THE IMMIGRATION OF INSECTS TO FLORIDA,
WITH A TABULATION OF RECORDS PUBLISHED SINCE 1970

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ABSTRACT

A table is presented of the recent (published since 1970) records of presence of exotic insects in Florida. The table includes 271 species, 209 of which were first collected in Florida after 1970. We assumed that these insects are immigrants, and we calculated mean rates of 7.7 and 12.0 immigrations per year in the 1970s and 1980s, respectively. We judge that about 20 recent immigrants are, or could become, major pests in Florida. At least 8% of the species appear to have arrived as stowaways, and many of the actual or potential major pests are among them. Immigrant species are not equitably distributed among orders or among families within orders. Species in the orders Lepidoptera and Coleoptera are especially well-represented. By far the largest proportion of recent insect immigrants to Florida comes from the Neotropical region. Our results suggest further information that is needed to answer questions about the invasibility of Florida.

RESUMEN

Se presenta una tabla con los registros recientes (publicados desde 1970) de la presencia de insectos exóticos en Florida. Esta tabla incluye 271 especies, 209 de las cuales fueron colectadas por primera vez en Florida después de 1970. Asumimos que estos insectos son migrantes y hemos calculado las tasas promedio entre 7.7 a 12.0 migraciones por año en las décadas de 1970 y 1980, respectivamente. Juzgamos que cerca de 20 migrantes recientes, son o pueden volverse, las mayores plagas en Florida. Al menos 8% de las especies parecen haber arribado como polinizadores, y muchas de las plagas mayores, actuales y potenciales se encuentran en este porcentaje. Las especies migrantes no están distribuidas equitativamente entre órdenes o entre familias en cada orden. Las especies del orden Lepidoptera están bien representadas. Una mayor proporción de insectos migrantes a Florida proviene de la región del Neotrópico. Nuestros resultados sugieren que se necesita una mayor información para contestar preguntas sobre esta invasión de plagas a Florida.

The recent (documented since 1970) records of immigration of insect taxa to Florida have not been tabulated previously. Here, we provide such a tabulation. The value of this exercise is to discover patterns that may provide insight into the processes of immigration, colonization, and local extinction by insects of diverse behaviors (cf. Sailer 1983, Simberloff 1986). This is the behavioral ecology of invasion.
What is an immigrant insect?

Whitehead & Wheeler (1990), despite the anthropocentric nature of the concept, decided that for practical reasons they could define a native insect species as one mentioned (as native) in early literature. Conversely, an immigrant insect species is one whose arrival is detectable now by lack of mention of it in early literature, but mention of it in later literature. The earliest collection date of museum-preserved specimens of a species might be used as the date of immigration for species thought to have immigrated.

We accept that Whitehead & Wheeler's (1990) method is reasonable for detection of immigration of pests (such as mosquitoes, mealybugs, scale insects, and whiteflies) and groups with popular appeal (such as butterflies). We also accept that it may be useful generally in the northeastern part of North America, where insect faunal lists were reasonably complete in the nineteenth century, and where immigrant insects have come from other, distant, continents. We have no confidence, however, that its application in Florida, especially southern Florida, will distinguish new immigrants, mainly from the nearby Neotropics, from those that have occupied Florida for hundreds or even thousands of years. We believe this conclusion will be especially true among species of little economic concern or popular appeal. One major difficulty is that lists and other knowledge of the insect fauna of Florida still are fragmentary. As is evident from our tabulation (see below), there is a lag time between discovery of specimens of an unrecorded species and mention of the discovery in the literature. For species of neither economic concern nor popular appeal, this lag may exceed 100 years (see, for example, Conoderus rufidens).

We have no easy solution to these problems. For most Neotropical insect species for which Florida is now part of their range, we cannot tell whether the founding members of Florida populations arrived 100 or 1,000 years ago, or indeed whether immigration and colonization took place intermittently over the past several thousands of years. [Although Deyrup at al. (1988) and Deyrup (in press) attempted to distinguish between new immigrants and old-established immigrants (among ants of the Florida Keys), no generally applicable method for the purpose has emerged, so we have not tried to emulate their example among the immigrants that we discuss. We invite readers to use our data to develop generally-applicable methods.] Answers to some of the questions demand more complete knowledge of the systematics and distribution of insects, especially for the more obscure groups, in Florida and the Greater Antilles, especially Cuba. Such studies are progressing, although slowly, and with regrettably poor contact between entomologists in Cuba and Florida. Answers to others of the questions demand comparative studies of the geneties of populations of such insects in Florida and the Greater Antilles, as well as measurement of overseas dispersal by use of traps at sea. We have no knowledge that such studies are in progress.

Methods

To construct our tabulation of immigrants, we searched published records (of presence of exotic insects in Florida), and then verified the resulting list of records by consulting authorities on the taxa included. We believe that our procedure has produced a reasonably-thorough tabulation but, of course, we cannot guarantee its completeness. We chose in advance to exclude four kinds of records from our tabulation: (1) those involving introductions (sensu Frank & McCoy 1990); (2) those published before 1971 (to make the task manageable); (3) those of species thought to be native to North America, north of Mexico, even if that part of their range is small (again, to make the task manageable); and (4) those of species we dubbed "taxonomic immigrants" - species whose "immigration" to Florida was a result of improper identification. Examples of the second kind of record
are two moths, *Eulepidotis metamorpha* Dyar and *Metalectra geminicincta* Schaus, that were reported in 1991 as new to Florida (Dickle 1991), and would have been included in our tabulation had they not, in fact, been reported prior to 1971. An example of the third kind of record is an ant, *Pseudomyrmex mexicanus* Roger, found ca. 1960 (Whitecomb et al. 1972) which would have been included in our tabulation if Texas had not been part of its native range. Examples of the fourth kind of record follow.

A cockroach determined as *Lechiptoptera bergrothi* (Griffini) later proved to have been misidentified (Atkinson et al. 1990b). A coccinellid determined as *Azya luteipes* Mulsant was found in 1975, but later it proved to be *A. orbignyana* Mulsant (Woodruff & Sailer 1977, Gordon 1985). A weevil determined as *Anthonomus flavus* Boheman was found in 1972 (Stegmaier & Burke 1974, Mead 1976a), but later it proved to be an undescribed species, *A. malpighiae* Clark & Burke, believed to be native to Florida (Clark & Burke 1985). A weevil, *Cyrtobagous salviniae* Calder & Sands, was described from South America, but part of the type series was from Florida (Calder & Sands 1985); Florida specimens collected before 1966 had been misidentified as *C. singularis* Hustache, a name which should thus be removed from Florida lists (Kissing 1966).

A scarab thought initially to be *Atoenius brevinsetus* Chapin was described later as a new species, *A. sciturus* Cartwright, with type locality in Florida (Woodruff 1975, Cartwright 1974). A scolytid found in 1986 and determined as being near to *Arapatus accinctus* Wood was identified later as *A. dentifrons* Wood (O'driscoll & Atkinson 1987, Atkinson et al. 1991). A moth described as *Lymphomyza navajo*秀 (Atkinson et al. 1991). Mealybugs collected in the early 1960s and mentioned in Tri-Ology as *Rhizoecus cacticus* Hambleton and *R. leucosomus* (Cookerell) were respectively *R. simplex* (Hambleton) and *R. acaticans* (Hambleton 1973). A moth reported as *Emperagruma pulchrum* (Burt) was identified later as *E. affinis* Rothchild. A butterfly reported as *Anartia lytra* (Godart) (Anderson 1974) was later identified as *A. chrysopelea* Hubner. A thrips determined as *Scirtothrips citri* (Moulton) later was found to be not that species but still has not been identified, although it is believed to be of exotic origin (Flowers 1989).

Doubtless, all or almost all of the 70 species of immigrant insects reported from northeastern North America by Hoebeke & Wheeler (1983) entered the continent as stowaways. The list of immigrant insects reported for Florida (Table 1) does not so readily reveal which species arrived as stowaways and which by other means, such as flight, wind dispersal, or rafting. One way of attempting to distinguish is to assume that all immigrant species reported for Florida whose names occur on the USDA-APHIS list of interceptions managed to arrive in Florida as stowaways. [Insects discovered on imported plants and plant materials at U.S. seaports and airports by USDA-APHIS inspectors are treated as pests and are recorded and destroyed. This is done under the Plant Quarantine and Plant Pest Acts to protect agriculture, horticulture, and other human interests from damage by exotic insects (Sailer 1978, 1983). USDA-APHIS publishes annually an impressively long list of insects thus intercepted.] We used this assumption with the fiscal year 1980 list of > 18,000 interceptions (PITSS 1982) and annotated our list of immigrant insects accordingly with the letters "PS" to indicate a potential stowaway.

**RESULTS**

Table 1 includes 271 exotic species, 209 of which were first collected in Florida after 1970. (Note that year of collection was not stated for a number of species which we reduced to 15 by questioning authorities.) Thirteen orders of insects are represented in our tabulation. Seven orders, Coleoptera, Diptera, Hemiptera, Homoptera, Hymenoptera, Lepidoptera, and Thysanoptera, together account for more than 90% of the immigrant species. This result is not surprising, as these seven include the most species-rich
TABLE 1. RECENT RECORDS OF INSECT SPECIES IMMIGRATING TO FLORIDA. THE TABULATION HAS 20 NAMES IN BOLD; THIS IS A SOMEWHAT ARBITRARY CONCEPT OF WHICH ARE, OR ARE LIKELY TO BE, THE WORST PESTS BASED UPON DAMAGE THEY CAUSE IN FLORIDA OR ELSEWHERE.

**BLATTARIA: BLATTELLIDAE**

*Blattella asahinai* Mizukubo, found in 1986, from Asia, named "Asian cockroach" (Roth 1986, Atkinson et al. 1990a).

*Chorisoneura parishi* Rehn, found in 1953, from South America (Atkinson et al. 1990a).

*Epilampra maya* Kehn, found in 1982 in and around houses, from Central America (Nickle & Sibson 1984, Atkinson et al. 1990a).

*Neoblattella detersa* (Walker), found ca. 1985, from the Greater Antilles (Peck & Beninger 1989).

*Symploce nursei* Hebard, found ca. 1985, from Haiti or the Bahamas (Peck & Beninger 1989).

**BLATTARIA: POLYPHAGIDAE**

*Myrmecoblatta wheeleri* Hebard, found in 1983, from Central America (Deyrup & Fisk 1984).

**COLEOPTERA: ANTHICIDAE**

*Anthicus crinitus* LaFerté, found in 1964, from Africa or Asia (Werner 1972).

**COLEOPTERA: BUSCHICIDAE**

*Heterobostruchus hamatipennis* (Lesne), found in 1988, from India via North Carolina (Mead 1988).

*Xylopuscus capucinus* (Fabricius), found in 1978 on cassava, from Asia perhaps via Africa or South America (Woodruff et al. 1978). PS

**COLEOPTERA: BRUCHIDAE**

*Acanthoscelides quadridentatus* (Schaeffer), found in 1986, is a potential biocontrol agent for *Mimosa pigra* L. (Leguminosae), from Central America (Center & Kipker 1991).

*Senusius lateralbonotatus* (Picard), year of find not stated, from Brazil, perhaps not established (Johnson & Kingsolver 1973).

**COLEOPTERA: CERAMBYCIDAE**

*Ebura cinereopilosa* Fisher, found in 1975, from Cuba (Turnbow & Hovore 1979).

*Empogonius annulicornis* Fisher, found in 1975, from Cuba (Hovore et al. 1978).

*Heterops dimidiata* (Chevrolat), found in 1975, from the Caribbean (Hovore et al. 1978).

**COLEOPTERA: CHRYSOMELIDAE**

*Microweosa ochrotoma* Stål, found in 1972 on watercress at a nursery, from South America (Woodruff 1974), earlier established in Alabama (Chamberlin & Tippins 1948).

*Ophraella dilatipennis* (Jacoby), found in 1975, from Central America (White 1979).

**COLEOPTERA: COCCINELLIDAE**

*Azya orbignya* Mulsant, found in 1975, a scale-insect predator, from the Neotropical region (Woodruff & Sailer 1977, Gordon 1985).

*Decadiomus bahamicus* (Casey), found in 1991, from the Caribbean, the Bahamas, or Bermuda (Bennett & Gordon 1991).

*Diomus roseicollis* Mulsant, year of find not stated, from Cuba (Gordon 1976).

**COLEOPTERA: COLODIIDAE**

*Bitoma brevipes* (Sharp), found in 1916, from Central America (Stephan 1989).

**COLEOPTERA: CURCULIONIDAE**

*Cytepistomus castaneus* (Roelofs), found in 1984, from Japan perhaps via northern USA (Mead 1984).
Elaeidobius subvittatus (Faust), found in 1985 on flowers of African oil palm, from Africa, important in pollination of the oil palm (O'Brien & Woodruff 1986).

Hypera postica (Gyllenhal), found in 1970, from Europe via California or Maryland, called alfalfa weevil (Munir & Sailer 1964).

Metamasius callizona (Chevolat), found in 1989 on Tillandsia (Bromeliaceae) in a nursery, from southern Mexico or Central America (O'Brien & Thomas 1990, O'Brien et al., 1990, Frank & Thomas 1991). PS

Metamasius hemipterus (L.), found in 1984 on cassava, from the Neotropical region, an eradication attempt was ineffective (Woodruff & Baranowski 1985, O'Brien & Thomas 1990). PS

Metamasius nomis Vaurie, found in 1972 on orchids in a greenhouse, probably eradicated, from South America (Woodruff 1973a, Mead 1976a).

Microlarimus lypriformis Wollaston, found in 1971 on puncturevine, from India or the Mediterranean region perhaps via the western USA or the Caribbean, into both of which areas it was introduced (Stegmaier 1973b, Mead 1974).

Myctides imberbis Lea, found in 1976 on rose-apple, from Australia (Woodruff 1977).

Necrurus saccharinus Marshall, found in 1972 on various grasses, from the Neotropical region (Woodruff 1972, Mead 1974).

Rhopalotria mollis (Sharp), found in 1986 on Zamia (Cycadaceae) from Mexico (Wibmer & O'Brien 1989).

Truchephyes arga Zimmerman, found in 1976, perhaps from Asia perhaps via Hawaii (O'Brien 1984).

COLEOPTERA: ELATERIDAE

Conoderus biforeatus (Palisot de Beauvois), found in 1887, from the Caribbean (Becker 1975).

Conoderus rufidens (F.), found in 1875, from the Caribbean (Becker 1975).

COLEOPTERA: LAEMOPHLOEIDAE

Laemophloeus bituberculus Reitter, found in 1963, from Puerto Rico (Thomas 1979).


Laemophloeus quinquearticulatus Grouvelle, year of find not stated, from South America (Thomas & Peck 1991).

Laemophloeus suturalis Reitter, year of find not stated, From Central America or South America (Thomas & Peck 1991).

Placnotus politissimus (Wollaston), found in 1960, from the Caribbean or South America (Thomas 1984).

COLEOPTERA: LYCTIDAE

Minthea rugicollis (Walker), found in 1967, from the Pacific (Mead 1987b). PS

COLEOPTERA: NITIDULIDAE

Colopterus posticus (Erichson), found in 1897 on fallen fruits of loquat, from the Neotropical region (Habeck et al. 1989b).

COLEOPTERA: SCARABAEIDAE

Aphodius granarius (L.), found in 1968, from Europe probably via northern USA (Woodruff 1973b).

Attenius havanensis Balthasar, found in 1968, from the Greater Antilles (Woodruff 1973b).

Onthophagus gazella (Fabricius), found in 1983, from Africa, was released in Georgia in 1975 to assist in decomposition of cattle dung (Fincher et al. 1983, Mead 1983c).

Onthophagus taurus Schreber, found in 1971, from Europe or North Africa (Fincher & Woodruff 1975).

Phyllophaga puberula (OnVal), found in 1960, from Cuba (Woodruff & Beck 1989).

COLEOPTERA: SCOLYTIDAE

TABLE 1. (Continued)

*Coccytodes dactylyperda* (F.), found in 1977, cosmopolitan (Atkinson et al. 1991).
*Coccytodes robustus* Eichhoff, found in 1985, from the Old World perhaps via the Greater Antilles (Atkinson et al. 1991).
*Coccytodes vulgatis* (Egger), found in 1885, from Asia or the Pacific (Atkinson et al. 1991).
*Pseudothyonos socius socius* (Blackman), found in 1986, from the Greater Antilles (Atkinson et al. 1991).
*Theoborus solitariae* (Rehde), found in 1986, from the Caribbean or Central America (Atkinson et al. 1991).
*Trioxihilus exiguit* Wood, found in 1866, from Mexico (Deyrup 1987).
*Xyleborus atratus* Eichhoff, year of find not stated, from Asia perhaps via southeastern USA (Atkinson et al. 1991).
*Xylosandrus crassiusculus* (Motschulsky), found in 1883, from Asia via South Carolina (Chapin & Oliver 1988, Deyrup & Atkinson 1987, Atkinson et al. 1988).

**COLEOPTERA: SILVANIDAE**

*Nauwibius sakhbergi* Crouville, found in 1949, from South America (Thomas and Peck 1991).
*Oryzaephilus acuminatus* Halstead, found in 1983 at a nursery on seeds of *Oryza* imported from India, believed eradicated (Thomas and Woodruff 1983).
*Sibmomus seuticiolos* (Walker), found in 1960, pantropical (Thomas 1979).
*Siviranus lewisi* Reitter, year of find not stated, from the Old World tropics (Thomas and Peck 1991).
*Siviranus recticollos* Reitter, found in 1975, from the Old World (Thomas 1979).

**COLEOPTERA: STAPHYLINIDAE**

*Aleochara puberula* Klug, found in 1975, pantropical and subtropical (Klimaszewski 1984).
*Athleta coriaria* (Kratz), found in 1985, from Europe (Frank 1985).
*Caelius caribeanus* Bierig, found in 1984, from the Caribbean (Frank 1985).
*Cephaloxyynum ramhouseki* Bierig, found in 1983, from Cuba (Newton 1986).
*Cephaloxyynum punicollos* Kratz, found in 1980, pantropical (Frank & Thomas 1984).
*Gabronthus mgoricicus* Tottonham, found in 1972, from Africa (Frank 1983).
*Helvota plumbea* (Waterhouse), found in 1973, from Europe (Frank & Thomas 1984).
*Myrmecosaurus ferruginus* Bruch, found in 1970 in nests of *Solenopsis invicta* Buren (Hymenoptera: Formicidae), itself an adventive species, from Argentina (Frank 1977).
*Oligota chrysopyga* Kratz, found in 1973, pantropical (Frank 1975).
*Oligota testaceorufa* Bernhauer, found ca. 1875, from the Lesser Antilles (Frank 1975).
*Oligota zonata* Bierig, found in 1973, from the Greater Antilles (Frank 1975).
*Oxytelus incisius* Motschulsky, found in 1969, pantropical (Frank & Thomas 1981).
*Philonthus centralis* (Gravenhorst), found in 1976, from the Old World (Frank 1983).
*Platycestethus spiculus* Erichson, found in 1974, from the Neotropical region (Frank 1976).

**COLEOPTERA: TENEBRIONIDAE**

*Poecilocrypticus formicophilus* Gebien, found in 1978, from South America (Steiner 1989).

**DIPTERA: AGROMYZIDAE**

*Melanagromyza caerulae* (Malo), found in 1967 on *Ipomoea* spp. (Solanaeae), from the Caribbean, Central America, or Mexico (Spencer & Stegmaier 1973).

**DIPTERA: BRAULIDAE**

*Braxia coeca* Nitzsch, found in 1983 on *Apis mellifera* L., the only known host, which is from the Old World perhaps via northern USA (Mead 1983a).
DIPTERA: CALLIPHORIDAE

Chrysomya sp. prob. rufifacies (Macquart), found in 1991, from Europe (Mead 1991b).

DIPTERA: CECIDOMYIIDAE

Olesicoccus coccidivora (Felt), found in 1971 as parasitoid of Saissetia and Pulvinaria scales on Barbados cherry, from South America (Mead 1974).

DIPTERA: CERATOPOGONIDAE

Culicoides jamaicensis Edwards, found in 1982, from the Caribbean (Wilkening et al. 1985).

Forcipomyia oligartha Saunders, found in 1927, from the Pacific or South America (de Meillon & Wirth 1979).

Monochelea multilineata (Lutz), found in 1963, from the Neotropical region (Wilkening et al. 1985).

DIPTERA: CHIRONOMIDAE

Goeldichironomus amazonicus (Fittkau), found in 1977, reported under name Simomyia amazonica Fittkau, from the Bahamas, Central America, or South America, probably brought to Florida as eggs or larvae on aquarium plants or other aquatic plants (Wirth 1979).

DIPTERA: CULICIDAE

Aedes albopictus (Skuse), found in 1986, probably from Japan via Texas, named "Asian tiger mosquito" (Peacock et al. 1988).

Aedes bahamensis Berlin, found in 1988, from the Bahamas (Pafume et al. 1988).

DIPTERA: LONCHAEIDAE

Neosilva persei (Romero & Ruppel), found in 1973 on cassava, from the Caribbean (Waddill & Weems 1978).

DIPTERA: OESTRIDAE

Oestrus ovis L., found in 1978, from the Old World (Mead 1978b).

DIPTERA: PHORIDAE

Beckerina setifrons Borgmeier, found in 1939, from Cuba (Barnes 1991).

Coniceromyia latimana (Malloch), found in 1972, from the Caribbean (Barnes 1991).

Megastigma luticauda (Borgmeier), found in 1971, from the Neotropical region (Barnes 1991).

DIPTERA: TEPHRITIDAE

Anastrepha ludens (Loew), found in 1972 in a trap, but further trapping failed to produce more, called Mexican fruit fly (Mead 1974). PS

Cerafisius capitata (Wiedemann), found on several occasions, each time believed eradicated, called Mediterranean fruit fly or "medfly" (Weems 1981, Mead 1984, 1986, 1990a). PS

HEMIPTERA: ANTHOCORIDAE

Paratriphleps laeviusculus Champion, found in 1966, on Manilkara zapotilla (Jacq.) (Sapotaceae), from the Caribbean and Central America (Bacher & Baranowski 1973).

HEMIPTERA: COREIDAE

Leptoglossus concolor Walker, found in 1954 on Comptonia sp. (Myricaceae), from Central America (Mead 1971, Baranowski & Slater 1986).

Setenira ferruginea Stål, found in 1927, from the Neotropical region (Baranowski & Slater 1986).

HEMIPTERA: LYGAEIDAE

Antilocoris pallidus (Uhler), found in 1968, from the Neotropical region (Slater & Baranowski 1990).
TABLE 1. (Continued)

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<thead>
<tr>
<th>Species</th>
<th>Location</th>
<th>References</th>
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<tbody>
<tr>
<td><em>Cistalia signoreti</em> Stål</td>
<td>found in 1969, from the Caribbean and South America (Slater &amp; Baranowski 1973, 1990).</td>
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<tr>
<td><em>Craspeduchus pulchellus</em> (F.)</td>
<td>found in 1901 on <em>Corchorus siliquosus</em> L. (Tiliaceae), from the Neotropical region (Baranowski &amp; Slater 1975).</td>
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<tr>
<td><em>Nysius scutellatus</em> Dallas</td>
<td>found in 1951, from the Caribbean (Ashlock 1977, Slater &amp; Baranowski 1990).</td>
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<tr>
<td><em>Oncopeltus auxilis</em> (Fab.)</td>
<td>found before 1976, from the Caribbean (Slater &amp; Baranowski 1990).</td>
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<tr>
<td><em>Oncopeltus cingulifer</em> Stål</td>
<td>found in 1969, from the Caribbean, Central America, or South America (Slater &amp; Baranowski 1990).</td>
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<tr>
<td><em>Ozophora divaricata</em> Barber</td>
<td>found in 1972, from the Caribbean (Baranowski &amp; Slater 1983).</td>
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<tr>
<td><em>Paragonatus costuricensis</em> (Distant)</td>
<td>found in 1957, from Central America, Mexico, or South America (Slater &amp; Baranowski 1990).</td>
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<tr>
<td><em>Paragonatus divergens</em> (Distant)</td>
<td>found in 1960 on <em>Baccharis halimifolia</em> L. (Compositae), from the Caribbean or Central America (Palmer &amp; Bennett 1988).</td>
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**HEMIPTERA: MIRIDAE**

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<tr>
<th>Species</th>
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<tr>
<td><em>Caulotops distanti</em> Reuter</td>
<td>found in 1984 on yucca, from Costa Rica (Henry 1985).</td>
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<tr>
<td><em>Ceratocapsus nigripunctus</em> Reuter</td>
<td>found in 1981 on <em>Batis maritima</em> L. (Bataceae), from Jamaica (Henry &amp; Wheeler 1982).</td>
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<tr>
<td><em>Hyalopsyllus diaphanus</em> (Reuter)</td>
<td>found in 1979 on <em>Crotalaria incana</em> L. (Fabaceae), from the Greater Antilles (Henry &amp; Wheeler 1982).</td>
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<tr>
<td><em>Jobertus chrysolectus</em> Distant</td>
<td>found in 1980 on <em>Ipomoea alba</em> L. (Solanaceae), from the Greater Antilles and Mexico (Henry &amp; Wheeler 1982).</td>
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<tr>
<td><em>Paracarus cubanus</em> Bruner</td>
<td>found in 1981 on avocado, from the Greater Antilles (Henry &amp; Wheeler 1982).</td>
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<tr>
<td><em>Paramizia carmelitana</em> (Carvalho)</td>
<td>found in 1981 by sweeping grasses and weeds, from Puerto Rico or South America (Henry &amp; Wheeler 1982).</td>
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<tr>
<td><em>Prerops cruciferus</em> (Berg)</td>
<td>found in 1989, from the Neotropical region (Henry 1990).</td>
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<tr>
<td><em>Probis hyalina</em> Maldonado</td>
<td>found in 1980 on <em>Parthenium hysterophorus</em> L. (Compositae), from Puerto Rico (Henry &amp; Wheeler 1982).</td>
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<tr>
<td><em>Rhinacloa pallidipes</em> Maldonado</td>
<td>found in 1988, from Puerto Rico (Henry 1984).</td>
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**HEMIPTERA: PENTATOMIDAE**

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<tr>
<td><em>Euschistus acuminatus</em> Walker</td>
<td>found in 1980 on jessamine, from the Caribbean (Baranowski et al. 1983).</td>
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<tr>
<td><em>Oebalus griseoscens</em> (Sailer)</td>
<td>found in 1983 on grass, from South America (Mead 1983d).</td>
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**HEMIPTERA: TINGIDAE**

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<tr>
<td><em>Leptidictya tabida</em> (Herrick-Schaeffer)</td>
<td>found in 1990 on sugarcane, from Central America or South America, called sugarcane lace bug (Hall 1991).</td>
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**HOMOPTERA: ALEYRODIDAE**

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<tr>
<td><em>Aleurocanthus woglumi</em> Ashby</td>
<td>found in 1976, from Asia perhaps via the Caribbean or Central America; an earlier establishment of this species in 1984 was eradicated by 1987, called citrus blackfly (Hart et al. 1978). PS</td>
<td></td>
</tr>
<tr>
<td><em>Aleurotula anthuricola</em> Nakahara</td>
<td>found in 1978, from South America (Mead 1978a, Nakahara 1989).</td>
<td></td>
</tr>
<tr>
<td><em>Bemisia berbericola</em> (Cockrall)</td>
<td>found in 1979 on wax myrtle, from South America via western USA (Denmark 1982).</td>
<td></td>
</tr>
<tr>
<td><em>Diaeroidea kirbyi</em> (Kotinsky)</td>
<td>found in 1972 on <em>Morinda citrifolia</em> L. (Rubiaceae), from Asia but now distributed widely (Nguyen &amp; Hamon 1989).</td>
<td></td>
</tr>
<tr>
<td><em>Parabemisia myricae</em> (Kuwana)</td>
<td>found in 1984 on snowberry, from eastern Asia, also known from Venezuela and California (Hamon 1986a, Hamon et al. 1990).</td>
<td></td>
</tr>
<tr>
<td><em>Peltaus hibiici</em> (Kotinsky)</td>
<td>found in 1971 on cassava, from Asia (Mead 1974).</td>
<td></td>
</tr>
</tbody>
</table>
HOMOPTERA: APHIDIDAE

**Melanaphis sacchari** (Zehnter), found in 1977 on sugarcane, pantropical and subtropical (Denmark 1982, 1988).

**Trichosiphonaphis polygoni** (van der Goot), found in 1974 on *Polygonum* (Polygonaceae), from Asia (Smith & Denmark 1982).

HOMOPTERA: CICADELLIDAE

**Dikrella cedrelae** (Oman), found in 1983 on *Cordia sebestena* L. (Ehretiaceae), from the Greater Antilles (Mead 1983c).

**Idona sexmaculata** (DeLong), found in 1983 on *Hibiscus tiliaceus* L. (Malvaceae), from the Caribbean (Mead 1983b).

**Protalebrula nema** McAtee, found in 1988 on *Cordia sebestena* L. (Ehretiaceae), from the Caribbean (Mead 1983b).

**Unerus colonus** (Uhler), found in 1983, from the Caribbean (Mead 1983c).

HOMOPTERA: COCCIDAE

**Coccus capparidis** (Green), found in 1974 on citrus, from the Neotropical region (Mead 1975c), PS

**Philepheda tuberculosa** Nakahara & Gill 1985, found in 1982 on ornamental trees, from Central America or South America (Hamon 1986b, Peña & McMillan 1986).

HOMOPTERA: DELPHACIDAE

**Delphacodes havanae** Muir & Gifford, found in 1972, from the Greater Antilles, Central America, or South America (Wilson 1984).

**Delphacodes migrifacies** (Muir), found in 1966, from the Caribbean, Central America, or South America (Anon. 1976).

**Perkinsiola saccharicida** Kirkaldy, found in 1982 on sugarcane, from Australia, called sugarcane delphacid (Nguyen et al. 1984, Sosa 1985).

HOMOPTERA: DIASPIDIDAE

**Aspidiotus tridentifer** Ferris, found in 1986 on *Zamia pumila* L. (Cycadaceae), from Mexico (Mead 1986).

**Chortinaspis subchortina** (Laing), found in 1972 on centipede grass, from Jamaica or Panama (Mead 1976a).

**Lepidosaphes laterochitinosa** Green, found in 1987 on agloamena imported from the Philippines, at a nursery, from southeastern Asia, perhaps eradicated (Mead 1987a). PS

**Morganella longispina** (Morgan), found in 1980 on oleander, from eastern Asia perhaps via Haiti (Hamon 1981).

**Oceanaaspis apracarique** (Adachi & Fullaway), found in 1985 on Norfolk Island pine at a nursery, from Hawaii, perhaps eradicated (Hamon 1985).

**Opuntiaspis carinata** (Cockerell), found in 1978 on *Beaucarnea* (Liliaceae) plants which had been shipped 2-3 years earlier, from Mexico via Texas (Hamon 1978). PS

**Parlatoria ziziphi** (Lucas), found in 1985 on citrus, from eastern Asia probably via the Caribbean, called black parlatoria scale (Mead 1985). PS

**Pseudoaonidia trilobitiformis** (Green), found in 1972 on *Izora* (Rubiaceae), pantropical (Denmark 1982). PS

HOMOPTERA: PSEUDOCOCIDAE

**Dysmicoccus neobrevipes** Beardsley, found in 1978 on *Furcraea* (Agavaceae), from the Pacific (Denmark 1982). PS

**Hypogalecoccus festivianus** (Lizer & Trelois), found in 1984 infesting cacti imported from Argentina at a nursery (Hamon 1984). PS

**Rhizoecus americanus** (Hambleton), found in 1959 on *Dieffenbachia* (Araceae) roots, from the Caribbean or South America (Hambleton 1973).

**Rhizoecus arabicus** Hambleton, found in 1982 on a gesneriad, from Central America or South America (Hamon 1982).

**Rhizoecus cacticans** Hambleton, found in 1963 on *Mesembryanthemum* (Mesembryanthemaceae) and misidentified as *R. leucosomus* (Cockerell), origin not stated (Hambleton 1973).
TABLE 1. (Continued)

Rhizoeus kibisci Kawai & Takagi, found in 1978 on a bromeliad, from Japan perhaps via Puerto Rico (Denmark 1982).

Rhizoeus mexicanus (Hambleton), found in 1978 on Mammillaria (Cactaceae) from Mexico (Hambleton 1970, Denmark 1982).

Rhizoeus simplex (Hambleton), found in 1961 on Neoregelia (Bromeliaceae) and misidentified as R. caecicus, from South America (Hambleton 1979).

Saccharicoccus sacchari (Cockerell), found in 1944, pantropical (Mead 1980b).

HYMENOPTERA: AGAONIDAE

Eupristina masoni Saunders, found in 1986 in fruits of banyan, from Asia (Stange & Knight 1987, Nadel et al., this symposium).

Eupristina sp. nr. altissima Balukrishnan & Abdurahman, found in 1987 in fruits of lofty fig, from Asia (McKey 1989, Nadel et al., this symposium).

Paraprisciota verticillata (Waterston), found in 1986 in fruits of laurel fig, from Asia perhaps via Hawaii (Stange & Knight 1987, Nadel et al., this symposium).

HYMENOPTERA: APHELINIDAE

Eretnocerus sp., found in 1984 as parasitoid of Parabemisia myricae, apparently an immigrant biocontrol agent (Hamon 1986a, Hamon et al. 1986).

HYMENOPTERA: BRACONIDAE

Opus anastrephae Vieereck, found in 1973 as parasitoid of Caribbean fruit fly, from the Caribbean (Swanson 1978, 1982).

HYMENOPTERA: EUCRITIDAE

Arrhenophagus albitibialis Girault, found in 1985-1986 as parasitoid of Pseudanourapis penagona (Targioni) and P. cockerelli (Cooley) (Homoptera: Diaspididae), from Asia (Dall & Stange 1979, Bennett & Noyes 1989).

Coenomalopoda shikokuensis (Tachikawa), found in 1986 as parasitoid of Froggattiella penicillata (Green) (Homoptera: Diaspididae), from Asia (Bennett & Noyes 1989).

Ooencyrtus chrysopae Crawford, found in 1976, from South America (Mead 1976).

HYMENOPTERA: EULOPHIDAE

Aphelinus flaviventris Kurdjumov, found in 1967, captured by net, from Asia (Mead 1974).

Euderomphale vittata Dozier, found in 1985 as parasitoid of spiralling whitefly on coconut and seagrape, from the Caribbean (Bennett & Noyes 1989).

Trichospius diatraeae Cherian & Margabandhu, found in 1983 in a light trap and in 1985 as parasitoid of pupae of Epineme detexta (Walker) (Lepidoptera: Geometridae), a pest of avocado, from Asia (Bennett et al. 1987).

HYMENOPTERA: FORMICIDAE

Anoetohes mayri Emery, found in 1986, origin not stated (Deyrup et al. 1988).

Epistatus hexamerus Brown, found in 1987 in leaf litter, from Asia (Deyrup 1988).

Gnamptogenys aculeaticoxae (Santschi), found in 1986, from South America (Deyrup et al. 1989).

Leptothorax torrei (Aguayo), found in 1984, from Cuba (Deyrup et al. 1988).

Monomorium ebuenum Forel, found in 1986, from the Caribbean (Deyrup et al. 1988).

Paratrechina guatemalensis Forel, found in 1982, from Central America or South America (Trager 1984).

Paratrechina pubens Forel, found in 1983, from the Caribbean (Trager 1984).

Quadristruma emmae (Emery), year of find not stated, pantropical (Smith 1979).

Smithistruma margaritae (Forel), found in 1986, from the Neotropical region (Deyrup et al. 1989).

Solenopsis corticalis Forel, found in 1945, from Cuba (Deyrup et al. 1988).

Strumigenys lanuginosus Wheeler, found in 1987, from the Neotropical region (Deyrup et al. 1989).
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Strumigenys rogeri Emery, found in 1982, from Africa, perhaps via the Caribbean (Deyrup & Trager 1984).
Strumigenys silvestrii Emery, found in 1967, from the Neotropical region (Johnson 1986).
Technomyrmex albipes (Fr. Smith), found in 1986 and perhaps eradicated, found again in 1990, from Asia (Deyrup 1991).
Tetramorium caldarium (Roger), year of find not stated, from Africa (Bolton 1979).

HYMENOPTERA: ICHNEUMONIDAE

Bathyplectus curculionis (Thomson), found in 1978, from Europe via California or New Jersey, where it was released as a biocontrol agent for alfalfa weevil (Murnir & Sailer 1984, Grant & Lembdin 1990).
Carinodes havanensis (Cameron), found in 1959, from the Greater Antilles (Heinrich 1987).
Eiphosoma atrovittatum Cresson, found in 1945, from Cuba (Dasch 1979).
Eiphosoma nigrovittatum Cresson, found in 1956, from the Greater Antilles (Dasch 1979).
Neodiaphysus flavivarius (Cresson), found in 1957, from Cuba (Heinrich 1987).

HYMENOPTERA: MEGACHILIDAE

Chalicedoma lanata (F.), found in 1990, from the Old World (Mead 1990b).

HYMENOPTERA: PTEROMALIDAE

Micranisa sp., found in 1986 in fruits of laurel fig, from Asia perhaps via Hawaii (Stange & Knight 1987, Nadel et al., this symposium).
Odontofoquantia galili Wiebes, found in 1986 in fruits of laurel fig, from Asia perhaps via Hawaii (Stange & Knight 1987).
Walkerella yashiroi (Ishii), found in 1986 in fruits of laurel fig, from Asia perhaps via Hawaii (Stange & Knight 1987).

HYMENOPTERA: TENTHREDINIDAE

Liliacina diversipes (Kirby), found in 1987, from Mexico, Central America or South America (Smith 1990).

HYMENOPTERA: TORYMIDAE

Megastigmus transvaalensis (Hussey), found in 1988 in seeds of Brazilian peppertree, from South Africa (Habeck et al. 1989a).
Philotrypes emeryi Grandi, found in 1986 in fruits of laurel fig, from Asia perhaps via Hawaii (Stange & Knight 1987).

HYMENOPTERA: VESPIDAE

Delta campisiforme (Fabricius), found in 1981, from Africa perhaps via Jamaica (Menke & Stange 1986).
Zeta argillaceum (L.), found in 1975, from South America (Menke & Stange 1986).

ISOPTERA: RHINOTERMITIDAE

Coptotermes formosanus Shtrak, found in 1980, from eastern Asia, named Formosan subterranean termite (Mead 1980a, Thompson 1985, Koehler et al. 1991). PS

LEPIDOPTERA: ARCTIIDAE

Empyreuma affinis Rothschild, found in 1978, from the Greater Antilles or the Bahamas, larvae feed on oleander (Adams & Goss 1978).

LEPIDOPTERA: LYCAENIDAE

Strymon limenia (Hewitson), found in 1971, from the Caribbean (Anderson 1974).

LEPIDOPTERA: LYMANTHRIIDAE

Lymantria dispar (L.), found in 1971 at a trailer park, from Europe via northeastern USA where it escaped from culture, called gypsy moth (Poucher 1974, Dixon & Foltz 1985). PS
LEPIDOPTERA: NOCTUIDAE

_**Achaea ablunaris**_ Walker, found in 1989, from South America (Dickel 1991).

_**Aglaonome kirtipalpis**_ (Walker), found in 1964, from South America (Dickel 1991).

_**Anomis luridula**_ Guenée, found in 1989, from the Neotropical region (Dickel 1991).

_**Blepta sp.**_ (Hampson), found in 1986, from the Bahamas, probably established earlier under the name "Nodaria" (Dickel 1991).

_**Callopistria jamaicensis**_ (Möschler), found in 1987, from Jamaica (Dickel 1991).

_**Conida punctifera**_ (Walker), found in 1978, from the Bahamas (Dickel 1991).

_**Dypterygia punctirea**_ (Walker), found in 1985, from the Dominican Republic (Dickel 1991).

_**Elaphria deltoidea**_ (Möschler), found in 1983, from Jamaica or South America (Dickel 1991).

_**Elousa albicans**_ Walker, found in 1984, from the Dominican Republic (Dickel 1991).

_**Epidormia pannosa**_ Guenée, found in 1988, from South America (Dickel 1991).

_**Epidormia pyraliformis**_ (Walker), found in 1983, from the Dominican Republic (Dickel 1991).

_**Eusepidotis striaepuncta**_ (Herrich-Schaeffer), found in 1984, from Cuba (Dickel 1991).

_**Eusistrapterus poeyi**_ Grote, found in 1987, from Cuba (Dickel 1991).


_**Hypena subulalis**_ Guenée, found in 1986, from South America (Dickel 1991).

_**Leucania dorsalis**_ Walker, found in 1984, from the Dominican Republic (Dickel 1991).

_**Leucania inconspicua**_ (Herrich-Schaeffer), found in 1984, from Cuba (Dickel 1991).

_**Leucania opalians**_ (Drandt), date of find not stated, from South America (Dickel 1991).

_**Leucania venecena**_ Möschler, date of find not stated, from Puerto Rico (Dickel 1991).

_**Litoprosopus haitiensis**_ Hampson, found in 1988, from Haiti (Dickel 1991).

_**Macristis genninipunctalis**_ Schaus, found in 1985, from Cuba (Dickel 1991).

_**Mecis cubana**_ Hampson, found in 1989, from Cuba (Dickel 1991).

_**Neuntuerta hemignyla**_ (Hampson), found in 1982, from the Bahamas (Dickel 1991).

_**Paecetes lunodes**_ (Guenée), found in 1989, from Central America or South America (Dickel 1991).

_**Physula albipunctilla**_ Schaus, found in 1980, from Cuba (Dickel 1991).

_**Pseudaletia sequax**_ Franchelmont, date of find not stated, from Mexico (Dickel 1991).

_**Pitichodis immunes**_ (Guenée), found in 1989, from the Lesser Antilles (Dickel 1991).

_**Spodoptera androgea**_ (Stoll), found in 1987, from South America (Dickel 1991).

LEPIDOPTERA: NYMPHALIDAE

_**Anartia chrysopelea**_ (Hübner), found in 1972, from Hispaniola, not established (Anderson 1974).

_**Hamadryas amphichloe**_ (Boisduval), found in 1978, from the Greater Antilles (Jenkins 1984).

LEPIDOPTERA: OECOPHORIDAE

_**Ethmia submissa**_ Busck, found in 1987, from Cuba (Dickel 1988).

LEPIDOPTERA: PAPILIONIDAE

_**Papilio androgeus**_ Cramer, found in 1976, from the Greater Antilles, became established for several years but is not known now (Patterson 1977).

LEPIDOPTERA: PIERIDAE

_**Phoebis orbis**_ (Poey), found in 1973, from the Greater Antilles (Bennett & Knudson 1976).

LEPIDOPTERA: PYRALIDAE

_**Anaspippa univittella**_ Dyar, found in 1983, from Cuba (Dickel 1988).

_**Bema neuricella**_ (Zeller), found in 1984, from Cuba or the Bahamas (Dickel 1987).

_**Cactoblastis cactorum**_ Berg, found in 1889 on _Opuntia_ (Cactaceae), from South America via the Caribbean (Habeck & Bennett 1990).
Epimorius testaceellus Ragonot, found in 1974, from Jamaica, reared from leaves of Tillandsia fasciculata Swartz (Bromeliaceae) (Ferguson 1991).
Lipographis suboscella Hulst, found in 1981, from the Bahamas (Dickel 1987).
Maruca testulalis (Lever), found in 1980, from Puerto Rico (Dickel 1981).
Neoleucinoides torus Capes, found in 1985, origin not stated (Dickel 1986).
Ozamia lucidalis (Walker), found in 1989 on Cereus (Cactaceae), from the Caribbean (Habeck & Bennett 1990).
Parapoynx diminutalis Snellen, found in 1976 on hydrilla, from Asia (Del Posse et al. 1976).
Sporylus cubensis Heinrich, found in 1984, from Cuba (Dickel 1987).
Stylopalpis lunigerella Hampson, found in 1985, from Cuba or the Bahamas (Dickel 1988).

LEPIDOPTERA: TINEIDAE

Opogona purpurialla Sweeney, found in 1986 on a citrus plant, from Hawaii (Mead 1987a, Heppner et al. 1987).
Opogona sacchari (Bojer), found in 1963, from Africa and the Indian Ocean perhaps via the Caribbean (Heppner et al. 1987, Davis & Peña 1980). PS

LEPIDOPTERA: TORTRICIDAE

Cryptaspasma lugubris Felder, found in 1981, origin not stated (Dickel 1987).

LEPIDOPTERA: URANIIDAE

Urania fulgens Walker, found in 1973, from Mexico (Emmel 1974).

NEUROPTERA: MYRMELEONTIDAE

Myrmeleon insertus Hagen, found in 1978, from the Greater Antilles (Lucas & Stange 1981).

ODONATA: AESHNIDAE

Coryphaeschna adnexa (Hagen), found in 1980, from Cuba, called blue-faced darner (Dunkle 1989).

ODONATA: LESTIDAE

Lestes spumarius Hagen in Selys, found in 1988, from Cuba or Bahamas, called Antillean spreadwing (Dunkle 1990).

ODONATA: LIBELLULIDAE

Crocothemis servilia, found in 1975, from Asia, called scarlet skimmer (Palisot 1978).
Erythemis plebeja (Burmeister), found in 1971, from Cuba, called black pondhawk (Dunkle 1989).
Micrathyria aequalis (Hagen), found in 1985, from Cuba or the Bahamas, called spot-tailed skimmer (Dunkle 1989).
Micrathyria didyma (Selys in Sagra), found in 1985, from Cuba or the Bahamas, called three-striped skimmer (Dunkle 1989).

ORTHOPTERA: TETTIGNIIDAE

Neoconocephalus affinis (Palisot de Beauvois), found in 1981, from the Caribbean (Walker & Greenfield 1983).
Neoconocephalus maxillosus (F.), found in 1969, from the Caribbean (Walker & Whitesell 1978).

PSOCOPTERA: HEMIPSOCIDAE

Hemipuscus chloroticus (Hagen), found in 1972, from Asia (Mockford 1973).

PSOCOPTERA: LIPOSCELIDAE

Embidopsocus femoralis (Badonnel), found in 1983, from Africa perhaps via Mexico (Mockford 1987).

PSOCOPTERA: PSOCIDAE

Trichadenoteneum circularoides Badonnel, found in 1952, from southern Africa (Mockford 1974).
TABLE 1. (Continued)

**THYSANOPTERA: PHLAEOTHRIPIDAE**

*Diceratothrips armatus* Bagnall, found in 1987 on grapefruit stems, from Central America or South America (Mead 1987c).

*Liothrips varicornis* Hood, found in 1974 on *Hibiscus* (Malvaceae), from Mexico (Mead 1976b).

*Nesothrips brevicollis* (Bagnall), found in 1971 on coconut palm, from Asia (Reinert & Nakahara 1976).

*Scothrips claripennis* (Moulton), found in 1971 on coconut palm, pantropical (Reinert & Nakahara 1976).

**THYSANOPTERA: THRIPIDAE**

*Caliothrips insularis* (Hood), found in 1913, from the Caribbean or South America (Nakahara 1991).

*Chuetanaphothrips signipennis* (Bagnall), found in 1985 on dracaena foliage plants imported from Central America (Denmark & Osborne 1985).

*Dichromothrips corbettii* (Priesner), found in 1976 on an orchid, from southeast Asia (Mead 1976b). PS

*Dimurothrips vesconyi* Bagnall, found in 1974, by sweeping weeds and grasses, from South America (Mead 1975a). PS

*Frankliniella schultzi* (Trybom), found in 1950, from Europe, Asia or Africa (Nakahara 1974). PS

*Organantheris indicus* Bhatti, found in 1988 on *Typha* (Typhaceae) and *Eichhornia* (Pontederiaceae), from Asia (Mead 1990b).

*Rhaebothrips lativentris* Karny, found in 1971 on grasses, from the Pacific but also occurs in the Caribbean (Stegmaier 1973a, Mead 1974).

*Salpingothrips armatofus* Kudo, found in 1972 on kudzu vine, origin not stated (Mead 1976a).

*Scirtothrips* sp. [not citri* (Moulton)], found in 1986 on grape, origin not stated (Flowers 1989).

*Taeniothrips eucharii* (Whetzel), found in 1966, from Asia (Denmark 1981, O'Neill 1962). PS

*Thrips hawaiiensis* (Morgan), found in 1967 on rose, blackberry, etc., from Asia or the Pacific (Anon. 1973, Mead 1976a). PS

*Thrips palmi* Karny, found in 1990 on *Bidens pilosa* L. (Compositae), from Asia (Mead 1991a).

1. For *Porthetria dispar* see *Lymexylon dispar*
2. For *Stalinympha amazonica* see *Goeldichironomus amazonicus*

orders, by far. Even if immigrants arrived in Florida at random, these orders would be expected to account for a disproportionate number of immigrant species.

The distribution of immigrant species among orders is in many ways like the one produced for the contiguous 48 states of the USA (Saier 1983), but different in some revealing ways (Fig. 1). Particularly notable is the much larger proportion of Lepidoptera, and much smaller proportion of Hemiptera plus Homoptera, in Florida, especially recently. The differences may reflect variation in the composition of the respective pools from which immigrants have been drawn, or differences in the rates of establishment - and, thus, rates of failure - for various kinds of insects in different places, or other, similar, phenomena (Simberloff 1986). The differences also could reflect variation in the interests of persons studying insect immigration in different places, such that the apparent distribution of immigrant species among orders is, at least in part, a biased representation of the real distribution (Simberloff 1986). We suspect that the larger proportion of Lepidoptera is at least in part the result of ability of many of these insects to fly long distances (e.g., to Florida from the Greater Antilles).
Fig. 1. Distribution of immigrant insect species among orders, for the contiguous 48 states of the USA (from Sailer 1983) and Florida. The upper figure compares all known records for the USA with recent (since 1970) records for Florida; the lower figure compares 1970-1980 records for the USA with recent records for Florida, for the five orders for which such information was available. Note that seven orders reported by Sailer (1983) were excluded, because they included no recent insect immigrants to Florida.
In many cases, immigrant species also are not very equitably distributed among families within orders. Three families (of 17), Curculionidae, Scolytidae, and Staphylinidae, together account for about 52% of the species of Coleoptera recorded in Florida for the first time since 1970. Two families (of seven), Aleyrodidae and Diapriidae, account for about 48% of the species of Hymenoptera first recorded in Florida within the same time span. Single families, Noctuidae and Miridae, account for about 56% of the recent immigrants of Lepidoptera (12 families total) and Hemiptera (six families total), respectively. The distributions of species among families are more equitable for other orders, but they still often are skewed noticeably.

The large number of recent immigrant insect species we have tabulated suggests that their rate of arrival and/or discovery in Florida is high. For the 107 species collected for the first time in Florida in 1970-1989, we calculated rates of 7.7 (s.d. = 4.6) immigrations per year in the 1970s and 12.0 (s.d. = 5.7) immigrations per year in the 1980s. These figures are greater than those proposed for the northeastern USA and eastern Canada (Hoebeke & Wheeler 1988), a land area 25 times the size of Florida, and similar to those proposed for the entire contiguous 48 states of the USA (Sailer 1983). Our judgement that about 20 recent immigrants are, or could become, major pests in Florida (see Table 1) exceeds Sailer's (1983) estimate that about seven potential major pests immigrate to the 48 contiguous states of the USA per year. [Note that ten (50%) of the actual or potential major pests recently reported in Florida for the first time were on the USDA-APHIS list as having been intercepted in fiscal year 1980.] All of these comparisons suggest either that the rate of immigration to the entire USA or the rate of immigration to Florida has increased dramatically since the early 1980s. On the other hand, the increase could be only apparent, being the result of improved detection or increased effort, particularly in Florida. The tendency for certain species to immigrate several times, noted by Sailer (1983), is evident in our tabulation.

The “PS” designation was applied to 21 species. Thus, we suggest that at least 8% of insect immigrations to Florida result from stowing-away. The percentage of species that have arrived as stowaways actually is much larger. First, the USDA-APHIS list applies only to “plant pests” (which, we believe, means phytophagous insects), whereas many of the species in Table 1 patently are not phytophagous; some even are natural enemies of phytophagous insects. Second, we examined the USDA-APHIS list only for fiscal year 1980, at the mid period of the two decades we considered; a cumulative list of the USDA-APHIS interceptions for the entire two decades surely would have revealed many more of our suspected stowaways. Third, we cannot evaluate considerable numbers of intercepted insects because they are identified on the USDA-APHIS list only to genus; unidentified congeneres of another 38 of the species in Table 1 appear on the USDA-APHIS list for fiscal year 1980. This last fact alone suggests that about 3 times as many (i.e., about 24%) of all the species on our list may have arrived as stowaways, more than that when we accept that the USDA-APHIS list does not deal with non-phytophagous species. We note that some of the exotic species intercepted year after year have yet failed to establish populations in mainland USA, which suggests the effectiveness of inspection or, more likely, the difficulty that certain species have in colonizing once they have immigrated. Some exotic species of European and Asian origin that have been intercepted have become established, however, even in recent years, which suggests that the best efforts of USDA-APHIS do not discover all of the insects arriving in seaports and airports, both in private and commercial shipments and the baggage of passengers.

The geographic origins of the recent insect immigrants to Florida are diverse. As one might suspect, the geographic origin of immigrants to Florida is not very similar to the origins of immigrants to the entire contiguous 48 states of the USA (Fig. 2). The principal difference is the much larger proportion of immigrants to Florida that comes
Fig. 2. Geographic origins of immigrant insect species. Data for the 48 contiguous states of the USA are from Sailer (1983). Data for Florida are from records of the 236 species for which we had precise information on region of origin.

from the Neotropical region, and the much smaller proportion that comes from the western Palearctic region (see Hoebeke & Wheeler 1983, Sailer 1983, Simberloff 1986).

DISCUSSION

**Florida's Neotropical Insect Fauna**

Six species of butterflies are listed among the Rare and Endangered Biota of Florida (Baggett 1982). They are Chlorostyron maesites Herrich-Schaeffer, Eunica tatila Herrich-Schaeffer, Strymon acis Drury, Eumaeus atala Poey, Heraclides aristodemus (Esper), and Anaea troglodyta F. These are Neotropical species, and all occur in Cuba and other islands. Butterflies have more popular appeal than do most insects, and have received more attention in two ways. First, their presence in Florida was discovered relatively quickly. Second, the color patterns of the Florida populations of S. acis, H. aristodemus, and A. troglodyta differ slightly from those of populations in the West Indies, leading to description of Florida subspecies S. a. bartrami Comstock & Huntington (Bartram's hairstreak), H. a. ponceanus Schaus (Schaus' swallowtail), and A. t. floridensis Johnson & Comstock (Florida leafwing) (Gerberg & Arnett 1989). It is unclear whether Florida populations of E. atala, which have been described as a distinct subspecies (E. a. floridensis Roeber, the Florida atala), differ in any substantial way from populations in the Bahamas (Baggett 1982, Riley 1975).
Florida's Rare and Endangered butterflies are Neotropical immigrants that would have been placed in our tabulation of immigrants (Table 1) had their first mention in the literature been after 1970. They would presumably have been placed on the USDA-APHIS list of plant pests had they been intercepted by inspectors. Indeed, the 1980 list of interceptions gives a Eucaea spicosa (unidentified) as having been found on a cycad imported from Mexico (FITSS 1982). Isolation of populations of three (perhaps four) of them in Florida, from populations in Cuba and other islands, has been sufficient to lead to slight characteristic differences in color pattern. These differences, in turn, have led to the description of the Florida populations as distinct subspecies. Perhaps these differences in color patterns have a genetic basis. If they do, then we suggest the same is likely true for many other immigrants, but that the phenotypic expression is less apparent. These butterflies may perhaps represent thousands of species of largely Antillean insects that depend in some way on cold-sensitive Neotropical plants, and have immigrated to southern Florida only since the last (Wisconsin) glaciation. The successful colonists among them subsequently may have diverged genetically from their parental populations.

Neotropical species that do not depend in some way on cold-sensitive Neotropical plants, and that can tolerate freezing temperatures, may have immigrated to, and sometimes colonized, Florida even before the last glaciation. As most of Florida from Tampa Bay southward appears to have been submerged as late as the early Miocene (Alt 1967, Winker & Howard 1977), these colonists likely arrived since then. Such colonists may have diverged more from their parental populations than did the six butterflies. Such wide divergence must depend not only on the earliest date of immigration, but also on maintenance of contact with the parental gene pool (i.e., frequency of arrival of subsequent immigrants).

**Invasibility of Florida**

All of the information we have presented might lead one to conclude that, for some reason, Florida is particularly prone to invasion (i.e., immigration plus colonization) by insects. We do not know with certainty the total number of insect species in Florida, nor the number of exotic origin, so we cannot ascertain the percentage of the fauna made up of exotics. For a wide range of organisms other than insects, however, the percentage appears to be substantial (data in Ewel 1986). Naturalized exotics constitute about 15% of Florida's plant species, 16% of its fish species, 22% of its amphibian species, 42% of its reptile species, 5% of its bird species, and 23% of its mammal species. Most of these percentages are near those reported for the insect faunas of supposedly "invasion-prone" regions, such as Hawaii (29%, Simberloff 1986) and Tristan da Cunha (25%, Holdgate 1960), but contrast with those reported for the insect faunas in regions thought to be less "invasion-prone," such as the contiguous 48 states of the USA (1.7%, Sailer 1983).

While these differences in percentages would seem to provide evidence of a convincing difference between regions that are "invasion-prone" and those that are not, they are deceptive in at least two ways. First, percentages, by their nature, can be misleading in cases such as these (Simberloff 1986). If exactly the same number of exotic insect species colonized, say, Hawaii and North America north of Mexico, then Hawaii's insect fauna would de facto contain a much higher percentage of exotics than North America's. This result occurs because North America's insect fauna is much larger than Hawaii's (data in Simberloff 1986). Spatial scale also comes into play here, as certain parts of North America, such as Florida, clearly are different from most of the rest of it in terms of their complements of exotic species. Second, one cannot truly assess the relative invasibility of a geographic region without rather detailed information on the sizes and
compositions of the pools from which immigrants are being drawn, the rates of immigration from those pools to the targets, and the rates of success that immigrants have in colonizing the targets (McCoy & Hee 1987, Simberloff 1986).

Because we lack good information on the size and composition of Florida’s insect fauna, as well as other necessary information, we cannot assess its relative invasibility with any degree of assurance. Whether its native species provide less “biotic resistance” to invasion than other regions (see Ewel 1986, Sailer 1983), whether its location predisposes it to ready immigration of flying, wind-blown, and rafting exotics from the Bahamas, the Yucatan peninsula of Mexico, Cuba and other islands of the Greater Antilles; and whether habitat changes induced by man enhance its colonization by immigrants (see Ewel 1986, Simberloff 1986) are important, interesting, but currently unanswerable questions. Once we possess the requisite information, then we can begin to address such questions rigorously.

THE SYMPOSIUM

The process of invasion by insects is complex. It requires the ability to move to a new location (“immigration”), the ability to establish populations at the new location (“colonization”), and the ability to resist local extinction there. The symposium addresses all of these components of invasion in relation to Florida.

Two of the contributions focus on the invasion of Florida by African honeybees. African bees will soon become well-established across the southern tier of the United States; the highest concentration of feral African bees will be in Florida. H.G. Hall discusses the process of New World African and European honeybee hybridization. He concludes that it is multifaceted, and that generalizations cannot be made about the entire process if only limited aspects are studied; the different components must be defined and evaluated. Among these components are climate (tropical or temperate), kind of colony (feral or managed), matriline (African or European), and kind of population (established or transient).

R. Hengeveld analyzes invasion of the New World by the African bee, as well as invasion of Europe by the collared dove. He constructs models of invasion, based on population growth and dispersal. His models appear to offer a more parsimonious explanation of invasions than do models based on invasion-proneness of species and biotopes.

J.C. Allen, Y. Yang, J.L. Knapp, and P.A. Stansly provide a model of the attack rate for a grazing herbivore, the citrus rust mite. They obtain the model as a Type 2 functional response analogous to Holling’s disc equation, and suggest that it can help to indicate what further data are needed to make reliable models for use in population dynamic studies and economic predictions. They suggest further that the model could, with only slight modification, be applied to most grazing herbivores. It might, therefore, be used profitably to make predictions about the potential effects of immigrant herbivores on native vegetation.

H. Nadel and her coauthors, J.H. Frank and R.J. Knight, discuss the weedy figs of southern Florida and the immigrant agaonid wasps that routinely pollinate them. They note that other immigrant wasps occupy the fruits of one of these fig species and may interact with the pollinators, and that more complex interactions likely occur among the diverse inhabitants of the fruits of native figs. They suggest that non-pollinating fig faunas, because of their potentially negative effect on agaonid populations, may play a role in control of weedy figs.

S. Koptur examines nectar-drinking ant abundance, recruitment of these ants to baits, and proportion of plants with extrafloral nectaries in three habitats in the Everglades. She finds that the habitat with the highest ant abundance and recruitment also has the most plants with extrafloral nectaries. As these ants are potential protectors
of plants against herbivores, they may reduce the abundance of native herbivores and reduce the amount of colonization and the persistence of immigrant herbivores in the habitats in which they are common.

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