

New Immigrant Insects in Hawaii: 1962 through 1976^{1,2}

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In December 1961, I delivered a presidential address before this Society which was titled "On Accidental Immigration and Establishment of Terrestrial Arthropods in Hawaii During Recent Years" (Beardsley, 1962). In it I reviewed and analyzed accidental insect immigration into Hawaii for the 25 year period of 1937 through 1961. I thought that this time around it might be of interest to review the same subject for the 15 year period since my earlier presentation, and to again analyze our accidental immigrants in an attempt to determine whether or not trends which were indicated in 1961 have continued, and if the inferences which were drawn then have been substantiated.

The data on which these remarks are based are contained largely in the Proceedings of this Society, mostly in the Notes and Exhibitions sections. The annual lists of new immigrant species contained in the "Proceedings" were a valuable starting point, but they do contain occasional errors and quite a few omissions. Omissions have resulted because not all new immigrant records for Hawaii are reported in the Notes and Exhibitions. Quite a few new records appear only in submitted papers published in the "Proceedings," or occasionally, in other journals (e.g.: Pacific Insects). I have attempted to include all such records which have come to my attention. I would like to urge all of you who either publish or find records of immigrant insects or other terrestrial invertebrates new to Hawaii in other journals to submit notes on these organisms for inclusion in this Society's "Proceedings." By so doing you will help to make a more complete and readily accessible record available for Hawaiian entomologists.

It has not always been possible to determine if a published name represented a new record for Hawaii. For example, a recent paper on Hawaiian Staphylinidae (Moore, 1975) contains a number of names new to Hawaiian literature. Unfortunately the author did not attempt to relate these names to previously published records of Hawaiian staphylinids. Therefore it was not possible to determine, without expending more time than I could afford, whether these names represented new records or merely name changes for species long established in Hawaii. The clarification of the status of such names must await more thorough taxonomic reviews of the groups concerned. I have omitted all such doubtful species from consideration here. Also omitted were records of species collected only once in Hawaii, as well as those records based solely on quarantine interceptions of material presumed to have originated in Hawaii. Records of these sorts may not represent permanently established species. For these reasons, the numbers of new immigrants presented in Table I are probably lower than the true totals.

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TABLE 1. *Number of New Accidental Immigrant Arthropod Species Reported in Hawaii: 1962-1976.*

YEAR	NUMBER REPORTED	YEAR	NUMBER REPORTED		
1962	10	1970	21		
1963	12	1971	24		
1964	24	1972	11		
1965	20	1973	25		
1966	20	1974	28		
1967	11	1975	24		
1968	15	1976	25		
1969	17				
1962-69	Total	129	1970-76	Total	158
1962-69	Average	16.1	1970-76	Average	22.6
1962-76	Total	287	1962-76	Average	19.1

TABLE 2. *New Accidental Immigrants by Major Taxonomic Categories 1937-61 vs. 1962-76.*

TAXON	1937-61	1962-76
INSECTA		
Collembola	0	2
Ephemeroptera	1	0
Odonata	0	1
Orthoptera (sens. lat.)	6	6
Dermaptera	0	1
Psocoptera	1	1
Mallophaga	6	1
Anoplura	6	2
Thysanoptera	27	5
Homoptera	42	49
Heteroptera	10	25
Neuroptera	2	0
Coleoptera	57	45
Trichoptera	1	2
Lepidoptera	25	25
Diptera	95	45
Hymenoptera	66	58
ARACHNIDA		
Acarina	35	14
Araneida	24*	3*
OTHER ARTHROPODA		
	6	2
TOTALS	410	287

*Suman (1964) reported 17 introduced or probably introduced spiders new to Hawaii, only three of which were collected for the first time after 1961.

TABLE 3. *Numbers of Accidental Immigrants in Taxonomic Groups with Species Mostly of at Least Moderate Size or of Economic Importance.*

TAXON	1937-1961	1962-1976
ORTHOPTERA	6	6
HOMOPTERA		
Aleyrodidae	2	6
Aphidoidea	17	16
Cicadellidae	6	6
Fulgoroidea	2	3
Membracidae	1	1
Psyllidae	1	2
TOTAL	29	33
HETEROPTERA		
Coreoidea	1	1
Cydnidae	0	2
Lygaeidae	1	6
Miridae	2	2
Pentatomidae	1	4
Plataspidae	0	1
Reduviidae	3	4
Tingidae	1	1
TOTAL	9	21
LEPIDOPTERA		
Geometridae	1	2
Hesperiidae	0	2
Noctuidae	13	10
Papilionidae	0	1
Pyrilidae	1	1
Sphingidae	0	3
Tortricoidea	1	1
TOTAL	16	20
COLEOPTERA		
Anthribidae	3	1
Carabidae	3	5
Cerambycidae	1	1
Chrysomelidae	1	0
Coccinellidae	0	2
Curculionidae	10	2
Dermestidae	3	3
Elateridae	1	4
Scarabaeidae	1	3
Scolytidae	7	6
TOTAL	30	27
DIPTERA		
Agromyzidae	5	1
Calliphoridae	1	3
Culicidae	0	1
Drosophilidae	7	3
Muscidae	5	2
Sarcophagidae	5	0
Tachinidae	1	3
Tephritidae	1	2
TOTAL	25	15

TABLE 3 (Cont.).

TAXON	1937-1961	1962-1976
HYMENOPTERA		
Apoidea	3	0
Braconidae	7	6
Ichneumonidae	4	5
Pompilidae	1	2
Sphecidae	9	3
Tenthredinidae	0	1
Vespidae	4	2
TOTAL	30	19
GRAND TOTAL	145	141

Rate of Accidental Immigration and Establishment

In 1961 I calculated that the average rate of accidental introduction and establishment of exotic terrestrial arthropods in Hawaii during the period 1937-1961 was approximately 16 species per year. Based upon the published and manuscript records of new introductions during the past 15 years, including those reported today, we have averaged a fraction more than 19 species per year during this period. This indicates a slight increase for the rate during the past 15 years, over that of the previous 25 years. The trend toward an increasing rate of accidental introductions seems even more apparent when we examine the actual numbers of immigrants reported during each year of this period (Table 1). During the first 8 years the average was almost exactly 16 species per year, or virtually no change from the average of the previous 25 years. However, during the past 7 years (1970 through 1976) an average of 22.6 new exotic species were discovered each year. These figures suggest that during the past few years there has been a definite increase in the rate at which new immigrants are becoming established.

The taxonomic distribution, by order, of the 287 new immigrants which have been discovered since 1961, is compared in Table 2 with that of the immigrants discovered during the previous 25 years (1937-1961). As would be expected, it is the larger more advanced orders of insects which continue to account for the great majority of new accidental introductions.

Returning to the rate of immigration, one question which might be asked about these data is whether they represent an actual increase in the annual rate of accidental introduction, or are merely the result of more diligent collecting that has turned up minute and cyptic species which may have been here for many years. I have no doubt that careful collecting by specialists in groups such as scale insects, microhymenoptera, microlepidoptera and acalypterate Diptera has resulted in the discovery of a number of immigrants in these groups which have long been present in Hawaii. However, it is likely that other such inconspicuous forms have become established during the past 15 years which have not yet been discovered, or at least not yet identified and reported.

Perhaps a better comparison between the rates of introduction during 1937-61 and 1962-76 could be obtained by comparing those taxonomic groups which contain larger, more obvious insects, and those which are of some direct economic significance. Species in such groups seem most likely to be discovered within a short time after they have become established in Hawaii. In Table 3 I have compared the numbers of immigrants in such conspicuous taxonomic groups which were col-

TABLE 4. Comparison of Direction of Origin of Immigrants in Certain Taxonomic Groups During 1937-61 and 1962-76.

TAXONOMIC GROUP	Total number of species considered		Direction of Origin					
			EAST		WEST		UNDETERMINED	
	1937-61	1962-76	1937-61	1962-76	1937-61	1962-76	1937-61	1962-76
ORTHOPTERA	6	6	1	3	4	3	1	0
HOMOPTERA (Auchenorrhyncha)	10	10	8	7	1	3	1	0
HETEROPTERA	10	25	3	8	4	13	3	4
HYMENOPTERA (Aculeata)	17	7	7	2	10	4	0	1
LEPIDOPTERA—Noctuidae	13	10	3	1	8	7	2	2
LEPIDOPTERA—Sphingidae	0	3	0	0	0	3	0	0
LEPIDOPTERA—Rhopalocera	0	3	0	1	0	2	0	0
TOTALS	56	64	22	22	27	35	7	7

TABLE 5. *New Pests and Potential Pests Established in Hawaii During the Period 1962-1976.*

TAXON	YEAR DISCOVERED
ORTHOPTERA	
Locustidae	
<i>Oedaleus abruptus</i> (Thurnberg)	1968
* <i>Schistocerca nitens nitens</i> (Thurnberg)	1964
<i>Trimerotropis pallidipennis</i> (Burmeister)	1966
Tettigoniidae	
<i>Euconocephalus nasutus</i> (Thurnberg)	1968
DERMAPTERA	
* <i>Forficula auricularia</i> L.	1975
HOMOPTERA	
Aleyrodidae	
* <i>Aleurocanthus spiniferus</i> (Quaintance)	1974
* <i>Dialeurodes citrifolii</i> (Morgan)	1966
<i>Odontaleyrodes rhododendri</i> (Takahashi)	1976
* <i>Orchamoplatus mammaeferus</i> (Quaintance and Baker)	1976
<i>Paraleyrodes naranjiae</i> Dozier	1976
<i>Paraleyrodes perseae</i> (Quaintance)	1969
Aphidoidea	
<i>Acyrtosiphon malvae</i> (Mosley)	1974
* <i>Aphis citricola</i> vander Goot	1965
* <i>Aphis nerii</i> Boyer de Fonscolombe	1965
<i>Aphis oenotherae</i> Oestlund	1964
<i>Aphis oestlundii</i> Gillette	1973
<i>Cinara atlantica</i> (Wilson)	1962
<i>Cinera fresai</i> Blanchard	1964
<i>Dactynotus pseudambrosia</i> Olive	1973
<i>Dactynotus sonchi</i> (Geoffroy)	1975
<i>Dysaphis tulipae</i> Boyer de Fonscolombe	1965
<i>Eulachnus</i> sp.	1973
<i>Nansonovia ribisonigri</i> Mosley	1964
* <i>Pemphigus</i> sp.	1971
* <i>Pineus pini</i> Koch	1970
* <i>Therioaphis maculata</i> (Buckton)	1975
<i>Whalgreniella nervata</i> (Gillette)	1966
Asterolecaniidae	
<i>Asterolecanium pseudomiliaris</i> Green	1976
<i>Asterolecanium robustum</i> (Green)	1964
Cicadellidae	
<i>Balclutha rufofasciata</i> (Mereno)	1975
<i>Carneocephala saggittifera</i> (Uhler)	1972
* <i>Empoasca stevensi</i> Young	1969
<i>Graphocephala cythura</i> Baker	1972
<i>Spanbergiella quadripunctata</i> Lawson	1976
<i>Zygina penapacha</i> Beamer	1974
Delphacidae	
<i>Sardia pluto</i> (Kirkaldy)	1976
Derbidae	
<i>Lamenia caliginea</i> (Stål)	1971
Diaspididae	
<i>Andaspis punicae</i> (Laing)	1965
* <i>Aspidiotus destructor</i> Signoret	1968
<i>Clavaspis herculeana</i> (Doane & Hadden)	1963
<i>Furchadaspis zamiae</i> (Morgan)	1976

TABLE 5 (Cont.).

TAXON	YEAR DISCOVERED
<i>Kuwanaspis vermiformis</i> (Takahashi)	1962
<i>Lepidosaphes araucariae</i> Beardsley	1964
<i>Lepidosaphes pini</i> (Maskell)	1971
* <i>Melanaspis bromeliae</i> (Leonardi)	1966
<i>Parlatoria fluggeae</i> (Hall)	1970
<i>Parlatoriopsis</i> sp.	1970
Flatidae	
* <i>Melormenis antillarum</i> Kirkaldy	1970
Membracidae	
* <i>Antianthe expansa</i> (Germar)	1971
Ortheziidae	
* <i>Arctorthezia occidentalis</i> (Douglas)	1962
<i>Nipponorthezia guadalcanalia</i> Morrison	1965
Pseudococcidae	
* <i>Brevennia rehi</i> (Lindinger)	1975
Psyllidae	
<i>Heteropsylla</i> sp.	1975
* <i>Psylla uncatoides</i> (Ferris and Klyver)	1966
HETEROPTERA	
Corizidae	
<i>Jadera haematoloma</i> (Herrich-Schaeffer)	1968
Lygaeidae	
<i>Neocoryphus bicrucis</i> (Say)	1971
* <i>Nysius caledoniae</i> Distant	1964
* <i>Nysius</i> sp., near <i>vinitor</i> Bergroth	1970
Miridae	
<i>Stenotus</i> sp.	1974
<i>Trigonotylus doddi</i> (Distant)	1975
Plataspidae	
* <i>Coptosoma xanthogramma</i> (White)	1965
Pentatomidae	
<i>Eysacoris ventralis</i> (Westwood)	1972
<i>Plautia stali</i> Scott	1968
<i>Thyanta accerra</i> McAtee	1965
Tingidae	
* <i>Stephanitis pyrioides</i> (Scott)	1976
THYSANOPTERA	
* <i>Gynaikothrips ficorum</i> (Marchal)	1964
MALLOPHAGA	
<i>Trinoton querquidule</i> (L.)	1966
ANOPLURA	
<i>Haematopinus quadripertusus</i> (Fahrenholz)	1963
<i>Linognathus vituli</i> L.	1965
COLEOPTERA	
Bruchidae	
<i>Callosobruchus pulcher</i> Pic	1973
Cerambycidae	
* <i>Phoracantha semipunctata</i> (Fabricius)	1965
Curculionidae	
* <i>Orthorhinus klugi</i> Bohoman	1965
* <i>Otiiorhynchus sulcatus</i> (Fabricius)	1976
Dermeestidae	
<i>Trogoderma inclusum</i> Le Conte	1969
Elateridae	
* <i>Conoderus amplicollis</i> (Gyllenhal)	1975

TABLE 5 (Cont.).

TAXON	YEAR DISCOVERED
LEPIDOPTERA	
Geometridae	
* <i>Cosymbia serrulata</i> (Packard)	1964
* <i>Semiothisa santaremaria</i> (Walker)	1970
Glyphipterigidae	
<i>Imma mylias</i> Meyrick	1975
Gracillariidae	
* <i>Caloptilia azaleella</i> (Brants)	1973
Hesperiidae	
* <i>Erionota thrax</i> L.	1975
* <i>Hylephilia phyleus</i> Drury	1970
Lyonetiidae	
* <i>Buccalatrix thurberiella</i> Busck	1973
Noctuidae	
* <i>Anomis flava</i> (Fabricius)	1964
<i>Anua indiscriminata</i> (Hampson)	1974
* <i>Bombotelia jocosatrix</i> Guenée	1968
* <i>Callopietria</i> sp.	1971
* <i>Leucania loreyi</i> (Duponchel)	1975
<i>Leucania striata</i> (Walker)	1969
* <i>Melipotis indomita</i> (Walker)	
<i>Pandesma anysa</i> (Guenée)	1975
* <i>Pericyma cruegeri</i> (Butler)	1971
* <i>Phlegetonia delatrix</i> (Guenée)	1964
Papilionidae	
* <i>Papilio xuthus</i> L.	1971
Phaloniidae	
* <i>Lorita abornana</i> Busck	1974
Pyalidae	
* <i>Herpetogramma licarsisalis</i> (Walker)	1967
Sphingidae	
* <i>Deilephia nerii</i> (L.)	1974
<i>Macroglossum pyrhostictum</i> (Butler)	1976
* <i>Theretra nessus</i> (Drury)	1974
DIPTERA	
Agronyzidae	
* <i>Ophiomyia phaseoli</i> (Tryon)	1968
Culicidae	
* <i>Aedes vexans nocturnus</i> (Theobald)	1962
Muscidae	
* <i>Atheregona reversura</i> Villeneuve	1974
HYMENOPTERA	
Tenthredinidae	
* <i>Cladius difformis</i> (Panzer)	1973
Vespidae	
* <i>Vespula vulgaris</i> (L.)	1973
ACARINA	
<i>Aceria aloinis</i> (Keifer)	1966
* <i>Aceria neocynodonis</i> Keifer	1966
<i>Eriophyes gardeniella</i> Keifer	1962
* <i>Ornithonyssus sylviarum</i> (Canestrini & Gonzago)	1965
MOLLUSCA	
* <i>Helix aspersa</i> Muller	1976

*Pests known to be of at least minor economic significance in Hawaii or elsewhere.

lected here for the first time during the two time periods under consideration. Species collected here only once and those collected prior to 1937 but not reported until after 1936, have been omitted. It is obvious that if we consider only the taxonomic groups listed, there were nearly as many accidental immigrants which became established during the 15 year period 1962-76, as there were during the previous 25 years; many more than the expected 3/5 ratio. My conclusion, based upon these data, is that the rate of accidental introduction and establishment of exotic insects in Hawaii during the past 15 years has been substantially greater than during the previous 25 years, and that this is particularly true for the past seven years, beginning in 1970.

Another question which might be raised is whether the present high rate of accidental introduction of insects into Hawaii represents a permanent trend, or does it merely reflect unusual wartime and immediate postwar conditions associated with the Viet Nam conflict? There was such an upsurge in accidental introductions beginning the latter part of World War II, and extending through the Korean War to about 1956, when the rate slackened somewhat. Possibly the upsurge in accidental immigrants which has occurred during the past few years is also a temporary one, and perhaps we shall see a decrease in the rate during the next few years. However, I believe that there are still a wide selection of unexploited or underexploited ecological niches in Hawaii, particularly within our man-altered urban, suburban, agricultural, and disturbed (exotic) forest ecosystems. There also exist, throughout the tropics and subtropics of the rest of the world, a vast array of insects and related arthropods which have the potential to exploit these niches if and when we provide the opportunity for them to do so. It is well to remember that a single gravid female, if she can find the proper environment for her progeny, may be all that is necessary to establish a new immigrant species in Hawaii. I believe it is quite possible that the arrival of single hitch-hiking females of such large, strong-flying insects as most Macrolepidoptera, for example, can result in the establishment of a species here. Modern jet aircraft with large passenger cabins and cargo holds, and large sealed freight containers, which arrive by both surface and air, probably bring in many such hitchhiking insects which escape detection upon arrival. I believe that we will continue to have an influx of new species in such groups as the noctuid moths, for example, which seem to be well adapted for spread by such means.

I believe, also, that we have ample evidence that new pests are still arriving here on living plant material smuggled into Hawaii from overseas. For example, the six species of Aleyrodidae which have become established here during the past ten years all are associated with ornamental plants or fruit trees, and could hardly have become established here except by being carried in on living plant material.

Origin of Accidental Immigrants

In 1961 I determined the direction of origin of immigrants in certain taxonomic groups in which the origin of the species usually could be fixed from published distributional data. The direction of origin was considered as either "east" (i.e.: from the New World), "west" (from elsewhere than the New World, generally from areas of the south and western Pacific, and southeast Asia), or "undetermined" (cosmopolitan species or those whose origin could not be fixed). It was shown that, for the groups considered, slightly more species had originated from the west than from the New World. In Table 4 the species in these taxonomic groups (plus two additional groups of Macrolepidoptera not previously represented) which arrived here during the period of 1962-1976 are similarly analyzed and compared with the 1937-1961 arrivals. These data indicate that in these taxonomic groups there is again

a slight preponderance of species from the west. The conclusion drawn in my earlier paper, that this is probably due mostly to greater similarities in climate and vegetation between Hawaii and most parts of the western and south Pacific than is the case with most of North America, still appears to be a valid one.

A further question which needs to be addressed is whether it is possible or feasible to improve quarantine regulations and their enforcement enough to reduce the rate at which new pests are becoming established in Hawaii. Not all accidental introductions are pests; many seem to be of little or no consequence, while a few are actually beneficial natural enemies of pests. However, it seems apparent from the list of significant and potentially significant new pests which have arrived here since 1961 (Table 5) that we have continued to receive new pests virtually every year. That no new serious arthropod pests of our two major export crops, sugar and pineapple, have become established here in more than 60 years is indeed fortunate; but how long will our luck hold?

It appears likely that an attempt will be made within the next few years to eradicate the three major tephritid fruit fly pest species from Hawaii. Assuming that this project is undertaken and successfully concluded, will it be possible to prevent the reinfestation of the state by one or more of these species from overseas sources? Both the Oriental fruit fly and the melon fly are widespread in tropical and subtropical areas of the western Pacific and southeast Asia. Can we successfully prevent gravid female flies or infested fruit from entering Hawaii and re-establishing these species? Unless quarantine enforcement and carrier disinsectization can be considerably enhanced, I believe that we would stand a good chance of re-infestation by one or the other of these species within a relatively short time following eradication; say, within ten years.

Two measures which I would recommend to reduce the influx of foreign insect pests into Hawaii are: 1) the reinstatement of routine thorough disinsectization of all aircraft and freight containers arriving from overseas, and 2) the enhancement of federal and state quarantine regulation enforcement through the provision of additional personnel and operations funds. Realistically, in view of the present tight fiscal constraints at both the federal and state levels, as well as the prevailing desire to avoid inconveniencing tourists or shippers in any way lest they take their business elsewhere, I do not foresee either of these recommendations being implemented during the immediate future.

Therefore, I feel confident that we entomologists can look forward to the continued influx of new immigrant insects into Hawaii. Which species will arrive and when is anybody's guess, but I strongly doubt that we will see any diminution in the rate at which new pests appear in Hawaii during the next several decades. The bright side of the picture, for us at least, is that new pests mean new pest control problems, and a continuing need for entomologists to combat them. Therefore, fellow entomologists, take heart; those pestiferous insects waiting just over the horizon for a trip to Hawaii may be our future job security.

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