W	O
	· *Hippelates* sp. near · *dissidens* (Tucker)	69.1	W	W
	· *Oscinella orbitalis* (Duda)	25.6	W	O
	· *Siphonella* sp.	0.4	W	O
	Ephydridae			
	Genus sp. (?)	0.4	W	O
	Milichiidae			
	Desmometopa tarsalis Loew	0.4	W	O
	Milichiella lacteipennis (Loew)	3.3	W	O
Turrialba April-May 1965	Anthomyzidae			
	Mumetopia nov. sp. nr. *nigrimana* (Coquillett)	1.8	W	O
	Chloropidae			
	· *Hippelates flavipes* Lw.	7.3	W	W
	· *Monochaetoscinella anonyma* (Williston)	7.3	W	O
	· *Oscinella orbitalis* (Duda)	61.8	W	O
	· "*Oscinella*" *rubicunda* variety · *costaricana* (Duda)	1.8	W	O
	· *Oscinella* sp.	1.8	W	O
	· *Siphonella* sp.	3.6	W	O
	Milichiidae			
	Desmometopa tarsalis Loew	1.8	W	O
	Milichiella lacteipennis (Loew)	12.8	W	O
Mexico Tuxpan May 1965				
	Chloropidae			
	· *Conioscinella* spp.	21.1	W	O
	· *Elachiptera* sp.	5.2	W	O
	· *Hippelates pusio* Lw.	5.2	W	O
	· *Hippelates* sp. nr. · *antiguanus* Duda	21.0	W	O
	· *Monochaetoscinella anonyma* (Williston)	10.6	W	O
	· "*Oscinella*" *rubicunda* variety · *costaricana* (Duda)	31.7	W	O
	· *Oscinella* sp.	5.2	W	O
Yugoslavia Piran Oct. 1966	Chloropidae			
	· *Oscinella frit* (L.) complex	100.0	W	O
Italy Napoli Oct. 1966	Chloropidae			
	· *Oscinella frit* (L.) complex	100.0	W	O
Israel Tel-Aviv Nov. 1966	Chloropidae			
	· *Oscinella frit* (L.)	100.0	W	O

Locality & Sample Period	Family & Species	Relative Attraction to Baits (%)	Attraction Intensity baits	man
Jordan Valley				
Nov. 1966	Chloropidae			
	Oscinella aharonii Duda	100.0	M	M
Kenya				
Nairobi Park (water holes)				
Nov.-Dec. 1966	Chloropidae			
	Elachiptera vulgaris (Adams)	16.7	W	O
	Oscinella sp. near *dimidiofrit* Becker	83.3	W	O
Uganda				
Kawanda (forest-grass)				
Dec.-Jan. 1966-67				
	Chloropidae			
	Conioscinella sp.	1.1	W	O
	Elachiptera scapularis (Adams)	25.6	W	O
	E. vulgaris (Adams)	45.5	W	O
	Oscinella sp. near *dimidiofrit* Becker	18.9	W	O
	Tropidoscinis nov. sp.	8.9	W	O

W = weak (less than 10 individuals collected in 12 hours.)
M = medium (between 21 and 50 individuals in 24 hours.)
S = strong (more than 50 individuals in 24 hours.)
O = no attraction established.

necessary to cling to soil particles or risk being blown away.

In Costa Rica *Hippelates* sp. near *dissidens* (Tucker) occurred in exceptionally high numbers on the dry slopes of volcanoes near San Jose. One sweep with a net in the dry grass and duff often produced over 100 individuals. This species was unattracted to man and only weakly to egg bait. Similarly, *Oscinella frit* (L.) in Europe and the Middle East, and *Oscinella* sp. near *dimidiofrit* Becker in Africa were collected in great numbers in grass and duff, but showed no attraction to man and were only very weakly attracted to rotting egg.

The West Indian and South American *Hippelates peruanus* Decker never was attracted to humans although rotting egg afforded a weak to moderate attraction for it. Sweep net samples indicated that *H. peruanus* might occur at higher densities than revealed by the bait trap samples, similar to *H. hermsi* in southern California (Mulla, 1962).

None of the species collected in eastern Peru, northeastern Costa Rica nor southern Mexico demonstrated any salient characteristics during the observation periods that would distinguish them. Most of these species apparently did not possess even a casual relationship to humans and otherwise occurred at extremely low population densities.

Considerations for Competitive Displacement and Coexistence - Preceding the introduction of any competing species, the adult habits of the candidate species must be considered. Adults must necessarily be continuously inconspicuous in the presence of man and animals. Also, the larvae must be coincident with *H. collusor*, or other target species, in identical microhabitats and abundant enough so that there would be competition between them for available food. In southern California *H. hermsi* may already fill this capacity during a major portion of the year coexisting with *H. collusor* which is the anthropophilic species.

Table 2. Species of Diptera under 4 mm long attracted to rotten egg baits in southern California.

Family and Species	Attraction Intensity baits	man
Chloropidae		
Hippelates collusor (Townsend)	S	S
H. dorsalis Loew	W	M
H. pusio Loew	M	W
H. robertsoni Sabrosky	M	M
Siphonella punctifrons Becker	W	O
Chyromyidae		
Chyromya sp.	W	O
Drosophilidae		
Drosophila buscki Coquillett	W	O
Ephydridae		
Allotrichoma sp.	W	O
Milichiidae		
Meoneura polita Sabrosky	W	O
Milichiella lacteipennis (Loew)	W	O
Milichiella sp.	W	O
Muscidae		
Fannia sp.	W	O
Hydrotaea sp.	W	O
Otitidae		
Euxesta anna Harriot	W	O
Physiphora demandata (Fab.)	W	O
Phoridae		
Megaselia spp.	W	O
Sciaridae		
Bradysia sp.	W	O
Thyreophoridae		
Omomyia regularis Curran	W	O
Trixoscelididae		
Trixoscelis frontalis (Fallen)	W	O
T. signifera Melander	W	O
Trixoscelis sp.	W	O

W = weak (less than 10 individuals collected in 12 hours.)
M = medium (between 21 and 50 individuals in 24 hours.)
S = strong (more than 50 individuals in 24 hours.)
O = no attraction established.

Among the various species of chloropids observed in the present study, several might be considered for further investigation into the possibilities for competitive displacement and/or coexistence. Of the foreign species, only *H. pusio* in Bermuda demonstrated the same degree of aggressiveness characteristic of our native *H. collusor*, *H. impressus*, (and occasionally *H. dorsalis*). Known foreign species that might best compete with *H. collusor* during periods of hot weather and which are relatively innocuous themselves are *H. annulatus*, *H. parviseta*, *H. peruanus*, and *Diplotoxa glabricollis* in South America, and strains of *Oscinella frit* in the Mediterranean area and *Oscinella* sp. near *dimidiofrit* in East Africa. Any consideration of the last two species would, however, have to take into account their potential as pests of grain in California.

Secondary considerations in which the adult gnats are moderately annoying are *H. flavipes* of the West Indies and *Oscinella aharonii* of the Middle East. *Hippelates australis* Chile, although innocuous compared to our native pestiferous species, shows a preference for cool and wet conditions, and therefore, could potentially compete with *H. impressus* and *H. robertsoni* in California.

Other species listed in Table I were apparently too scarce in each respective locality to merit serious consideration for competitive displacement, or their role in competition is doubtful (e.g. Otitidae, Milichiidae, etc.).

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THE INTRODUCTION OF NATURAL ENEMIES IN CALIFORNIA FOR THE BIOLOGICAL CONTROL OF NOXIOUS FLIES AND GNATS

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Pestiferous soil-breeding chloropid eye gnats and species of flies in the families Muscidae, Calliphoridae and Sarcophagidae breeding in stockpiled animal excrement have been considered as targets for biological control in California since 1962. Through 1968 the species of special concern were *Hippelates collusor* (Townsend), *H. impressus* Becker, *H. pusio* Loew, and *H. robertsoni* Sabrosky in the Chloropidae; *Musca domestica* L., *Stomoxys calcitrans* L., *Fannia canicularis* L., and *F. femoralis* Stein in the Muscidae, and *Phaenicia* and *Sarcophaga* species in the Calliphoridae and Sarcophagidae, respectively. Species of *Muscina*, *Ophyra* and *Fannia scalaris* (F.) were of limited concern.

Continuing studies begun in 1962 are to determine the biotic complexes already associated with each of these target pests in California, and to evaluate the relative importance of each constituent in the dynamics of regulation. Coincident with these domestic studies, foreign exploration for additional natural enemies of the same and related host species over a major portion of their known range in both the Eastern and Western Hemispheres has been conducted. This report documents progress of these studies and the importation program into California to the present.

Collection Methods

Natural enemies of chloropids were extracted from larval and pupal habitats by artificially exposing their developmental stages therein and by direct observation of their activity (Bay et al., 1964; Legner and Bay, 1965; Legner et al., 1966; Legner and Bay, 1964). Natural enemies of flies in stockpiled animal excrement were extracted by water-flotation and by direct egg, larval and pupal collections (Legner, 1965; Legner et al., 1967).

Discussion

Natural Enemy Species Present in California - Domestic studies have revealed the presence of a considerable array of predatory and parasitic natural enemies of these various