# Introduction To
# THE BEHAVIORAL ECOLOGY OF INTRODUCTION

# THE INTRODUCTION OF INSECTS INTO FLORIDA

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ABSTRACT

About 351 insect species have been introduced into Florida for potential release since 1890, though many were never released. Published and unpublished records show that 154 were released, almost all of them (151) as biological control agents of insect pests and weeds. An estimated 24.5% and 66.7% of the species released against insect pests and weeds, respectively, established populations in Florida. The proportion of insect predators (26.7%) was very similar to that of insect parasitoids (23.9%) established. Insect pests targeted were mainly Homoptera (48%), Lepidoptera (24%), and Coleoptera (10%). Most of the insect pests (79%) and weeds (75%) targeted are not native to Florida; 43% of the insect pests are native to Asia, and 50% of the weeds are native to South America. None of the native insect pests and weeds targeted occurs only in Florida. There was no clear relationship of the number of individuals released, nor of their geographic origin, nor of the county in which they were released, to the probability of establishment.

RESUMEN

Desde 1890, cerca de 351 especies de insectos han sido introducidas en Florida con la intención de ser liberadas, aunque muchas de ellas nunca lo fueron. Reportes publicados, así como inéditos, muestran que 154 especies fueron liberadas en el campo, casi todas (151) como agentes de control biológico contra insectos plagas y malezas. Se calcula que un 24,5% de las especies liberadas contra insectos plaga y un 66,7% de las especies liberadas contra malezas lograron establecer poblaciones en Florida. La proporción de especies depredadoras establecidas (26,7%) es muy similar a la proporción de especies parasitoides estableGidas (23,9%). Las plagas contra las cuales las liberaciones fueron hechas, son principalmente Homoptera (48%), Lepidoptera (24%) y Coleoptera (10%). La mayoría de los insectos plaga (79%) y malezas (75%) involucradas no son nativas de Florida; 43% de los insectos plaga son originarios de Asia y 50 de las malezas son nativas de Sur América. Ninguna de estas especies de insectos plaga o malezas ocurren exclusivamente en Florida. No existe una clara relación entre la probabilidad de establecimiento del agente de control biológico y el número de individuos liberados, su origen geográfico o el condado donde se liberaron.

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Insects have been introduced into countries around the world for various purposes. Perhaps the most common purpose, at least in this century, has been for biological control (see Sailer 1972, van den Bosch & Messenger 1973, DeBach 1974, DeBach &

Rosen 1976). Perkins & Swezey (1924) and Imms (1926) provide insights into some of the earliest organized biological control efforts in the USA, in Hawaii.

Documenting the history of insect introductions into any region is a daunting, yet important task. Laing & Hamai (1976), Clausen (1978), Luck (1981), and Funasaki et al. (1988) provide examples of tabulations of the biological control agents introduced into various regions. Denmark (1964) and Denmark & Porter (1973) previously have documented the introduction of biological control agents into Florida, and here we expand the scope of documentation, and bring it up-to-date. The current review complements our previous review of Florida's recent immigrant insects (Frank & McCoy 1992).

## METHODS

We chose to include in our list of introduced insects all taxa that could be verified as legitimate introductions (see Frank & McCoy 1990). Where some question exists as to the legitimacy of a particular introduction, we have so indicated. Because most introduced insects were imported as biological control agents, we also have included a list of targets of these agents. It should not be assumed that the species included on the list of targets are necessarily important pests, nor that species not included on the list are necessarily unimportant pests. Particularly in what might be considered the "early days" of biological control, before World War II, insect species might have been considered important pests based on wrongful information [see Eichmann 1943, see *Ignelater luminosus* (Illiger) (Coleoptera: Elateridae) in Table 2] or important pests might even have been misidentified (see Clausen 1942, see *Metaphycus helvolus* (Compere) (Hymenoptera: Encyrtidae) in Table 2].

We constructed our tabulations of introduced insects and of targets from both published and unpublished records. We then verified the tabulation by consulting authorities on the included taxa and biological control practitioners. We cannot guarantee completeness, however. More specific information on the methods employed to construct tabulations of the two kinds of organisms follows.

### *Targets of Classical Biological Control Efforts*

Our tabulation of pest organisms that have been targeted in Florida for classical biological control (Table 1) includes a variety of information. We have given, when we have the information, the pest organisms' most widely used common names, their probable geographical origins, their exact (when documented) or probable decades of arrival in Florida, and the economic and/or ecological beneficiaries of their control (e.g., crops attacked).

Some biological control agents were imported with the notion of releasing them against *Parlatoria ziziphi* (Lucas) and *Toxoptera citricida* (Kirkaldy). Any releases of these agents ultimately were made against other pests, however (*T. citricida* does not even occur in Florida), so we have not included them in our tabulation. Other agents were introduced against *Heliothis* spp. and *Spodoptera* spp., but without specification of which particular species were the intended targets. We refrained from guessing, and included in our tabulation only the species of those genera that we know were targets.

We tried to distinguish between adventive pests and those that are native to Florida, although a few ambiguities remain. Adventive pests are those of foreign origin, and they may be subdivided into those that immigrated and those that were introduced (see Frank & McCoy 1990 for definitions of these and related terms).

For some immigrant pests, a record of their arrival in Florida exists. For example, *Leptinotarsa decemlineata* (Say) (Coleoptera: Chrysomelidae) migrated eastward from the Rocky Mountains after the widespread planting of potatoes provided a food source.

TABLE 1. PEST ORGANISMS THAT HAVE BEEN TARGETED IN FLORIDA FOR CLASSICAL BIOLOGICAL CONTROL, WITH THEIR COMMON NAMES, PROBABLE ORIGINS, EXACT OR PROBABLE DECADE OF ARRIVAL IN FLORIDA, AND ECONOMIC/ECOLOGICAL IMPACTS. A = ADVENTIVE, N = NATIVE, NA = NORTH AMERICA, CA = CENTRAL AMERICA, SA = SOUTH AMERICA, AF = AFRICA, AS = ASIA, AU = AUSTRALIA, EU = EUROPE, WI = WEST INDIES, FIN = FREQUENT IMMIGRANT FROM THE NORTHERN USA (EUROPEAN ORIGIN), FIS = FRQUENT IMMIGRANT FROM THE WEST INDIES AND/OR OVERWINTERS IN SOUTH FLORIDA.

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COLEOPTERA: CHRYSOMELIDAE

*Leptinotarsa decemlineata* (Say), Colorado potato beetle. A: NA, 1920, potato

COLEOPTERA: COCCINELLIDAE

*Epilachna varivestis* Mulsant, Mexican bean beetle. A: NA/CA, 1920, beans

COLEOPTERA: CURCULIONIDAE

*Anthonomus grandis* Boheman, boll weevil. A: NA, 1910, cotton

*Asynonychus godmanni* Crotch, Fuller rose weevil. A: SA, 1870, citrus/ornamentals

*Diaprepes abbreviatus* (L.), Apopka weevil OR cane root borer. A: WI, 1960, citrus/sugarcane

*Hypera postica* (Gyllenhal), alfalfa weevil. A: Eu, 1970, alfalfa and other legumes

COLEOPTERA: SCARABAEIDAE

*Euetheola humilis* (LeConte), sugarcane beetle. N, sugarcane

DIPTERA: CULICIDAE

*Aedes aegypti* (L.), yellow fever mosquito. A: Af, <1850, humans

DIPTERA: MUSCIDAE

*Musca domestica* L., house fly. A: Af, <1850, humans/livestock

*Stomoxys calcitrans* (L.), stable fly. A: Af, 1900, livestock

DIPTERA: TEPHRITIDAE

*Anastrepha suspensa* (Loew), Caribbean fruit fly. A: WI, 1920, fruits/citrus

HEMIPTERA: PENTATOMIDAE

*Nezara viridula* (L.), southern green stinkbug. A: Af, <1850, vegetables

HEMIPTERA: TINGIDAE

*Leptodictya tabida* (Herrich-Schaeffer), sugarcane lace bug. A: NA/CA/SA, 1990, sugarcane

HOMOPTERA: ALEYRODIDAE

*Aleurocanthus woglumi* Ashby, citrus blackfly. A: As, 1930/1970, citrus

*Aleurodicus disperus* Russell, spiralling whitefly. A: WI/CA/SA, 1950, citrus/coconut

*Bemisia tabaci* Gennadius, sweetpotato whitefly. A: As, 1890, field crops/ornamentals

*Dialeurodes citri* (Ashmead), citrus whitefly. A: As, 1870, citrus/ornamentals

*Dialeurodes citrifolii* (Morgan), cloudywinged whitefly. A: As, 1900, citrus

HOMOPTERA: APHIDIDAE

*Acyrthosiphon pisum* (Harris), pea aphid. A: Eu/As, 1900, peas/alfalfa

*Aphis gossypii* Glover, cotton aphid. N, cotton/curcurbits

*Aphis spiraecola* Patch, spirea aphid. A: As, 1920, citrus

*Myzus persicae* (Sulzer), green peach aphid. N, fruits

*Sipha flava* (Forbes), yellow sugarcane aphid. N, sugarcane

*Therioaphis maculata* (Buckton), spotted alfalfa aphid. A: Eu/As, 1960, alfalfa/clover

*Toxoptera aurantii* (Fonscolombe), black citrus aphid. ?, ?, citrus

TABLE 1. (Continued)

HOMOPTERA: COCCIDAE

*Ceroplastes cirripediformis* Comstock, barnacle scale. A: As, 1870, citrus/ornamentals
*Coccus hesperidum* L., brown soft scale. A: As, 1870, citrus
*Saissetia neglecta* DeLotto, Caribbean black scale. N?, citrus

HOMOPTERA: DELPHACIDAE

*Perkinsiella saccharicida* Kirkaldy, sugarcane leafhopper. A: Au,1980, sugarcane
*Saccharosydne saccharivora* (Westwood), West Indian canefly. A: WI, ?, sugarcane

HOMOPTERA: DIASPIDIDAE

*Aonidiella aurantii* (Maskell), California red scale. A: As, 1890, citrus
*Aspidiotus destructor* Signoret, coconut scale. A: As, 1910, coconut
*Chrysomphalus aonidum* (L.), Florida red scale. A: As, 1880, citrus
*Fiorinia theae* Green, tea scale. A: As, 1910, camellia/citrus
*Lepidosaphes beckii* (Newman), purple scale. A: As, 1850, citrus
*Pseudaulacaspis cockerelli* (Cooley), false oleander scale. A: As, 1940, ornamentals
*Pseudaulacaspis pentagona* (Targioni-Tozzetti), white peach scale. A: As, 1880, fruits/ornamentals
*Unaspis citri* (Comstock), citrus snow scale. A: As, 1880, citrus
*Unaspis euonymi* (Comstock), euonymus scale. A: As, 1960, ornamentals

HOMOPTERA: MARGARODIDAE

*Icerya purchasi* Maskell, cottony cushion scale. A: Au, 1890, citrus

HOMOPTERA: PSEUDOCOCCIDAE

*Antonina graminis* Maskell, Rhodesgrass mealybug. A: As, 1940, grasses
*Dysmicoccus boninsis* (Kuwana), gray sugarcane mealybug. A: As, 1960, sugarcane
*Dysmicoccus brevipes* (Cockerell), pineapple mealybug. A: SA, 1910, sugarcane/pineapple
*Planococcus citri* (Risso), citrus mealybug. A: As, 1890, citrus
*Saccharicoccus sacchari* (Cockerell), pink sugarcane mealybug. A: Af, 1940, sugarcane

HYMENOPTERA: DIPRIONIDAE

*Neodiprion lecontei* (Fitch), redheaded pine sawfly. N, pine trees

HYMENOPTERA: FORMICIDAE

*Solenopsis invicta* Buren, red imported fire ant. A: SA, 1940, humans

LEPIDOPTERA: GELECHIIDAE

*Pectinophora gossypiella* (Saunders), pink bollworm. A: As, 1950, cotton

LEPIDOPTERA: GEOMETRIDAE

*Epimecis detexta* (Walker), avocado looper. N, avocado

LEPIDOPTERA: LASIOCAMPIDAE

*Malacosoma disstria* (F.), forest tent caterpillar. N, trees

LEPIDOPTERA: LYMANTRIIDAE

*Lymantria dispar* (L.), gypsy moth. A: FIN, trees

LEPIDOPTERA: NOCTUIDAE

*Alabama argillacea* (Hübner), cotton leafworm. A: SA/FIS, cotton
*Anticarsia gemmatalis* HGbner, velvetbean caterpillar. A: FIS, field crops
*Helicoverpa zea* (Boddie), corn earworm. N, cotton/field crops
*Heliothis virescens* (Boddie), tobacco budworm. N, field crops
*Pseudoplusia includens* (Walker), soybean looper. A: FIS, field crops

*Spodoptera frugiperda* (J. E. Smith), fall armyworm. N, field crops
*Trichoplusia ni* Hübner, cabbage looper. N, field crops

LEPIDOPTERA: PYRALIDAE

*Diaphania hyalinata* (L.), melonworm. A: FIS, cucurbits
*Diaphania nitidalis* Stoll, pickleworm. A: FIS, cucurbits
*Diatraea saccharalis* (F.), sugarcane borer. A: WI/CA/SA, 1860, sugarcane
*Elasmopalpus lignosellus* (Zeller), lesser cornstalk borer. N, field crops

EPIDOPTERA: YPONOMEUTIDAE

*Plutella xylostella* (L.), diamondback moth. A: Eu/Af, ?, cole crops

ORTHOPTERA: GRYLLOTALPIDAE

*Scapteriscus abbreviatus* Scudder, short-winged mole cricket. A: SA, 1900, grasses
*Scapteriscus borellii* Giglio-Tos, southern mole cricket. A: SA, 1900, grasses
*Scapteriscus vicinus* Scudder, tawny mole cricket. A: SA, 1900, grasses

THYSANOPTERA: THRIPIDAE

*Selenothrips rubrocinctus* (Giard), red-banded thrips. A: As, ?, fruits

ARALES: ARACEAE

*Pistia stratiotes* L., waterlettuce. N?, waterways

CAROPHYLLALES: AMARANTHACEAE

*Alternanthera philoxeroides* (Martius) Grisebach, alligatorweed. A: SA, 1890, waterways

HALORAGALES: HALORAGACEAE

*Myriophyllum spicatum* L., Eurasian watermilfoil. A: Eu/As, 1960, waterways

HYDROCHARITALES: HYDROCHARITACEAE

*Hydrilla verticillata* (Lf.) Royle, hydrilla. A: Eu/As, 1960, waterways

LAMIALES: VERBENACEAE

*Lantana camara* L., lantana. N, pastures

LILLIALES: PONTEDERIACEAE

*Eichhornia crassipes* (Martius) Solms, waterhyacinth. A: SA, 1880, waterways

MYRTALES: MYRTACEAE

*Melaleuca quinquenervia* (Cavanilles) S.T. Blake, melaleuca. A: Au, 1900, wetlands

SAPINDALES: ANACARDIACEAE

*Schinus terebinthifolius* Raddi, Brazilian peppertree. A: SA, 1890, woodlands

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Although it is native to the USA, it is not native to Florida. For another example, *Scapteriscus* spp. (Orthoptera: Gryllotalpidae) arrived as immigrants in the ballast of ships from southern South America. They are native neither to the USA nor to Florida.

For introduced pests, a written record of their arrival almost always exists. They were brought to Florida for various reasons and either were liberated in the wild or escaped into the wild. That they have become pests shows in retrospect that the reasons for their introductions were ill-considered. Only one insect species occurs among these introduced pests: *Icerya purchasi* Maskell (Homoptera: Margarodidae). In this incident, a citrus grower, unfamiliar with the concept of host-specificity, and before state regulations prohibited such action, imported in 1893 a specialist biological control agent [*Rodolia cardinalis* (Mulsant) (Coleoptera: Coccinellidae)], even though its prey, *I. purchasi*, did not then occur in Florida. The prey was imported simultaneously as food for the biological control agent and, while the agent dispersed and perished, the prey

TABLE 2. INSECTS IMPORTED INTO FLORIDA. THREE SYMBOLS ARE USED TO INDICATE THE FATE OF BIOCONTROL AGENTS THAT WERE RELEASED: * = SPECIES THAT BECAME ESTABLISHED, ~ = SPECIES THAT DID NOT BECOME ESTABLISHED, AND ? = SPECIES RELEASED VERY RECENTLY WHOSE FATE IS YET UNKNOWN. THIS CLASSIFICATION IGNORES RELEASES OF INSECTS THAT COULD NOT BE DISTINGUISHED FROM SPECIES ALREADY PRESENT IN FLORIDA, AND IT ASSUMES THAT INSECTS RELEASED SEVERAL YEARS AGO, BUT THAT HAVE NOT BEEN REPORTED SUBSEQUENTLY FROM FLORIDA, ARE NOT ESTABLISHED.

BLATTARIA: OXYHYDROIDAE

*Gromphadorina* sp., from Madagascar, brought to Florida without authorization by the pet trade and sold to the public; four of these giant hissing roaches were released in Tampa by a disgruntled owner who feared they would be confiscated and killed by Florida Dept. of Agriculture & Consumer Services inspectors (Chen 1989). ?

COLEOPTERA: BRUCHIDAE

*Lithraeus atronotatus* (Pic), from Brazil, imported in 1989 by D. H. Habeck against *Schinus terebinthifolius*, was not cultured and was not released (AD 1989, D. H. Habeck pers. comm.).

COLEOPTERA: CARABIDAE

*Calosoma argentinense* Csiki, from Argentina, released in 1941 and 1943-1944 and 1945-1946 against *Spodoptera frugiperda*, not established (Annand 1945, 1947, Clausen 1956, Gross & Pair 1986). ~

*Calosoma sycophanta* L., from Europe via the northeastern USA, 16 were released in 1915 in Alachua County, against *Anticarsia gemmatalis*, not established (Watson 1917, Dowden 1962). ~

*Pheropsophus aequinoctialis* (L.), from Uruguay, Brazil and Bolivia, imported into quarantine in 1986-1989, reared in quarantine and studied as a potential natural enemy of *Scapteriscus* spp. (Gryllotalpidae), but the studies were not completed due to lack of funds and are unpublished, and the surviving specimens ultimately were killed in quarantine (Frank 1990).

*Scarites* sp., from Trinidad, misidentified by shipper as *Pheropsophus* and imported in 1987, terminated in quarantine (AD 1987).

*Stenaptinus jessoensis* (Morawitz), from Japan, a known natural enemy of *Gryllotalpa*, imported in 1986 by J. H. Frank and studied in quarantine in comparison with *Pheropsophus aequinoctialis*; the specimens were reared through several generations on eggs of *Scapteriscus*, but ultimately all died in quarantine (Frank 1990).

COLEOPTERA: CHRYSOMELIDAE

*Agasicles hygrophila* Selman & Vogt, from Argentina, released in 1965-1972 against *Alternanthera philoxeroides*, in Alachua, Baker, Bradford, Broward, Calhoun, Citrus, Clay, Dixie, Duval, Escambia, Flagler, Glades, Hendry, Hillsborough, Marion, Palm Beach, Polk, Putnam, St. John's, St. Lucie, and Volusia counties, established; from Argentina via California, imported in 1974 by N. R. Spencer; from Argentina, imported and released in 1979 in Alachua County by G. R. Buckingham (Zeiger 1967, Denmark & Porter 1973, AD 1974, Coulson 1977, Buckingham et al. 1983, Buckingham & Habeck 1990). *

*Octotoma scabripennis* Guérin, from the Neotropical region via Australia, imported into quarantine in 1981-1982 as a potential biocontrol agent for *Lantana camara*, but died in quarantine (AD 1981, 1982, Habeck et al. in press, D. H. Habeck pers. comm.).

*Uroplata girardi* Pic, from the Neotropical region via Australia, imported into quarantine in 1981 as a potential biocontrol agent for *Lantana camara*, but died in quarantine (AD 1981, Habeck et al. in press, D. H. Habeck pers. comm.).

COLEOPTERA: CICINDELIDAE

*Megacephala fulgida* Klug, from Brazil, imported in 1985 by R. I. Sailer and studied in quarantine as a potential natural enemy of *Scapteriscus* mole crickets, reared through several generations by B. Munir and then by R. C. Hemenway, but never released; the surviving specimens ultimately were killed (Frank 1990).

COLEOPTERA: COCCINELLIDAE

*Brumoides suturalis* (F.), from Pakistan via New Jersey, released in 1954-1955 against *Dialeurodes citri*, aphids and other Homoptera on citrus and sugarcane in Orange, Lake, Marion, Indian River, St. Lucie, and other counties, not established (Selhime 1956, Denmark 1964, Charpentier et al. 1972, Gordon 1985, Browning 1990). ~

*Catana parcesetosa* (Sicard), from Pakistan, released in 1956 from Orlando (Orange County) against *Dialeurodes citri*, not established (Denmark 1964, Gordon 1985). ~

Chilocorus *cacti* (L.), from Jamaica, imported in 1989 by F. D. Bennett for laboratory comparison with native material of this species, not released (AD 1989).

*Chilocorus kuwanae* Silvestri, from Japan via Maryland and Delaware, a predator of Diaspididae, brought to Florida in 1989, by F. D. Bennett as a potential biocontrol agent of *Fiorinia theae*, *Unaspis euonymi* and *U. citri*, but material died in quarantine (BIRL 1992, F. D. Bennett pers. comm.)

*Chilocorus nigritus* F., from Pakistan or India, imported in 1910 or 1911 by R. S. Woglum against *Aonidiella aurantii*, but without record of release (Woglum 1913).

*Coccidophilus* sp., perhaps *citricola* Brèthes, from Brazil, imported in 1989 by H. W. Browning against *Unaspis citri*, but adults died in quarantine (AD 1989, H. W. Browning pers. comm.).

*Coccinella septempunctata* L., from India, released in Gadsden County in 1958 against *Myzus persicae* and *Therioaphis maculata*, not established; 3,400 eggs and larvae released in 1959 in two fields against *Sipha flava*, not established, even though it fed on this prey in the laboratory; approved for importation in 1960 under the name "*C. punctata*", and approved for importation in 1961; later established in the northeastern USA and brought from New Jersey via Delaware to Florida by R. I. Sailer in 1976 and released in 1976-1977 against *Acyrthosiphon pisum*, now established and spread widely in Florida (Denmark 1964, Charpentier et al. 1972, Denmark & Porter 1973, Angalet & Jacques 1975, Angalet et al. 1979, Gordon 1985, Mizell & Tedders 1990, BIRL 1992). *

*Coelophora inaequalis* (F.), from Hawaii via Puerto Rico, 19 adults were released at two sites against *Sipha flava* in 1939, establishment was uncertain at first, but was clear by the late 1970s (Charpentier et al. 1972, Clausen 1956, 1978, Gordon 1985, Bennett et al. 1990). *

*Cryptognatha gemellata* Mulsant, from Trinidad, released in 1936 against *Aspidiotus destructor*, not established (Dohanian 1937, Gordon 1985). ~

*Cryptognatha nodiceps* Marshall, from Trinidad, released in 1936 and 1938 against *Aspidiotus destructor* in Dade County, established (Dohanian 1937, Bartlett 1938, Clausen 1956, Rosen & DeBach 1978, Gordon 1985). *

*Cryptolaemus montrouzieri* Mulsant, from Australia via California, imported in 1930 against *Planococcus citri*, established (Watson & Thompson 1933, Muma 1955, Denmark 1964, Gordon 1985, Browning 1990). *

TABLE 2. (Continued)

*Delphastus catalinae* (Horn), from California, 12 individuals imported in September 1916, reared in a laboratory and released into an insectary; more were imported in 1917 and released against *Dialeurodes citri*; the finding of numerous *Delphastus* individuals in 1918 at a release site prompted distribution to other sites in several counties (Watson 1917, 1918a,b, 1919, 1920, 1921, 1922, 1923a, 1924, Merrill 1922, Muma 1955, Denmark 1964, Browning 1990). The identity of this insect is an enigma because *D. catalinae* is now restricted to a small area of California, while a second species [*D. pallidus* (LeConte)] was described from Florida in 1878 and is restricted to Florida, and a third [*D. pusillus* (LeConte)] occurs throughout the southern tier of states (Gordon 1985). No voucher material of the insects imported from California seems to exist; no specimens of *D. catalinae* could be found in the Florida State Collection of Arthropods in 1992, though specimens collected at Cortez, Manatee County, on 14-I-1918 are in the Florida State Collection of Arthropods. The last were identified by H. B. Swartsel (the collector) as *D. catalinae*, but in 1921 were identified by A. J. Mutchler (American Mus. Nat. Hist.) as *D. pusillus*. A letter from Mutchler to Merrill concerning them is in the archives of the Florida Department of Agriculture and Consumer Services. The explanation may be that Watson and Merrill deluded themselves into believing that *D. catalinae* had become established in Florida - but they were dealing with specimens of *D. pusillus*, which is native to Florida. ~

*Delphastus pusillus* (LeConte), from California, imported by J. R. Watson in 1917 under its junior synonym *D. sonoricus* Casey against *Dialeurodes citri*, though not specified whether released, but *D. pusillus* is a widespread species which already was present in Florida (Merrill 1922).

*Delphastus* sp. A. ("mottled brown"), from Puerto Rico, imported by H. Spencer (Subtropical Insect Laboratory, USDA, Orlando) in May 1938 against *Aspidiotus destructor*, 800 individuals, 738 were released, not established (Bartlett 1938, 1939, Clausen 1956, Rosen & DeBach 1978); this may have been *Delphastus nebulosus* Chapin (F. D. Bennett, pers. comm.). ~

*Delphastus* sp. B. ("black"), from Puerto Rico, imported by H. Spencer (Subtropical Insect Laboratory, USDA, Orlando) in May 1938 against *Aspidiotus destructor*, 49 individuals, 44 were released, not established (Bartlett 1938, 1939, Clausen 1956, Rosen & DeBach 1978; this may have been *Zilus variipennis* (Sicard) and/or *Z. gilvifrons* Chapin (F. D. Bennett, pers. comm.). ~

Egius *platycephalus* Mulsant, from Puerto Rico, imported in 1988 by F. D. Bennett against *Parlatoria ziziphi*, failed to breed, and no releases were made (AD 1988).

*Harmonia dimidiata* (F.), from China via California, released in 1925-1926 against *Aphis spiraecola*, established [mentioned in earlier literature at first as *Leis conformis* (Boisduval), presumably by confusion of identity, and then as *Leis dimidiata 15-spilota* and *L. d. quinquedecimmaculata* (Hope)], established (Watson & Thompson 1933, 1940, 1941, Denmark 1964, Clausen 1978, Gordon 1985, Browning 1990). *

*Hippodamia convergens* Guérin, perhaps from Texas, released in 1930 against aphids; permit issued in 1966 for its importation and release against aphids, but is native to Florida (Denmark 1964, Denmark & Porter 1973 (F. D. Bennett, pers. comm).

*Hippodamia variegata* (Goeze), from India, 900 adults and 7,950 eggs were released in Gadsden and Palm Beach counties and perhaps other localities in 1957 against *Acyrthosiphon pisum*, *Myzus persicae*, *Sipha flava*, *Therioaphis maculata*, and other aphids, 94 adults and 212 eggs in 1958, not established (Denmark 1964, Charpentier et al. 1972, Gordon 1985, Jackson 1990). ~

*Menochilus sexmaculatus* (F.), from Pakistan or India, imported in 1910 or 1911 against [citrus] aphids by R. S. Woglum, released; from India via Texas, imported in 1954 by A. G. Selhime, released in 1955 in Indian River, St. Lucie, Lake, Marion, Orange and Seminole counties against "citrus aphids", not established (Essig 1931, Selhime 1955, Gordon 1985). ~

*Nephaspis oculata* (Blatchley), from Hawaii, 600 released in 1982 in Broward County and 600 in Dade County under the erroneous name *Nephaspis amnicola* by R. I. Sailer and C. R. Thompson against *Aleurodicus dispersus*, but occurred already in Florida (AD 1982, ROBO 1982, Bennett & Noyes 1989).

*Nephus binaevatus* (Mulsant), from California, imported in 1923 by J. R. Watson against mealybugs, but not specified whether released, and not now present in Florida (Watson 1923b).

*Pentilia castanea* Mulsant, from Trinidad, over 600 individuals were imported and the survivors were released in 1936 against *Aspidiotus destructor*, but the species did not become established (Dohanian 1937); there is uncertainty over the identification because specimens were identified as above by USDA taxonomists, whereas in Trinidad the species was recorded as *P. insidiosa* Mulsant (Dohanian 1937); a species under the latter name from Trinidad was distributed to Bermuda, Fiji, Principe, and Puerto Rico (Bartlett 1978). ~

*Pentilia egena* Mulsant, from Brazil, imported in 1989 by H. W. Browning against *Unaspis citri*, but no releases were made (AD 1989, H. W. Browning pers. comm.).

*Pseudoazya trinitatis* (Marshall), from Trinidad via Puerto Rico, released in 1938 against *Aspidiotus destructor* in Dade County; specimens were found in 1939 but not subsequently (Bartlett 1938, Clausen 1956, Rosen & DeBach 1978, Gordon 1985). ~

*Rhyzobius lophanthae* (Blaisdell), perhaps from Australia via California, but no records of the introduction into Florida have been located; this is an Old World species which either was introduced into Florida or immigrated from California (Gordon 1985).

*Rodolia cardinalis* (Mulsant), from Australia via California, released in 1893 by a commercial plant-growing business in Pinellas County, in misunderstanding of its use in biological control, but together (inadvertently) with its prey, *Icerya purchasi*, which resulted not in its establishment, but in establishment of its prey, causing a severe infestation, the first in Florida (Berger 1915); after ill-conceived attempts to control the pest by physical methods, *R. cardinalis* was reintroduced in 1899 from California and established in Pinellas County, leading to highly successful biological control. There surely cannot be any more perfect example of the principles of biological control. This example provides *prima facie* evidence of the need for regulation of importation of biocontrol agents; a further importation and release was approved in 1971 (Berger 1915, Merrill 1922, Denmark 1964, Denmark & Porter 1973, Mizell 1990). *

*Scymnus nubilis* Mulsant, from India, released (from Quincy) in Gadsden County in 1957 against *Myzus persicae* and *Therioaphis maculata*; in 1957, 66 adults and 126 eggs (from India) were released at at one site, and in 1958, 3,200 eggs were released at three sites, and in 1959, 800 adults were released at one site from Belle Glade (Palm Beach County) against *Sipha flava*, not established, even though the species was reared successfully in the laboratory on *Sipha flava* (Clausen 1959, Denmark 1964, Charpentier et al. 1972, Gordon 1985, Jackson 1990). ~

*Serangium flavescens* (Motschulsky) from Pakistan, imported in 1910 against *Dialeurodes citri* by R. S. Woglum, but specimens were dead upon arrival, imported in 191 by R. S. Woglum, but arrived in winter when prey was not avail-

TABLE 2. (Continued)

able, and all died before releases could be made (Woglum 1913, Gordon 1985, Browning 1990).

*Stethorus utilis* (Horn) (as *S. atomus* Casey), origin not stated, released in 1956 from Weirsdale (Marion County), but is native to Florida (Denmark 1964).

*Sticholotis madagassa* Weise, from India, an unsolicited shipment received in 1979, presumably against *Pseudaulacaspis* spp., dead on arrival in Florida (AD 1979).

*Zagloba aeneipennis* (Sicard), from Trinidad, released in 1936 against *Aspidiotus destructor*, not established (Dohanian 1937, Gordon 1985). ~

COLEOPTERA: CURCULIONIDAE

*Bagous affinis* Hustache, from India, imported in 1982-1983, 1986, and 1990-1991 by C. A. Bennett and G. R. Buckingham against *Hydrilla verticillata*, released in 1987 in Osceola County, established temporarily (AD 1982, 1983, 1986, 1990, 1991, Buckingham 1988, Buckingham & Habeck 1990). *

*Bagous dilgiri* Vazirani, from India, imported in 1983 by G. R. Buckingham against *Hydrilla verticillata*, terminated in quarantine (AD 1983, Bennett & Buckingham 1991, G. R. Buckingham pers. comm.).

*Bagous laevigatus* O'Brien & Pajni, from India, imported in 1983 and 1986 by G. R. Buckingham against *Hydrilla verticillata*, terminated in quarantine after host-range testing (AD 1983, 1986, G. R. Buckingham pers. comm.).

*Bagous vicinus* Hustache, from India, imported in 1983 by G. R. Buckingham against *Hydrilla verticillata*, terminated in quarantine (AD 1983, Bennett & Buckingham 1982, G. R. Buckingham pers. comm.).

*Bagous* n. sp., from Australia, imported in 1987, 1988, and 1991 by G. R. Buckingham against *Hydrilla verticillata*, released in 1991 in Broward, Palm Beach and Sumter counties, establishment still uncertain (AD 1987, 1988, 1991, Center 1992, G. R. Buckingham pers. comm.). ?

*Eubrychius* sp., from China, imported in 1991 by G. R. Buckingham against *Myriophyllum spicatum*, but culture was lost in quarantine (AD 1991, G. R. Buckingham pers. comm.).

*Neochetina bruchi* Hustache, from Argentina, imported in 1974 by N. R. Spencer against *Eichhornia crassipes*, released in 1974, established; imported in 1975 by G. E. Allen and released in Lee County (AD 1974, 1975, Perkins & Maddox 1976, Grissell 1978, Cassani et al. 1981, Center & Durden 1986, Haag 1986, Buckingham & Habeck 1990). *

*Neochetina eichhorniae* Warner, from Argentina, released in 1972 first in Broward County against *Eichhornia crassipes*, established; released in 1974 in Glades and Lee counties; imported in 1975 by G. E. Allen (Perkins 1973, AD 1975, Cassani et al. 1981, Center & Durden 1986, Haag 1986, Buckingham & Habeck 1990). *

*Neohydronomus affinis* Hustache, from Brazil via Australia, imported in 1986 and 1988 by D. H. Habeck against *Pistia stratiotes*, released in 1987-1988 in Broward, Palm Beach, and St. Lucie counties, established [mentioned earlier by error as *N. pulchellus* Hustache], now widely distributed in Florida (AD 1986, 1988, Thompson & Habeck 1989, Buckingham & Habeck 1990, Dray et al. 1990, D. H. Habeck pers. comm.). *

*Omolabus piceus* Germar, from Brazil, imported in 1989 by D. H. Habeck against *Schinus terebinthifolius*, not released (AD 1989, D. H. Habeck pers. comm.).

*Oxyops vitiosa* Pascoe, from Australia, imported into quarantine in 1992 as a potential biocontrol agent for *Melaleuca quinquenervia*, not released (Habeck et al. in press, D. H. Habeck pers. comm.).

*Phytobius leucogaster* (Marsham), from California, imported in 1978-1979 by G. R.

Buckingham against *Myriophyllum spicatum*, released in 1979 in Levy County, probably not established (AD 1978, 1979, Buckingham & Habeck 1990, G. R. Buckingham pers. comm.). ~

COLEOPTERA: ELATERIDAE

*Ignelater luminosus* (Illiger), from Puerto Rico, released in 1943 against scarab larvae, especially *Euetheola humilis* [given as *E. rugiceps* (LeConte), which is a synonym] attacking sugarcane, though it is other genera and species of Scarabaeidae, not this one, which have been implicated as pests of sugarcane in Florida; not established (Annand 1944, Clausen 1956). ~

COLEOPTERA: PSELAPHIDAE

*Fustiger elegans* Raffray, from Argentina, imported in 1987 by D. P. Wojcik against *Solenopsis invicta*, not released (AD 1987, D. P. Wojcik pers. comm.).

DIPTERA: CECIDOMYIIDAE

genus and species indet. (three species), from Brazil, imported in 1992 by F. D. Bennett as potential biocontrol agents for *Schinus terebinthifolius* (F. D. Bennett pers. comm.).

DIPTERA: CHIRONOMIDAE

*Polypedilum dewulfi* Goetghebuer, from Burundi, imported in 1990 by G. R. Buckingam & C. A. Bennett against *Hydrilla verticillata* (AD 1990, G. R. Buckingham pers. comm).

*Polypedilum wittae* (Freeman), from Burundi, imported in 1990 by G. R. Buckingam & C. A. Bennett against *Hydrilla verticillata* (AD 1990, G. R. Buckingham pers. comm).

DIPTERA: CRYPTOCHETIDAE

*Cryptochetum iceryae* (Williston) [not *C. monophlebi* Skuse], from Australia via California, imported in 1917 and released against *Icerya purchasi* in Pinellas County, and reported as established (Thorpe 1930, Denmark 1964, Bartlett 1978), but not seen in recent years (F. D. Bennett pers. comm.). *

DIPTERA: CULICIDAE

*Toxorhynchites amboinensis* (Doleschall), from Indo-Malaysia via Louisiana, released ca. 1986 and in subsequent years in Duval and St. Lucie counties against *Aedes aegypti* and other mosquitoes whose larvae inhabit artificial containers, does not survive winters and is not established (G. A. Curtis pers. comm., E. Schreiber pers. comm.). ~

*Toxorhynchites splendens* (Wiedemann), from Burma via Hawaii, Indiana, and Louisiana, released in Bay County in 1986-1988, in Leon and Sarasota counties in 1990, in Palm Beach and Walton counties in 1991, and in Hillsborough County in 1992, against *Aedes aegypti* and other mosquitoes whose larvae inhabit artificial containers, has not survived the winter at any of the localities (E. Schreiber, pers. comm.). ~

DIPTERA: EPHYDRIDAE

*Hydrellia balciunasi* Bock, from Australia, imported in 1988, 1989 and 1991 by G. R. Buckingham against *Hydrilla verticillata*, released in 1989 in Broward County, in 1990 in Broward County, and in 1991 in Broward, Collier, and Sumter counties, establishment not certain (AD 1988, 1989, 1991, Buckingham & Habeck 1990, Center 1992, G. R. Buckingham pers. comm). ?

*Hydrellia pakistanae* Deonier, from India, Pakistan, and China, imported in 1986 and 1990 by G. R. Buckingham against *Hydrilla verticillata*, released in 1987 in Polk and Marion counties, in 1988 in Broward, Glades, and Palm Beach counties, in

TABLE 2. (Continued)

1989 in Broward, Glades, Osceola, and Polk counties, in 1990 in Broward, Glades, Jefferson, Lake, Okeechobee, Osceola, and Palm Beach counties, established (AD 1986, 1990, Buckingham 1988, Buckingham & Habeck 1990, Center 1992, G. R. Buckingham pers. comm.). *

*Hydrellia* sp., from India, China, and Japan, imported in 1990, 1991, and 1992 by G. R. Buckingham against *Hydrilla verticillata*, not yet released (AD 1990, G. R. Buckingham pers. comm.).

DIPTERA: SARCOPHAGIDAE

*Heliocobia rapax* (Walker), from Cuba, 65 puparia were imported in 1927 and released against *Diatraea saccharalis*; there were no recoveries (Charpentier et al. 1972). ~

DIPTERA: TACHINIDAE

*Archytas incertus* (Macquart), from Argentina, released in 1944 against *Spodoptera frugiperda*, not established (Clausen 1956, Gross & Pair 1986). ~

*Archytas* sp. (as *Pseudoarchytopsis* sp.), from Uruguay, imported in 1943-1944 against *Spodoptera frugiperda* (Annand 1945).

*Compsilura concinnata* (Meigen), from Europe via northeastern USA, 896 shipped to Alachua County in 1915, and 2,125 in 1916, against *Spodoptera frugiperda*, but numbers (if any) released seem not to have been recorded, not established (Dowden 1962). ~

*Evbrissa vittata* (Meigen) (as *Phania vittata*), from Japan via Delaware, imported in 1976 by W. H. Whitcomb as a potential biocontrol agent for *Nezara viridula*, though not reported by Jones (1988) as a parasitoid of this host (BIRL 1992).

*Hemisturmia* sp., from Puerto Rico, imported in 1991 by J. L. Capinera and H. A. Smith against *Diaphania hyalinata* and *D. nitidalis* (AD 1991, J. L. Capinera pers. comm.).

*Incamyia cuzcensis* Townsend, from Paraguay and Peru, imported in 1979 against noctuids (AD 1979).

*Incamyia* sp., from Paraguay and Peru, imported in 1979 against noctuids (AD 1979).

*Lixophaga diatraeae* (Townsend), from Cuba, Puerto Rico, and Trinidad, released in 1926-1927 (about 3,000 adults, from Cuba, at three sites) and 1936 (160 adults, from Puerto Rico, at three sites, in Hendry, Indian River, and Palm Beach counties) and 1938-1939 (27,292 adults, from Cuban stock, at one site) and 1948 (661 adults, from Cuba, at several sites) and 1949 (551 adults, from Cuba, at several sites) and 1950-1961 (82,674 adults, from Cuban stock, on one plantation in Indian River County: 11,441 in 1950, 10,185 in 1951, 8,703 in 1952, 9,803 in 1953, 11,555 in 1954, 10,914 in 1955, 11,937 in 1956, 8,786 in 1957, and 250 in 1961) and 1961 (491 puparia, from Trinidad, at one site) and 1967 (500 adults reared from material collected in southern Louisiana whose origin was Trinidad, in experimental plots) and 1969 (9,000 adults, from Trinidad, at several sites), against *Diatraea saccharalis*, but no recoveries were made; from Barbados via Trinidad, released in 1973 (28,500 adults in Palm Beach County and 18,000 in Hendry County), and from Louisiana via Mississippi, in 1974 (60,000 in Palm Beach County), augmentatively, but the program was discontinued; not recovered in recent years (Watson 1928, Annand 1944, Gifford 1964, Charpentier et al. 1967, 1972, Bennett 1971, Summers et al. 1976, Clausen & Oatman 1978, Hall 1986, Bennett et al. 1990, F. D. Bennett pers. comm.). ~

*Lixophaga sphenophori* (Villeneuve), from New Guinea (perhaps via Hawaii), released in 1963 or 1964 against *Diatraea saccharalis* [(though it is a natural enemy of *Sphenophorus* (Curculionidae)], not established (Gifford 1964). ~

*Lydella thompsoni* Herting, a palearctic species which is established in the northern USA, released (erroneously under the name *L. grisescens* Robineau-Desvoidy) in 1963 or 1964 against *Diatraea saccharalis*, not established (Gifford 1964). ~

*Metagonistylum minense* Townsend, from Brazil; 191 adults from stock imported from Puerto Rico (origin Brazil) were released in 1938 at three sites, and in 1939-1942, 3,000 adults from São Paulo, Brazil were released (against *Diatraea saccharalis* in Indian River County); recoveries were made in 1940-1941, 1943, and 1945, but not subsequently, and not established (Holloway & Mathes 1942, Scaramuzza & Ingram 1942, Annand 1944, Gifford 1964, Charpentier et al. 1972, Clausen 1978, Bennett et al. 1990).~

*Ormia depleta* (Wiedemann), from São Paulo, Brazil, imported in 1985-1986 by R. I. Sailer and in 1986-1989 by J. H. Frank, first bred by S. A. Wineriter in 1987 (Wineriter & Walker 1990), released in April 1988 in Alachua County and October 1988 in Manatee County against *Scapteriscus* spp., with subsequent releases in 1989-1992 in Baker, Broward, Citrus, Collier, Dade, Duval, Highlands, Hillsborough, Lee, Marion, Okaloosa, Orange, Osceola, Palm Beach, Pasco, Pinellas, Polk, St. John's, Sarasota, and Volusia counties, and now established widely in peninsular Florida (Frank 1990, Parkman & Frank 1992). *

*Paratheresia claripalpis* (van der Wulp), from Peru, over 4,000 adults released in 1932 in Palm Beach and Indian River counties, 46 adults released in 1936 in Indian River County, against *Diatraea saccharalis*, achieving up to 29% parasitism in 1936, but no longer present by 1964, when 390 adults from Trinidad were released at one site, and 1969 when 750 adults from Trinidad were released at one site, with only one specimen recovered; not established permanently (Jaynes 1938, 1939, 1939, Scaramuzza & Ingram 1942, Gifford 1964, Bennett 1971, Charpentier et al. 1972, Clausen 1978, Bennett et al. 1990). ~

*Phorocera* sp., from Argentina, imported in 1943-1944 against *Spodoptera frugiperda* (Annand 1945).

*Sturmiopsis inferens* Townsend, from India via Delaware, 156 adults and puparia were imported in 1962 by J. R. Gifford, 66 adults in 1964 by G. A. Mann, as a potential biocontrol agent for *Diatraea saccharalis*, which was parasitized in the laboratory, but no releases were made; more were imported in 1971 by T. E. Summers; a few were imported in 1974-1975 by N. R. Spencer among shipments of *S. parasitica*, acting as quarantine clearance for shipments to the sugarcane zone (Gifford 1964, Charpentier et al. 1972, AD 1974, 1975, BIRL 1992, N. R. Spencer pers. comm.).

*Sturmiopsis parasitica* (Curran) from Ghana via India, imported in 1974-1975 by N. R. Spencer, acting as quarantine clearance for shipments to the sugarcane zone, against *Diatraea saccharalis*, intended for release (AD 1974, 1975, N. R. Spencer pers. comm.).

*Sturmiopsis* sp., from India via Delaware, imported in 1964 by G. A. Mann as a biocontrol agent for *Diatraea saccharalis* (BIRL 1992).

*Trichopoda pilipes* (F.), from Hawaii (USA) via Delaware, imported in 1972 and 1973 by W. H. Whitcomb, from Montserrat via Delaware, imported in 1973 by W. H. Whitcomb and N. R. Spencer as a biocontrol agent for *Nezara viridula* (AD 1973, BIRL 1992, N. R. Spencer pers. comm.).

*Trichopoda* sp. (as *Trichopodopsis argentinensis* Blanchard), from Argentina via Delaware, imported in 1974 by W. H. Whitcomb and N. R. Spencer as a potential biocontrol agent for *Nezara viridula*, terminated in quarantine (AD 1974, BIRL 1992, N. R. Spencer pers. comm.).

*Trichopoda* sp., from Japan via Delaware, imported in 1976 by W. H. Whitcomb against *Nezara viridula* (AD 1976).

genus and species indet., from Argentina via Delaware, imported in 1974 by N. R.

TABLE 2. (Continued)

Spencer against *Alabama argillacea*, terminated in quarantine (AD 1974, N. R. Spencer pers. comm.).

genus and species indet., from Brazil, imported in 1975 by W. H. Whitcomb against *Anticarsia gemmatalis* and *Pseudoplusia includens* (AD 1975).

genus and species indet., from Argentina, imported in 1979 against *Spodoptera* spp. (AD 1979).

genus and species indet., from Colombia, emerged in quarantine from *Urbanus proteus* L. which was imported by R. I. Sailer in 1982 as host for *Ardalus* sp. (AD 1982).

HEMIPTERA: MIRIDAE

*Tytthus mundulus* (Breddin), from Hawaii, imported in 1982-1984 by H. A. Denmark, R. Nguyen, D. L. Harris, and O. Sosa against *Perkinsiella saccharicida*, released in 1982-1984 in Hendry and Palm Beach counties (201 in Palm Beach County and 20 in Hendry County in 1982-1983), but not established (AD 1982, 1983, 1984, ROBO 1982, 1983, Nguyen et al. 1984, Bennett et al. 1990). ~

HEMIPTERA: PENTATOMIDAE

*Cantheconidia furcellata* (Wolff) (also as *Eocanthecona furcellata* (Wolff)), from Thailand, imported in 1980 by J.-M. Tseng and R. I. Sailer as a predator of *Malacosoma disstria*, *Anticarsia gemmatalis*, *Pseudoplusia includens* (Walker), and *Leptinotarsa decemlineata* (Say), released in 1981 in Alachua (13,000) and Gadsden (756) counties (AD 1980, ROBO 1981, Stange 1982). ~

HEMIPTERA: REDUVIIDAE

*Zelus longipes* (L.), from Jamaica via Trinidad, 275 adults were released in 1959 against *Saccharosydne saccharivora*, but already was present in Florida (Bennett 1960, Simmonds 1969, Charpentier et al. 1972, Bennett et al. 1990, F. D. Bennett pers. comm.).

HYMENOPTERA: APHELINIDAE

*Aphelinus asychis* Walker (as *A. semiflavus* Howard), from Israel, 890 adults were released in 1957 at one site against *Sipha flava*, and some specimens were obtained later in the field, but without permanent establishment (Denmark 1964, Charpentier et al. 1972). ~

*Aphelinus flavipes* (Foerster), from Taiwan via Delaware, imported and released in 1972 and 1973 by N. R. Spencer as a biocontrol agent for *Myzus persicae*, released in Alachua County, but could not be differentiated from native species so establishment uncertain (BIRL 1972, N. R. Spencer pers. comm.).

*Aphelinus gossypii* Timberlake, permit issued in 1969 for its importation and release in Florida; from Hong Kong, imported as a biocontrol agent of *Aphis spiraecola* in 1988 by F. D. Bennett, but lost in quarantine due to activity of an accompanying hyperparasite, *Tassonia gloriae* Girault (Hym.: Encyrtidae), and to a shortage of host material (Denmark & Porter 1973, AD 1988, Mizell & Tedders 1990).

*Aphytis aonidiae* (Mercet) (as *A. citrinus* Compere), permit issued in 1967 for its importation and release in Florida, probably against *Aonidiella aurantii* (Denmark & Porter 1973).

*Aphytis coheni* DeBach, permit issued in 1967 for its importation into Florida, presumably against *Aonidiella aurantii* (Denmark & Porter 1973).

*Aphytis gordoni* DeBach & Rosen, from Hong Kong via Delaware, imported in 1971 by A. G. Selhime as a potential biocontrol agent for *Unaspis citri* (Selhime & Brooks 1979, BIRL 1992).

*Aphytis holoxanthus* DeBach, from Hong Kong via Israel, New Jersey, and California, 15,500 adults imported by D. W. Clancy in 1960 and released against *Chrysomphalus aonidum* in Lake, Orange, Polk, Hillsborough, and DeSoto counties, es-

tablished by 1961 and very successful, and by mid-1964 had dispersed over the entire citrus-growing area; imported in 1989 by H. W. Browning (as *Aphytis* sp.) before specific identity was known, not released (Clancy et al. 1963, Denmark 1964, Selhime et al. 1969, Denmark & Porter 1973, Selhime & Brooks 1979, McCoy 1985, Browning 1990, H. W. Browning pers. comm.). *

*Aphytis lepidosaphes* Compere, from China via California, released in 1958 against *Lepidosaphes beckii* and *Chrysomphalus aonidum*, but had already arrived in Florida as an immigrant, discovered in 1958, and become established (Clancy & Muma 1959, Denmark 1964, Selhime & Brooks 1979, Rosen & DeBach 1978).

*Aphytis lingnanensis* Compere, from Hong Kong via New Jersey, imported in 1971 by A. G. Selhime and C. W. McCoy, and in 1972 by A. G. Selhime, released in 1971 against *Unaspis citri*, believed to have become established, but inability to distinguish material of this species from that of a presumed native species (*A.* sp. nr. *lingnanensis*) and three other imported strains of the same species from elsewhere have made definitive conclusions impossible; one of these strains was a hybrid between stock from Florida and from Puerto Rico, and the second was collected from *Aonidiella aurantii* in California; the third of the strains, from Thailand, was imported in 1989 (via Australia) and was released in 1990 by H. W. Browning (AD 1989, Selhime & Brooks 1979, McCoy 1985, Browning 1990, BIRL 1992, H. W. Browning pers. comm.).

*Aphytis* sp. nr. *lingnanensis* Compere, permit issued in 1972 for its importation and release, presumably against *Unaspis citri* (Denmark & Porter 1973).

*Aphytis melinus* DeBach, permit issued in 1971 for its importation and release in Florida, presumably against *Aonidiella aurantii* (Denmark & Porter 1973).

*Aphytis theae* (Cameron), from India, imported in 1975-1976 by N. R. Spencer against *Fiorinia theae*, released in Alachua County in 1976-1978 by F. Collins and W. H. Whitcomb, but did not survive the winters (AD 1975, 1976, Rosen & DeBach 1977, Grissell 1978, Munir & Sailer 1985, Mizell 1990, Bennett & Capinera in press). ~

*Aphytis yanonensis* DeBach & Rosen, from Japan via Texas, imported by F. D. Bennett in 1987, released against *Unaspis citri* (AD 1987, F. D. Bennett pers. comm.). ~

*Aphytis* sp., from China and Hong Kong, imported in 1986 by R. I. Sailer and in 1987 and 1988 by F. D. Bennett and J. H. Frank against *Parlatoria ziziphi*, died in quarantine (AD 1986, 1987, 1988, F. D. Bennett pers. comm.).

*Aphytis* sp., from Egypt, imported by H. W. Browning against *Parlatoria ziziphi*, died in quarantine (AD 1990, H. W. Browning pers. comm.).

*Aphytis* sp., from Hong Kong via Delaware, imported in 1973 by A. G. Selhime as a potential biocontrol agent for *Unaspis citri* (Denmark & Porter 1973, BIRL 1992).

*Aphytis* sp., from India, imported in 1979 and 1980 by G. R. Buckingham against *Pseudaulacaspis cockerelli*, not released (AD 1979, 1980, G. R. Buckingham pers. comm., H. B. Glenn pers. comm.).

*Aphytis* sp., from India, unsolicited, in 1985, against *Parlatoria ziziphi*, could not be cultured and was not released (AD 1986, H. B. Glenn pers. comm.).

*Aphytis* sp., from Japan via Texas, reared in quarantine on *Aspidiotus nerii* Bouch), 72,750 were released in Dade County against *Unaspis citri*, but not currently distinguishable from existing species, so establishment uncertain (H. B. Glenn pers. comm.).

*Aphytis* sp., from Puerto Rico, imported in 1990 against *Parlatoria ziziphi*, but not reared and not released (AD 1990, F. D. Bennett pers. comm.).

*Encarsia clypealis* (Silvestri), from Mexico, imported in 1976 by A. G. Selhime, released in Broward County against *Aleurocanthus woglumi*, not established (Dowell et al. 1979, Browning 1990). ~

TABLE 2. (Continued)

*Encarsia formosa* Gahan (most likely this species, from the neotropical region), brought to Florida in 1928-1929 as a potential natural enemy of *Dialeurodes citri*, though probably already occurred in Florida, where it attacks *Trialeurodes* and *Bemisia* (Watson 1930, F. D. Bennett pers. comm.).

*Encarsia* sp. near *formosa* (Gahan), from Mexico, imported in 1990 by F. D. Bennett against *Bemisia tabaci*, but not reared, and not released (AD 1990, F. D. Bennett pers. comm.).

*Encarsia* sp. nr. *haitiensis* Dozier, from the Caribbean via Hawaii, imported in 1982 against *Aleurodicus dispersus* by R. I. Sailer and C. R. Thompson, 10 released in 1982 in Broward County, but not established; also tested in quarantine against *Dialeurodes citrifolii* (AD 1982, ROBO 1982, Stange 1986, Bennett & Noyes 1989). ~

*Encarsia lahorensis* (Howard), imported from Pakistan in the winter of 1911-1912 by R. S. Woglum when host material was not available, and all died before releases could be made (Woglum 1913); from Pakistan via California, imported in 1975 by R. I. Sailer and placed in sleeve cages on trees in Alachua County; imported in 1977 by R. I. Sailer and released in Alachua County, later the same year in Polk County, established, with subsequent dissemination to 64 more of the 67 counties (e.g., released in Bay County in 1982 by J. A. Hogsette), against *Dialeurodes citri* (AD 1975, Nguyen & Sailer 1979, Grissell 1979, ROBO 1982, Sailer et al. 1984, Nguyen 1986, Browning 1990). *

*Encarsia lounsburyi* (Berlese & Paoli), from India, released in 1977 against *Fiorinia theae*, but was difficult to distinguish from a species already occurring in Florida under the same name, and establishment is uncertain (Bennett & Capinera in press, F. D. Bennett pers. comm.).

*Encarsia lutea* (Masi), from Israel, imported in 1990 by F. D. Bennett and R. Nguyen against *Bemisia tabaci*, and from Sudan, imported in 1991 by F. D. Bennett (AD 1990, 1991).

*Encarsia nigricephala* Dozier, from Mexico, imported by F. D. Bennett in 1990 against *Bemisia tabaci*, and from Guatemala, imported in 1991, but not bred and not released (AD 1990, 1991, F. D. Bennett pers. comm.).

*Encarsia opulenta* (Silvestri), from India via Mexico (in part via Texas), by A. G. Selhime, about 2,000 parasitoids were released in Broward County in 1976 against *Aleurocanthus woglumi*, established and highly successful (Hart et al. 1978, Grissell 1978, 1979, Selhime et al. 1982, McCoy 1985, Nguyen 1987, Browning 1990); released in Brevard (46,900), Lee (42,000), Martin (13,400) and Okeechobee counties in 1981 by W. Grandberry (Dowell et al. 1979, ROBO 1981). *

*Encarsia pergandiella* Howard, from Mexico, imported in 1990 by F. D. Bennett (as *E. tabacivora*) against *Bemisia tabaci*, and from Guatemala, imported in 1991, but already was present in Florida, so no attempt was made to culture or to release it (AD 1990, 1991, F. D. Bennett pers. comm.).

*Encarsia* sp. nr. *protransvena* Viggiani, from Puerto Rico, imported in 1988 by F. D. Bennett against *Dialeurodes citrifolii*, but not released (AD 1988, F. D. Bennett pers. comm.).

*Encarsia sankarani* Hayat, from India, imported into quarantine in 1976 by N. R. Spencer as a potential biological control agent for *Fiorinia theae*; believed to have been shipped to Dade County; there is no published record of its release, but it now occurs in south Florida (AD 1976, Hayat 1989, Bennett & Capinera in press, F. D. Bennett, pers. comm., N. R. Spencer pers. comm). *

*Encarsia smithi* (Silvestri), from India via Mexico, imported in 1979 as a contaminant

of *E. clypealis* cultures which in turn was imported as a biocontrol agent for *Aleurocanthus woglumi* at a time when its behavior (female larvae are parasitoids of *Aleurocanthus*, but male larvae are adelphoparasitoids of *Encarsia*) was not understood; released in 1979-1980 in several counties as a contaminant of laboratory cultures of *Encarsia opulenta*, in 1981 in Brevard (34) and Lee (7) counties by W. Grandberry, established (ROBO 1981, Holder & McCluskie 1982, Nguyen et al. 1983, Browning 1990). *

*Encarsia* sp., permit issued in 1971 for its importation into Florida against an unspecified pest (Denmark & Porter 1973).

*Encarsia* sp. (of *Citrina* Group) (as *Aspidiotiphagus* sp.), from Hong Kong via Delaware, imported in 1972 by A. G. Selhime as a potential biocontrol agent for *Unaspis citri* (BIRL 1992).

*Encarsia* spp., from the Cayman Islands, imported by F. D. Bennett in 1987 against *Dialeurodes citrifolii*, and from Puerto Rico, imported by F. D. Bennett in 1987 and 1989, and from the Dominican Republic, imported in 1990 by H. W. Browning; was neither cultured nor released (AD 1987, 1989, 1990, H. W. Browning pers. comm.).

*Encarsia* spp., from Brazil and Costa Rica and Grenada and Guadeloupe and Honduras and Mexico and Puerto Rico, imported in 1990 by F. D. Bennett against *Bemisia tabaci*, and from Brazil and Guatemala and Venezuela, imported in 1991 by F. D. Bennett (AD 1990, 1991).

*Encarsia* sp., from Jamaica, imported in 1989 by F. D. Bennett and H. W. Browning against *Unaspis citri*, not cultured and not released (AD 1989, H. W. Browning pers. comm.).

*Encarsia* sp., from Puerto Rico, imported in 1987 and 1990 by F. D. Bennett against *Parlatoria ziziphi*, not released (AD 1987, 1990).

*Encarsia* spp. (as *Aspidiotiphagus* sp.), from Hong Kong and China, imported in 1986, 1987, and 1988 by F. D. Bennett and J. H. Frank against *Parlatoria ziziphi*, reared on *Aspidiotus nerii*, 1,400 released in 1987 in Dade County against *Chrysomphalus aonidum* and *Pseudaulacaspis cockerelli*, 9,000 released in 1988 in Dade County against *Pseudaulacaspis cockerelli* and *Unaspis citri*, but not currently distinguishable from existing species, so establishment uncertain; from Hawaii in 1989, imported by F. D. Bennett, not released (AD 1986, 1987, 1988, H. B. Glenn pers. comm.).

*Encarsia* sp. (as *Aspidiotiphagus* sp.), from Japan via Texas, imported in 1988 by H. B. Glenn, reared on *Aspidiotus nerii*, 800 released in 1988 and 8,200 in 1989 against *Unaspis citri*, but not currently distinguishable from existing species, so establishment uncertain (H. B. Glenn pers. comm.).

*Encarsia* spp., from Hong Kong and China, imported in 1986 and 1988 by R. I. Sailer and F. D. Bennett against *Dialeurodes citrifolii*; was not bred in laboratory and was not released (AD 1986, 1988).

*Eretmocerus mundus* Mercet, from Israel, imported by F. D. Bennett and R. Nguyen in 1990, and from Sudan in 1991, against *Bemisia tabaci* (AD 1990, 1991).

*Eretmocerus* sp., from an unspecified country, released in 1952 from Winter Haven (Polk County) against *Dialeurodes citri*, not established (Denmark 1964, Browning 1990). ~

*Eretmocerus* spp., from California, imported by F. D. Bennett in 1989 against *Bemisia tabaci*, and 100 adults were shipped from quarantine to Bradenton (Manatee County) and 65 to Apopka (Orange County) with release intended; from Brazil, Costa Rica, Honduras, Mexico, and Puerto Rico, imported by F. D. Bennett in 1990, and from Brazil, Guatemala, and Venezuela, imported by F. D. Bennett in 1991 (AD 1990, 1991).

TABLE 2. (Continued)

*Pteroptrix chinensis* (Howard), from Hong Kong, imported in 1989 by H. W. Browning for biological studies against *Chrysomphalus aonidum* and *Aonidiella aurantii*, and no releases were made (AD 1989, H. W. Browning pers. comm.).

HYMENOPTERA: APHIDIIDAE

*Aphidius gifuensis* Ashmead, from Taiwan via Delaware, imported in 1972 by N. R. Spencer as a biocontrol agent for *Myzus persicae*, released in a greenhouse in Alachua County but was difficult to distinguish from native species and establishment is uncertain (Denmark & Porter 1973, BIRL 1992, N. R. Spencer pers. comm.).

*Aphidius matricariae* Haliday, from France, 1400 adults were released in 1957 at two sites, and 300 adults from India were released in 1958 at two sites, against *Myzus persicae* (from Quincy, Gadsden County) and *Sipha flava* (from Belle Glade, Palm Beach County); not established (Denmark 1964, Charpentier et al. 1972, Denmark & Porter 1973, Peña 1990). ~

*Aphidius picipes* (Nees), from France via Delaware, imported in 1972 and 1973 by N. R. Spencer as a biocontrol agent for *Myzus persicae* (BIRL 1992).

*Aphidius smithi* Sharma & Rao, from India via New Jersey, released in 1958 at two sites (including from Belle Glade, Palm Beach County) against *Acyrthosiphon pisum* and sugarcane aphids, current status in Florida not reported (Denmark 1964, Angalet & Coles 1966, Charpentier et al. 1972, Clausen 1978, Grant & Lambdin 1990, Jansson & Peña 1990). ~

*Aphidius*sp., origin not stated, released in 1958 against *Myzus persicae*, not established (Jackson 1990). ~

*Binodoxys indicus* Subba Rao & Sharma, from India via Delaware, imported in 1971 by A. G. Selhime as a potential biocontrol agent for *Aphis gossypii* (Denmark & Porter 1973, BIRL 1992).

*Praon exsoletum* (Nees), from the Mediterranean, 900 adults were released in 1957 at three sites from Belle Glade, Palm Beach County, against *Sipha flava*, but there were no recoveries (Denmark 1964, Charpentier et al. 1972). ~

*Trioxys complanatus* Quilis, from France, 635 adults were released in 1957 at one site (from Belle Glade, Palm Beach County) against *Sipha flava*, not established (Denmark 1964, Charpentier et al 1972). ~

HYMENOPTERA: BETHYLIDAE

*Goniozus indicus* Ashmead, from India via Delaware, imported in 1961 by J. R. Gifford as a potential biocontrol agent of *Diatraea saccharalis*; 87 cocoons were received; although it parasitized this host in the laboratory, there were no releases (Gifford 1964, 1965, Charpentier et al. 1972, BIRL 1992).

HYMENOPTERA: BRACONIDAE

*Alabagrus stigma* (Brullé), from Peru, released in 1932 against *Diatraea saccharalis*, established, causes 5-20% parasitism; from Argentina, imported in 1979 against *Spodoptera* [even though it already was established in Florida!] (Jaynes 1938, 1939, Wilson 1941, Annand 1944, AD 1919, Bennett 1971, Charpentier et al. 1967, 1972, Hall 1986, Bennett et al. 1990, D. G. Hall pers. comm.). *

*Apanteles angaleti* Muesebeck, from India, released in Gadsden County in 1955-1957 against *Helicoverpa* and *Heliothis* spp., not established (Jackson 1990). ~

*Apanteles diatraeae* Muesebeck, from Arizona, 416 adults were released in 1934 in Indian River County against *Diatraea saccharalis*, but no recoveries were made (Scaramuzza & Ingram 1942, Gifford 1964, Charpentier et al. 1972, Bennett et al. 1990). ~

*Apanteles* sp., from Uruguay, imported in 1945-1946 against *Spodoptera frugiperda* (Annand 1947).

*Apanteles* sp., from India via Delaware, imported in 1964 by J. R. Gifford as a biocontrol agent for *Diatraea saccharalis* (BIRL 1992).

*Apanteles* sp., from Colombia, emerged in quarantine from *Urbanus proteus* L. which was imported by R. I. Sailer in 1982 as host for *Ardalus* sp. (AD 1982).

*Ascogaster quadridentata* Wesmael, from Europe, released against *Diatraea saccharalis* (though a parasitoid of codling moth), not established (Gifford 1964). ~

*Biosteres arisanus* (Sonan), permit issued for its importation in 1967 (as *Biosteres oophilus*); from Hawaii, imported in 1974 (as *Opius oophilus*) by P. D. Greany against *Anastrepha suspensa*, 400 released in 1974 and 8,804 in 1975, in Dade County, not established (Denmark & Porter 1973, AD 1974, Grissell 1978, Swanson 1978, Baranowski 1986, H. B. Glenn pers. comm.).~

*Biosteres vandenboschi* (Fullaway), permit issued for its importation in 1967; from India via Hawaii, imported in 1969 (as *Opius persulcatus*) by R. M. Baranowski, against *Anastrepha suspensa*, but no culture was established and no releases were made; from Hawaii (as *Opius vandenboschi*), 455 released in 1985, 777 in 1986, 720 in 1987, and 306 in 1988, in Dade County against *Anastrepha suspensa*, not established (Denmark & Porter 1973, Baranowski 1986, H. B. Glenn pers. comm.). ~

*Bracon kirkpatricki* (Wilkinson), probably from Kenya, released in 1975 against *Pectinophora gossypiella*, probably not established [this release may have resulted from work in Arizona reported by Bryan et al. 1973] (Mead 1976). ~

*Bracon vestiticida* (Viereck), from Peru, imported in 1941 and released in Alachua County against *Anthonomus grandis*, not established (Annand 1944, Berry 1947, Clausen 1978, Cate et al. 1990). ~

*Bracon* sp., from India via Delaware, imported in 1964 by J. R. Gifford as a potential biocontrol agent for *Diatraea saccharalis*, 50 adults were imported, but would not parasitize this host in the laboratory (Gifford 1964, Charpentier et al. 1972, BIRL 1992).

*Uga menoni* Kerrich, from Korea via Delaware, imported in 1990, released in 1990 by L. Nong and F. D. Bennett in Alachua County as a potential biocontrol agent for *Epilachna varivestis*, not established (BIRL 1992, Nong & Bennett in press). ~

genus and species indet., from Argentina, imported in 1988 by R. M. Baranowski as a parasitoid of Phoridae which were contaminants of a shipment of natural enemies of *Anastrepha suspensa*, not released from quarantine (AD 1988, H. B. Glenn pers. comm.).

*Campyloneurus mutator* F., from India via Delaware, imported in 1964 by J. R. Gifford as a potential biocontrol agent for *Diatraea saccharalis*; 266 adults were imported; though it was reared on *D. saccharalis* in the laboratory, mass-rearing was unsuccessful and none was released (Charpentier et al. 1972, BIRL 1992).

*Cardiochiles diaphaniae* Marsh, from Colombia, imported in 1984 by J. E. Peña and V. H. Waddill, 6 females and 1 male released in Dade County in 1984 against *Diaphania hyalinata* and *D. nitidalis*, but not established (AD 1984, Stange 1986, Jansson & Peña 1990, J. E. Peña pers. comm.); imported in 1989 and 1991, 124 females and 168 males released in 1992 in Dade County, recovered before but not after hurricane Andrew (September 1992) and released in 1992 in Alachua County by J. L. Capinera (AD 1989, 1991, Bennett & Capinera in press, J. L. Capinera pers. comm., J. E. Peña pers. comm.). ~

*Chelonus annulipes* Wesmael, from Europe; 6,000 adults were received in 1938 from the European Corn Borer Laboratory (Moorestown, NJ) and were released in

TABLE 2. (Continued)

two locations against *Diatraea saccharalis*; not established (Gifford 1964, Charpentier et al. 1972). ~

*Chelonus blackburni* Cameron, probably from Hawaii, released in 1975 against *Pectinophora gossypiella*, probably not established [this release may have resulted from work in Arizona reported by Bryan et al. 1973] (Denmark & Porter 1973, Mead 1976). ~

*Chelonus busckiella* Viereck, from Colombia, imported in 1991 by J. L. Capinera against *Diaphania hyalinata* and *D. nitidalis* (AD 1991, J. L. Capinera pers. comm.).

*Chelonus heliopae* Gupta, from India, released in Gadsden County in 1955-1957 against *Heliothis virescens*, not established (Denmark 1964, Jackson 1990).

*Chelonus narayani* Subba Rao, from India, released in Gadsden County in 1954-1957 against *Helicoverpa* and *Heliothis* spp., not established (Jackson 1990). ~

*Chelonus texanus* Cresson, from Bolivia, imported in 1980 against *Spodoptera* spp. (AD 1980).

*Chelonus* sp., from Colombia, imported in 1984 by J. E. Peña, but not released (AD 1984, J. E. Peña pers. comm.).

*Cotesia flavipes* Cameron, from India via Delaware, imported in 1962, released in 1963 in Palm Beach County against *Diatraea saccharalis*, established, achieves on average 40-55% parasitism of the target late each season (Denmark 1964, Gifford 1964, Gifford & Mann 1967, Charpentier et al. 1972, Clausen 1978, Hall 1986, Bennett 1970, Bennett et al. 1990, BIRL 1992). *

*Cotesia plutellae* Kurdjumov, from Malaysia via England, imported in 1990 by R. K. Jansson and F. D. Bennett as a potential biocontrol agent for *Plutella xylostella*, <200 released in 1990 in Dade County by R. K. Jansson, and 118 in Seminole County by G. L. Leibee, not established; from southeast Asia via a commercial producer of biocontrol agents in Texas, large numbers released by a vegetable grower in Orange County in 1990; from southeast Asia via Hawaii, Washington and then via a commercial producer of biocontrol agents in Texas, >20,000 released in experimental plots of vegetables in Lake County in 1992 by E. R. Mitchell & J. R. McLaughlin in 1992, too recently to determine whether establishment occurred (Jansson & Peña 1990, G. L. Leibee pers. comm., E. R. Mitchell & J. R. McLaughlin pers. comm.). ?

*Diachasmimorpha longicaudata* (Ashmead), from Mexico and Hawaii, 200 released in 1972 (in Dade County), 146,637 in 1973 (in Broward, Collier, Dade, Highlands, Indian River, Lee, Manatee, Martin, Monroe and Palm Beach counties), 1,006,413 in 1974 (in Brevard, Broward, Charlotte, Collier, Dade, Glades, Hendry, Hillsborough, Lee, Manatee, Martin, Monroe, Okeechobee, Palm Beach, Polk, Sarasota, St. Lucie and and Volusia counties), 18,200 in 1975 (in Dade, Collier and Orange counties), 1,350 in 1976 (in Dade County), and 1,600 in 1977 (in Dade County) against *Anastrepha suspensa*, established, causing reduction of target populations by 40% (Denmark & Porter 1973, Grissell 1978, Baranowski 1979, 1986, Swanson 1982, Thompson 1989, Browning 1990, H. B. Glenn pers. comm.). *

*Diachasmimorpha tryoni* (Cameron), from Hawaii (as *Biosteres tryoni*), 579 released in 1982, 239 in 1983, 400 in 1984, 7,709 in 1985, 16,880 in 1986 and 4,815 in 1987, by H. B. Glenn, all in Dade County against *Anastrepha suspensa*, recovered, perhaps established (Denmark & Porter 1973, ROBO 1982, Baranowski 1986, H. B. Glenn pers. comm.). *

*Digonogastra amabilis* (Bréthes), perhaps from Argentina, released against *Diatraea saccharalis*, date of importation and county of release not specified, not established (Gifford 1964). ~

*Digonogastra kimballi* Kirkland, from Mexico via Missouri, about 200 adults released in 1981, released in 1981 against *Diatraea saccharalis* in Palm Beach County by O. Sosa, but no recoveries were made and probably is not established (ROBO 1981, Bennett et al. 1990 [as *Iphiaulax* sp.], O. Sosa pers. comm., D. G. Hall pers. comm.). ~

*Digonogastra rimac* (Wolcott), from Peru, in 1932 12,984 adults were released at two sites, and in 1936 over 2,000 in 1936 were released at two sites (189 in Indian River County and 2,032 in Palm Beach County), against *Diatraea saccharalis*; a very few individuals were recovered in the field in 1934 (2 years after the first release), but permanent establishment has not occurred (Jaynes 1938, 1938, Gifford 1964, Charpentier et al. 1967, 1972, Oatman & Clausen 1978, Bennett 1971, Bennett et al. 1990). ~

*Doryctobracon areolatus* (Szépligeti), from Trinidad (as by R. M. Baranowski and F. D. Bennett against *Anastrepha suspensa*, but material received from Brazil in 1989 belonged to other species such as *D. areolatus*, etc. (F. D. Bennett pers. comm., H. B. Glenn pers. comm.).

*Doryctobracon crawfordi* (Viereck), permit issued for its importation and release in 1968 (as *Parachasma crawfordi*); from Ecuador, 11 adults were collected in Ecuador in 1986 by F. D. Bennett, with the possibility of their use against *Anastrepha suspensa*, but was not cultured successfully and no release was made (Denmark & Porter 1973, H. B. Glenn pers. comm.).

*Doryctobracon fluminensis* (Costa Lima), from Colombia, imported in 1984 by R. M. Baranowski and J. E. Peña against *Anastrepha suspensa*, but not cultured in the laboratory and not released (AD 1984, Stange 1986, H. B. Glenn pers. comm.).

*Doryctobracon trinidadensis* Gahan, permit issued for its importation in 1968 (as *Parachasma trinidadense*); from Trinidad, 23 released in 1975, 86 in 1978, 731 in 1985, 2,036 in 1986, and 803 in 1987, in Dade County (as *Opius trinidadense*) against *Anastrepha suspensa*, not recovered since 1986, presumably not established (Denmark & Porter 1973, Swanson 1978, Baranowski 1986, H. B. Glenn pers. comm.). ~

*Glyptapanteles flavicoxis* (Marsh), from India via Delaware, imported at an unspecified date; its original host was *Lymantria obfuscata* Walker, and it was imported against *Lymantria dispar* (BIRL 1992).

*Glyptapanteles* sp. probably *caffreyi* (Muesebeck), from Ecuador, imported in 1982-1983 by V. H. Waddill, 2,025 released in 1982-1983 in Dade County against *Anticarsia gemmatalis*, current status unknown (Boethel & Orr 1990). ~

*Habrobracon brevicornis* Wesmael, from India (as *Bracon brevicornis*), released in Gadsden County in 1955-1957 against *Helicoverpa* and *Heliothis* spp., also released elsewhere against *Diatraea saccharalis*, not established (Gifford 1964, Jackson 1990). ~

*Hypomicrogaster diaphaniae* Muesebeck, from Colombia, imported in 1984 by J. E. Peña, as a potential biocontrol agent for *Diaphania hyalinata* and *D. nitidalis*, but never released (Jansson & Peña 1990, J. E. Peña pers. comm.).

*Hypomicrogaster* sp., from Colombia, imported in 1991 by J. L. Capinera against *Diaphania hyalinata* and *D. nitidalis* (AD 1991, J. L. Capinera pers. comm.).

*Iphiaulax* sp. [perhaps *Rhaconotus roslinensis* Lal), from India, 134 adults were imported in 1965, but they failed to parasitize the target (*Diatraea saccharalis*) in the laboratory, and no releases were made (Charpentier et al. 1972, F. D. Bennett pers. comm.).

*Lipolexis scutellaris* Mackauer, from Malaysia, imported in 1991 by S. Watts against *Toxoptera aurantii* [and as a precaution lest *T. citricida* (Kirkaldy) should arrive in Florida], and sent to Dade County (AD 1991).

TABLE 2. (Continued)

*Meteorus laphygmae* Viereck, from Colombia via Missouri, imported in 1975 by T. R. Ashley against *Spodoptera* spp., but died in quarantine (AD 1975).

*Meteorus* sp., from Paraguay and Peru, imported in 1979 against noctuids (AD 1979).

*Microplitis demolitor* (Wilkinson), from Australia, released in 1985 against *Helicoverpa* and *Heliothis* spp. and *Pseudoplusia includens* (Powell 1989, Boethel & Orr 1990). ~

*Microplitis manilae* (Ashmead), from Thailand, imported by M. Shepard in 1981, 5,000 released in 1982 in Dade County against *Spodoptera frugiperda* by V. H. Waddill, not established (ROBO 1982, Gross & Pair 1986, V. H. Waddill pers. comm.). ~

*Microplitis rufiventris* Kokujev, from Egypt, released in 1983-1984 in Dade County by S. D. Pair and V. H. Waddill against *Spodoptera frugiperda*, not established (Gross & Pair 1986). ~

*Myosoma chinensis* Szépligeti, from India via Delaware, imported in 1963 by J. R. Gifford (as *Bracon chinensis*) and 1964 by G. A. Mann (a total of 176 adults) as a biocontrol agent for *Diatraea saccharalis*, but would not parasitize this host in the laboratory and was not released (Gifford 1964, Charpentier et al. 1972, BIRL 1992).

*Opius bellus* Gahan, from Trinidad, imported in mid-1970s from Trinidad as a potential biocontrol agent of *Anastrepha suspensa*, not released; from Brazil, imported by R. M. Baranowski and F. D. Bennett in 1989 with other material, but only 1 female was in the shipment and was not released (Swanson 1978, Baranowski 1986, AD 1989, F. D. Bennett pers. comm., H. B. Glenn pers. comm.).

*Phaenocarpa anastrephae*Muesebeck, from Brazil, 1 female was imported accidentally in 1989 by R. M. Baranowski and F. D. Bennett in a shipment of other material, but was not released (F. D. Bennett pers. comm., H. B. Glenn pers. comm.).

*Protomicroplitis* sp., from Paraguay and Peru, imported in 1979 against noctuids (AD 1979).

*Psyttalia concolor* Szépligeti, from Réunion via France and Delaware, imported by R. M. Baranowski, 127 released in 1978 (Dade County), 8,618 released in 1979 (Dade County), 22,410 in 1980 (19,335 in Dade County, 135 in Broward County, 318 in Citrus County, 481 in Hillsborough County, 1,435 in Palm Beach County, 318 in Pasco County, and 388 in Polk County), and 1,783 in 1983, against *Anastrepha suspensa*, established (Swanson 1982, Baranowski 1986, BIRL 1992, H. B. Glenn pers. comm.). *

*Psyttalia fletcheri* (Silvestri), permit issued in 1968 for its importation; from Hawaii, 1,755 released in 1988 in Dade County against *Anastrepha suspensa*, not established (Denmark & Porter 1973, H. B. Glenn pers. comm.). ~

*Psyttalia incisi* (Silvestri), from Hawaii, 236 released in 1983, 438 in 1985, and 2,160 in 1988, all in Dade County against *Anastrepha suspensa*, probably not established (Baranowski 1986, H. B. Glenn pers. comm.). ~

*Rhaconotus signipennis* Walker, from India via Delaware, 129 adults imported in 1964 by G. A. Mann and J. R. Gifford as a potential biocontrol agent for *Diatraea saccharalis*, but no releases were made (Gifford 1964, Charpentier et al. 1972, BIRL 1992).

*Rhaconotus* sp., from India via Delaware, imported in 1964 against *Diatraea saccharalis* by G. A. Mann (BIRL 1992).

*Stantonia lamprosemae* Muesebeck, from Colombia, imported in 1991 by J. L. Capinera against *Diaphania hyalinata* and *D. nitidalis* (AD 1991, J. L. Capinera pers. comm.).

*Stenobracon deesae* (Cameron), from India via Delaware, 497 adults were imported in

1964 against *Diatraea saccharalis* by J. R. Gifford, but no releases were made (Gifford 1964, BIRL 1992).

*Stenobracon nicevillei* Bingham, from India via Delaware, 171 adults were imported in 1964 against *Diatraea saccharalis*, by J. R. Gifford and G. A. Mann; this host was parasitized in the laboratory, but no releases were made (Gifford 1964, Charpentier et al. 1972, BIRL 1992).

*Triaspis vestiticida* Viereck, from Peru, imported in 1941 against *Anthonomus grandis*, released in Alachua County but not established (Annand 1944, Berry 1947, Clausen 1978, Cate et al. 1990).

*Urosigalphus schwarzi* Gibson, from Guatemala, imported in 1974 by W. H. Whitcomb against *Anthonomus grandis*, but died in quarantine (AD 1974).

*Utetes anastrephae* (Viereck) (as *Opius anastrephae* and *Bracanastrepha anastrephae*), permit issued for its importation in 1968; from Brazil, a shipment of other material imported by R. M. Baranowski and F. D. Bennett in 1989 happened to have 3 females and 1 male, which were not released, in part because the species was found in 1973 apparently as an immigrant to Florida and parasitoid of *Anastrepha suspensa* (Denmark & Porter 1973, Frank & McCoy 1992, F. D. Bennett pers. comm., H. B. Glenn pers. comm.).

*Zelomorpha* sp., from Costa Rica, imported in 1982 by M. Shepard, G. Carner, and V. H. Waddill, 6 released in Dade County in 1982 (recoveries were made early in 1983) and in 1983 and 1985 against *Anticarsia gemmatalis*, current status unknown (ROBO 1982, Boethel & Orr 1990, V. H. Waddill pers. comm.). ~

genus and species indet. (subfamily Opiinae), from Argentina, imported in 1988 by R. M. Baranowski against *Anastrepha suspensa*, but not released from quarantine (AD 1988, H. B. Glenn pers. comm.).

HYMENOPTERA: CHALCIDIDAE

*Brachymeria* sp., from Colombia, imported in 1984 by J. E. Peña as a potential biocontrol agent for *Diaphania hyalinata* and *D. nitidalis*, but never released (Jansson & Peña 1990, J. E. Peña pers. comm.).

*Dirhinus giffardii* Silvestri, from Réunion via Delaware, imported in 1978, against *Anastrepha suspensa*, 1,750 released in 1978 in Dade County, 17,040 released in 1979 in Dade County, 66,748 released in 1980 (59,185 in Dade County, 1,330 in Broward County, 105 in Collier County, 171 in Hernando County, 1,484 in Hillsborough County, 35 in Lee County, 35 in Martin County, 2,200 in Monroe County, 1,690 in Palm Beach County, 171 in Pasco County, and 342 in Pinellas County), and 4,000 in 1986 by R. M. Baranowski, not established (Swanson 1982, Baranowski 1986, BIRL 1992, H. B. Glenn pers. comm.).

*Dirhinus himalayanus* Westwood, from Morocco via France, imported in 1990 against *Musca domestica* by P. B. Morgan for laboratory evaluation (AD 1990, P. B. Morgan pers. comm.).

*Spilochalcis diaphaniae* (Ashmead), from Colombia, imported in 1984 by J. E. Peña against *Diaphania hyalinata* and *D. nitidalis*, but never released (Jansson & Peña 1990, J. E. Peña pers. comm.).

*Spilochalcis* sp., from Colombia, imported in 1991 by J. L. Capinera and H. A. Smith against *Diaphania hyalinata* and *D. nitidalis* (AD 1991, J. L. Capinera pers. comm.).

HYMENOPTERA: DIAPRIIDAE

*Basalys* sp., from Mauritius, an unsolicited shipment in 1974 received by R. S. Patterson against *Stomoxys calcitrans* (AD 1974).

*Coptera merceti* (Say), France, imported in 1986, 1987, and 1988 by P. B. Morgan and R. S. Patterson against *Musca domestica* and *Stomoxys calcitrans*; from Hun-

TABLE 2. (Continued)

gary, imported in 1986 and 1988; all for laboratory study, without release (AD 1986, 1987, 1988, P. B. Morgan pers. comm.).

*Trichopria cilipes* Kieffer, from France, imported in 1990 against *Stomoxys calcitrans*, all for laboratory study, without release (AD 1990, P. B. Morgan pers. comm.).

*Trichopria painteri* Huggert & Morgan, from Zimbabwe, imported in 1986 together with *T. cilipes*, described later, used for laboratory study, without release (P. B. Morgan pers. comm).

*Trichopria stomoxydis* Huggert, from Mauritius, imported in 1981 and 1983 by P. B. Morgan against *Stomoxys calcitrans*; from Hungary and from Zimbabwe, imported in 1986 by R. S. Patterson against *Musca domestica* and *Stomoxys calcitrans*; from Mauritius via France, imported in 1988-1989 by P. B. Morgan and D. R. Barnard; all for laboratory study, without release (AD 1981, 1983, 1986, 1988, 1989, Stange 1986, P. B. Morgan pers. comm.).

HYMENOPTERA: DRYINIDAE

*Pseudogonatopus variistriatus* Fenton, from Jamaica via Trinidad and New Jersey, imported in 1959 and released from Belle Glade (Palm Beach County) against *Saccharosydne saccharivora*, not established (Bennett 1960, Denmark 1964, F. D. Bennett pers. comm.) [note that a native species, *P. arizonicus* Perkins, has been reported from *S. saccharivora* in Florida (Gifford 1964, Olmi 1984)]. ~

HYMENOPTERA: ENCYRTIDAE

*Anagyrus antoninae* Timberlake, from Japan via Texas, released in 1950 in Palm Beach County (from Belle Glade), in 1954 in Hendry County, in 1955 in Palm Beach and Martin counties, and in 1957 in Palm Beach County against *Antonina graminis*, established, but not found in recent surveys and possibly displaced by *Neodusmetia sangwani* and *Pseudectroma* sp. (Questel & Genung 1957, 1961, Denmark 1964, Bartlett 1978, Frank 1990, Bennett & Capinera in press, Bennett in this symposium). *

*Anagyrus diversicornis* Mercet, from Europe, released from Belle Glade (Palm Beach County), by USDA-ARS, date unspecified, against *Antonina graminis*, not established (Denmark 1964).

*Comperiella bifasciata* Howard, from Asia via California, imported in 1926 by J. R. Watson against *Chrysomphalus aonidum* and released in Polk County (Watson 1926).

*Copidosoma floridanum* (Ashmead), from Argentina via Delaware, against *Anticarsia gemmatalis* and *Pseudoplusia includens* (AD 1975).

*Copidosoma* sp., origin not stated, released from Quincy (Gadsden County) against *Trichoplusia ni*, year of release not stated (Denmark 1964). ~

*Hambletonia pseudococcina* Compere, from South America via Puerto Rico, imported in 1943 but received dead, imported and released in Highlands, Palm Beach, and St. Lucie counties in 1944 against *Dysmicoccus brevipes*, became established first in Highlands County (Clausen 1956, Bartlett 1978). *

*Leptomastidea abnormis* (Girault), from Italy via California, released under the name *Leptomastix abnormis* in Pinellas County in 1917 against *Planococcus citri*, and recorded in 1923 from that county (Watson 1924); the current widespread distribution of the species in eastern North America may have resulted from its much earlier immigration with host material (Bartlett 1978). *

*Leptomastix dactylopii* Howard, from the neotropics via California, imported in 1939 and released in 1940 in Sarasota County against *Planococcus citri* (Watson & Thompson 1940, 1941); the species is believed to be native to Brazil though dis-

tributed widely in the West Indies and parts of the southern USA [and may thus have occurred in Florida long before this release] (Bartlett 1978). *

*Metaphycus helvolus* (Compere), from Africa via California, fewer than 2,000 parasitoids were released in 1970-1971 against *Saissetia oleae* (Bernard), not established, but then it was discovered that the intended target in Florida was *S. neglecta* (rather than *S. oleae*, even though *S. oleae* is widespread) (Denmark & Porter 1973, McCoy 1985, Browning 1990, F. D. Bennett pers. comm.). ~

*Metaphycus luteolus* Timberlake, permit issued in 1971 for its release in Florida, presumably against *Coccus hesperidum* (Denmark & Porter 1973).

*Neodusmetia sangwani* (Subba Rao), from India via New Jersey, released in 1957 (from Belle Glade) in Palm Beach County against *Antonina graminis*, with further releases in the same county in 1959 via Texas, established and widespread (Denmark 1964, Bennett & Capinera in press). *

*Ooencyrtus kuvanai* (Howard), from Japan via northeastern USA, released in 1971 in Santa Rosa County against *Lymantria dispar* (Denmark & Porter 1973, Poucher 1974) [spellings *kuwanai*, *kuwanae*, *kuwani*, and *kuvanae* in assorted publications are erroneous]. ~

*Ooencyrtus submetallicus* (Howard), from Montserrat via Trinidad and Delaware, imported in 1973 and 1974 by N. R. Spencer and W. H. Whitcomb as a potential biocontrol agent for *Nezara viridula*, but occurs already in Florida (AD 1973, 1974, BIRL 1992, F. D. Bennett pers. comm., N. R. Spencer pers. comm.).

*Pseudaphycus mundus* Gahan, from Louisiana, released in 1932, 1934, and 1936 in Palm Beach, Hendry, and Indian River counties against *Dysmicoccus boninsis*, *D. brevipes*, and *Saccharicoccus sacchari*, under the mistaken belief that it was *Aphycus terryi* Fullaway (imported to Louisiana from Hawaii), established (Bynum 1937, Gahan 1946, Charpentier et al. 1972, Bartlett 1978, Bennett et al. 1990). *

*Pseudectroma europaea* (Mercet), from France, released in 1957 and 1959 (from Belle Glade) in Palm Beach County against *Antonina graminis*, not established (Denmark 1964, Bennett & Capinera in press). ~

*Tachinaephagus stomoxicida* Subba Rao, from Mauritius via California, imported in 1981, 1982 and 1983 by P. B. Morgan and R. S. Patterson against *Stomoxys calcitrans*; from Mauritius via France, imported in 1989-1990 by D. R. Barnard and P. B. Morgan; the imported material was used only for laboratory study, without release (AD 1981, 1982, 1983, 1989, 1990, P. B. Morgan pers. comm.).

*Tachinaephagus zealandicus* Ashmead, permit issued in 1971 for its importation and release in Florida; from Mauritius, imported in 1975 by P. B. Morgan against *Stomoxys calcitrans*; from Mauritius via France, imported in 1989 by D. R. Barnard; this species is adventive in the USA and was reported from Florida by Butler et al. (1981); the imported material was used only for laboratory study, without release (AD 1975, 1989, Denmark & Porter 1973, P. B. Morgan pers. comm.).

*Thomsonisca sankarani* Subba Rao, from India, imported in 1978 by G. R. Buckingham (from *Pseudaulacaspis barberi* Green), 40 released in Dade County against *Pseudaulacaspis cockerelli* by R. M. Baranowski (AD 1978, F. D. Bennett pers. comm., G. R. Buckingham pers. comm., H. B. Glenn pers. comm.).

genus and species indet., from Brazil, imported in 1989 by P. B. Morgan against *Stomoxys calcitrans*, used for laboratory study and not released (AD 1989, P. B. Morgan pers. comm.).

HYMENOPTERA: EUCOILIDAE

*Trybliographa daci* Weld, from the Indo-Australian region via France, imported by R. M. Baranowski in 1977 against *Anastrepha suspensa*, 6,259 released in 1979 (all

TABLE 2. (Continued)

in Dade County), 37,016 released in 1980 (925 in Broward County, 105 in Collier County, 34,634 in Dade County, 800 in Hillsborough County, and 552 in Monroe County) by R. W. Swanson and others, established (ROBO 1981, Baranowski 1986, Glenn & Baranowski 1987, BIRL 1992, H. B. Glenn pers. comm.). *

*Trybliographa* sp. (as *Ganaspis* sp.), from Brazil, imported in 1989 by F. D. Bennett against *Anastrepha suspensa* (AD 1989).

HYMENOPTERA: EULOPHIDAE

*Aceratoneuromyia indica* (Silvestri), permit for importation issued in 1967; from Costa Rica, imported in mid-1970s by R. M. Baranowski and R. W. Swanson against *Anastrepha suspensa*; from Colombia, imported in 1984 by R. M. Baranowski and J. E. Peña, 4,000 released in Dade County, recovered on 4 separate occasions and believed to be established; received from Texas in 1986, 2,000 released in 1986, 2,100 in 1987, all in Dade County (Denmark & Porter 1973, AD 1984, H. B. Glenn pers. comm.). *

*Ardalus* sp., from Colombia, imported in 1982 by R. I. Sailer, original host *Urbanus proteus* L., so presumably against some pest hesperiid, died in quarantine (AD 1982).

*Dahlbominus fuscipennis* (Zetterstedt), permit issued in 1971 for its importation and release in Florida; from Europe via the northeastern USA, released by R. C. Wilkinson in 1971 against *Neodiprion lecontei*, not established (Denmark & Porter 1973, A. T. Drooz pers. comm., R. C. Wilkinson pers. comm.). ~

*Edovum puttleri* Grissell, from Colombia via Missouri, imported in 1983 by R. I. Sailer against *Leptinotarsa decemlineata*, 30 released in Alachua County in 1983 by B. Munir, current status unknown (ROBO 1983, Stange 1986, Jansson & Peña 1990). ~

*Euplectrus* sp. nr. *comstocki* Howard (as *plathypenae* Ashmead), from Colombia via Missouri, imported in 1975 by T. R. Ashley against *Spodoptera* sp., released in 1976 as a biocontrol agent for *Anticarsia gemmatalis* (AD 1975, Grissell 1978). ~

*Euplectrus puttleri* Gordh, from Brazil, imported by B. Puttler and V. H. Waddill and released in 1981-1982 in Collier (90), Dade (133), and Palm Beach counties (242), against *Anticarsia gemmatalis*, established (ROBO 1981, 1982, Boethel & Orr 1990, V. H. Waddill pers. comm.). *

*Goetheana shakespearei* Girault, from Africa via Puerto Rico, imported by J. R. Watson (under the name *Dasyscapus parvipennis* Gahan) in 1939 against *Selenothrips rubrocinctus*, 500 puparia without record of release; from Africa via California, imported under the name *Goetheana parvipennis* (Gahan), about 40 adults were released in 1986 in Dade County in a greenhouse against *S. rubrocinctus*; from Africa via Puerto Rico, about 40 adults were released against *S. rubrocinctus* in Dade County; pupae were found in 1992 in Dade County at a location far from the release sites, so evidently established, but not clearly as a result of the releases, perhaps independently as an immigrant (Watson & Thompson 1940, Mizell & Tedders 1990, Bennett et al. 1993, H. Glenn & F. D. Bennett pers. comm.). *

*Horismenus elineatus* Schauff, from Bolivia via Texas, imported against *Elasmopalpus lignosellus*, about 450 released in Gadsden County and about 200 in Jackson County by J. E. Funderburk in 1990, not established; from Bolivia via Texas and Hawaii, imported by D. G. Hall and F. D. Bennett in 1991, about 7,500 released in 1992 in Palm Beach and Hendry counties, too recently to determine whether establishment occurred (D. G. Hall pers. comm., J. E. Funderburk pers. comm.). ?

*Horismenus* sp., from Mexico via Texas, imported in 1976 against *Anthonomus grandis* (AD 1976).

*Pediobius facialis* (Giraud), from Japan via Delaware, imported in 1982 by R. I. Sailer, released in 1981-1982 in Dade County (1,000) by V. H. Waddill against *Trichoplusia ni* (ROBO 1981, 1982 BIRL 1992).

*Pediobius foveolatus* (Crawford), permit issued for its importation and release in 1968; from India via Maryland, imported in 1973 and 1974 via Maryland by N. R. Spencer against *Epilachna varivestis*, about 1,500 released in 1974 in Gadsden County and 1,000 in Alachua County, released in 1975-1976 resulting in 3 years of reduced populations of the target, though the parasitoid does not overwinter in northern Florida so needs reintroduction each year; from Japan via Delaware, imported in 1982 by R. I. Sailer for study (AD 1973, 1974, 1982, Denmark & Porter 1973, Grissell 1978, Sailer 1981, Boethel & Orr 1990, Jansson & Peña 1990, BIRL 1992, N. R. Spencer pers. comm.). ~

*Tetrastichus ceroplastae* Girault, permit issued in 1969 for its importation into Florida [this species is recorded from the Indian Ocean islands of Madagascar and Mauritius as a parasitoid of scale insects] (Denmark & Porter 1973).

*Tetrastichus fennahi* Schauff, from Puerto Rico, imported in 1977 but died during shipping or in quarantine; from the Dominican Republic, imported in 1990 by H. W. Browning against *Diaprepes abbreviatus*, but no culture was established and no releases were made (AD 1977, 1990, H. W. Browning pers. comm.).

*Tetrastichus gala* Walker, from the Dominican Republic, imported in 1990 by H. W. Browning against *Diaprepes abbreviatus*, but no culture was established and no releases were made (AD 1990, H. W. Browning pers. comm.).

*Tetrastichus giffardianus* Silvestri, permit issued in 1968 for its importation into Florida against *Anastrepha suspensa* [occurs in Hawaii] (Denmark & Porter 1973).

*Tetrastichus haitiensis* Gahan, from Puerto Rico, released in 1969 in Palm Beach County, in 1970 in Orange County, and in 1971 in Palm Beach County, against *Diaprepes abbreviatus*, at first did not establish, but established by 1978 (Sutton et al. 1972, Denmark & Porter 1973, Beavers & Selhime 1975, Beavers et al. 1980, Woodruff 1981), and recovered from eggs of the host in Miami in 1986 (Bennett et al. 1990); from Puerto Rico, imported in 1977 but died during shipping or in quarantine, and in 1984 and in 1990 against *Diaprepes abbreviatus* (AD 1977, 1984, 1990); from the Dominican Republic, imported in 1990 (mixed with *T. fennahi* and hyperparasitoids) by H. W. Browning against *Diaprepes abbreviatus*, and 16 adults were shipped from quarantine to Lake Alfred (Polk County), but it was not possible to maintain a culture on laboratory-cultured *D. abbreviatus*, and no releases were made; unclear whether its presence in Miami is the result of introduction or of immigration (AD 1990, H. W. Browning pers. comm). *

*Tetrastichus* sp., from Jamaica via Trinidad, sent to New Jersey in 1959 with the intention that it be forwarded to Florida against *Saccharosydne saccharivora*, but without record of receipt in Florida and without record of release in Florida (Bennett 1960, F. D. Bennett pers. comm.).

HYMENOPTERA: FORMICIDAE

*Formica integra* Nylander, from west-central Georgia, released in an ecological experiment in 1973 in Alachua County, not for biocontrol purposes, destroyed by native ants (*Camponotus*) (Wilkinson et al. 1980). ~

*Solenopsis* (*Labauchena*) *daguerrei* Santschi, from Argentina, imported in 1987 by D. P. Wojcik against *Solenopsis invicta*, not released (AD 1987, D. P. Wojcik pers. comm.).

*Solenopsis* (*Labauchena*) sp., from Brazil, imported in 1986-1987 and 1989 by D. P. Wojcik against *Solenopsis invicta*, not released (AD 1986, 1987, 1989, D. P. Wojcik pers. comm.).

TABLE 2. (Continued)

HYMENOPTERA: ICHNEUMONIDAE

*Agrypon caribbaeum* Bland, from St. Croix (US-VI), imported in 1983 and brought to Homestead (Dade County) in 1984 as a potential biocontrol agent for *Diaphania hyalinata* and *D. nitidalis*, but not released (Jansson & Peña 1990, J. E. Peña pers. comm.).

*Bathyplectus anurus* (Thomson), from France via Delaware, imported in 1977 by D. B. Bouk (graduate student, Univ. Florida) as a biocontrol agent for *Hyperapostica*; via Kentucky and Delaware, imported in 1978 by R. I. Sailer; via Kentucky and Michigan, imported by R. I. Sailer in 1983 and 1,800 released in 1983 in Alachua County by B. Munir and R. I. Sailer; probably not established (AD 1983, ROBO 1983, Munir & Sailer 1984, Stange 1986, Grant & Lambdin 1990, BIRL 1992). ~

*Campoletis flavicincta* (Ashmead), from Argentina, imported in 1979 against *Spodoptera* spp., *Anticarsia gemmatalis*, etc. (AD 1979).

*Campoletis grioti* (Blanchard), from Uruguay, being screened in quarantine in 1978-1980 against *Spodoptera frugiperda* (Stange 1982).

*Casinaria* sp., from Colombia, imported in 1991 by J. L. Capinera and H. A. Smith against *Diaphania hyalinata* and *D. nitidalis* (AD 1991, J. L. Capinera pers. comm.).

*Aubertillus alternecoloratus* (Cushman), from India via Delaware, imported in 1964 by J. R. Gifford as a potential biocontrol agent for *Diatraea saccharalis*; 266 adults were received; although it parasitized *D. saccharalis* in the laboratory, no individuals were released (Gifford 1964, Charpentier et al. 1972, BIRL 1992).

*Centeterus* sp., from India via Delaware, imported in 1964 by J. R. Gifford as a potential biocontrol agent for *Diatraea saccharalis* (BIRL 1992).

*Coccygomimus* sp., from India, in 1964-1965, 125 adults were received as potential biocontrol agents for *Diatraea saccharalis*; there were no releases (Charpentier et al. 1972).

*Corsoncus magus* (Cresson), from Costa Rica, 35 released in 1982 by M. Shepard, G. Carner and V. H. Waddill in Dade County against *Anticarsia gemmatalis*, current status unknown (ROBO 1982, Boethel & Orr 1990, V. H. Waddill pers. comm.). ~

*Eiphosoma dentator* (F.), from Colombia, imported in 1991 by J. L. Capinera and H. A. Smith against *Diaphania hyalinata* and *D. nitidalis* (AD 1991, J. L. Capinera pers. comm.).

*Eiphosoma vitticole* Cresson, from Bolivia, imported in 1978 and 1980 by G. R. Buckingham against *Spodoptera frugiperda*, released in 1980 in Dade County, not established (AD 1978, 1980, Ashley et al. 1982, Stange 1982, G. R. Buckingham pers. comm). ~

*Enicospilus merdarius* (Gravenhorst), from Uruguay, imported in 1945-1946 against *Spodoptera frugiperda*, though this species is native to Florida (Annand 1947).

*Enicospilus* sp., from Paraguay and Peru, imported in 1979 against noctuids, died in quarantine (AD 1979).

*Exenterus amictorius* (Panzer), from Europe via North Carolina, released in 1969 against *Neodiprion lecontei*, not established (Wilkinson 1969, Denmark & Porter 1973, R. C. Wilkinson pers. comm.).

*Exeristes roborator* (F.), a palearctic species, released against *Diatraea saccharalis*, date and county not specified, not established (Gifford 1964). ~

*Microcharops anticarsiae* Gupta (as *M. bimaculata* (Ashmead)), from Colombia, Brazil, Argentina and Costa Rica, imported in 1975 and 1980-1982 by M. Shepard, G. Carner and V. H. Waddill, stock from Costa Rica released in 1982 by V. H.

Waddill in Dade (5,040) and Palm Beach (60) counties, and in 1983 by L. Douthit in Broward (485) and Dade (3,687) counties, and this or other stock in 1984-1986, against *Anticarsia gemmatalis*, current status unknown (ROBO 1982, 1983, Gupta 1987, Boethel & Orr 1990, V. H. Waddill pers. comm.). ~

*Netelia* sp., from Paraguay and Peru, imported in 1979 against noctuids, died in quarantine (AD 1979).

*Pleolophus basizonus* (Gravenhorst) permit issued in 1971 for its importation and release; from Europe via North Carolina, released against *Neodiprion lecontei* in 1971, not established (Denmark & Porter 1973, A. T. Drooz pers. comm., R. C. Wilkinson pers. comm.). ~

*Polycyrtus* sp., from Colombia, imported in 1984 by J. E. Peña and V. H. Waddill as a potential biocontrol agent for *Diaphania hyalinata* and *D. nitidalis*, but never released (AD 1984, Jansson & Peña 1990, J. E. Peña pers. comm.).

*Thymebatis* sp., from Paraguay and Peru, imported in 1979 against noctuids, died in quarantine (AD 1979).

genus and species indet.,from India via Delaware, imported in 1964 by J. R. Gifford as a potential biocontrol agent for *Diatraea saccharalis* (BIRL 1992).

genus and species indet., from Brazil, imported in 1976 by N. R. Spencer against *Anticarsia gemmatalis*, not released (AD 1976, N. R. Spencer pers. comm.).

HYMENOPTERA: MYRMARIDAE

*Anagrus armatus* Ashmead, from Jamaica via Trinidad and New Jersey, 1,014 adults were released in 1959 at nine sites from Belle Glade (Palm Beach County) against *Saccharosydne saccharivora*, but probably already occurred in Florida (Bennett 1960, Denmark 1964 [as *Anagyrus* sp.], Gifford 1964, Simmonds 1969, Charpentier et al. 1972, Bennett et al. 1990, F. D. Bennett pers. comm.).

*Erythmelus* sp., from Venezuela, imported in 1991 by D. G. Hall, F. D. Bennett, and R. Nguyen as a potential natural enemy of *Leptodictya tabida*, but did not reproduce in captivity and was not released (AD 1991, Nguyen & Hall 1991, F. D. Bennett pers. comm., D. G. Hall pers. comm.).

HYMENOPTERA: PERGIDAE

*Heteroperryia hubrichi* Malaise, from Brazil, imported into quarantine in 1989-1991 as a potential biocontrol agent for *Schinus terebinthifolius* by D. H. Habeck and F. D. Bennett, but no releases were made (AD 1989, 1990, 1991, Habeck et al. in press, D. H. Habeck pers. comm.).

*Lophyrotoma zonalis* (Rohwer), from Australia, imported into quarantine in 1992 as a potential biocontrol agent for *Melaleuca quinquenervia*, but no releases have been made (Habeck et al. in press, D. H. Habeck pers. comm.).

HYMENOPTERA: PERILAMPIDAE

*Perilampus* sp., from Colombia, imported in 1991 by J. L. Capinera with parasitoids of *Diaphania hyalinata* and *D. nitidalis*, but is a hyperparasitoid and was not released (AD 1991, J. L. Capinera pers. comm.).

HYMENOPTERA: PLATYGASTERIDAE

*Amitus hesperidum* Silvestri, from India via Mexico (in part via Texas), by A. G. Selhime, about 22,000 parasitoids were released in 1976 in Broward County against *Aleurocanthus woglumi*, established and highly successful in reducing target populations (Grissell 1978, Hart et al. 1978, Dowell et al. 1979, Selhime et al. 1982, McCoy 1985, Nguyen 1988, Browning 1990); with additional importation from Mexico and release in Brevard (11,286), Lee 5,102), and Martin (2,489) counties in 1981 by W. Grandberry (ROBO 1981), and subsequent releases in Collier, Dade, Highlands, Hillsborough, Indian River, Manatee, Monroe,

TABLE 2. (Continued)

Okeechobee, Palm Beach, Pinellas, Sarasota, and St. Lucie counties (Nguyen 1988). *

*Amitus* sp., from Puerto Rico, imported in 1990 by F. D. Bennett against *Bemisia tabaci*, released in 1990 in Alachua, Collier, Dade and Manatee counties, and specimens were captured in the field up to a year after release (F. D. Bennett pers. comm.). ?

*Amitus* sp., from Guatemala, imported in 1991 by F. D. Bennett against *Bemisia tabaci*, but was not released (AD 1991).

*Fidiobia citri* (Nixon), from Jamaica and California, imported in 1989 by H. W. Browning against *Diaprepes abbreviatus* and *Asynonychus godmanni*, but culture died and no releases were made (AD 1989, H. W. Browning pers. comm.).

*Platystasius asinus* Loiacono, from Chile, imported in 1990 from a laboratory culture against *Diaprepes abbreviatus* and other weevil pests of citrus bh H. W. Browning; 22 adults were shipped from quarantine to Lake Alfred (Polk County), released in 1991 but establishment yet uncertain (AD 1990, H. W. Browning pers. comm.). ?

HYMENOPTERA: PTEROMALIDAE

*Catolaccus grandis* (Burks) (as *Heterolaccus*), from Mexico, imported in 1974 by W. H. Whitcomb against *Anthonomus grandis*, for trans-shipment to Texas, but died in quarantine (AD 1974).

*Dibrachoides druso* (Walker), from Europe, imported in unspecified year by unspecified person, released against *Hypera postica*, current status unknown [Florida is not listed among the states in which this insect was released in 1957-1975 by Dysart & Day 1976] (Grant & Lambdin 1990). ~

*Muscidifurax raptor* Girault & Sanders, permit issued in 1971 for its release in Florida; from Germany via France, imported in 1984 by P. B. Morgan as a biocontrol agent for *Musca domestica*; from Hungary, imported in 1986-1987 by R. S. Patterson; from Brazil, imported in 1987 and 1989 by P. B. Morgan and R. S. Patterson; from Hungary via France, imported in 1989 by D. R. Barnard; this species was reported from Florida by Mitchell et al. (1974); the imported material was used only for laboratory study, without release (Denmark & Porter 1973, AD 1984, 1987, 1989, P. B. Morgan pers. comm.).

*Nasonia vitripennis* (Walker), from France and from Zimbabwe, imported in 1986 by P. B. Morgan against *Musca domestica* and *Stomoxys calcitrans*; from Brazil, imported in 1987 by P. B. Morgan; this species may be native to Florida; the imported material was used only for laboratory study, without release (AD 1986, 1987, P. B. Morgan pers. comm.).

*Pachycrepoideus vindemiae* (Rondani), from Mauritius, imported in 1974 and 1983; from Brazil, imported in 1987 by P. B. Morgan; this species was reported from Florida by Morgan & Patterson (1975) and was reported as attacking *Paratheresia claripalpis*, a beneficial insect (see above), by Jaynes (1930); the imported material was used only for laboratory study, without release (AD 1974, 1983, 1987, Stange 1986, P. B. Morgan pers. comm.).

*Scutellista cyanea* Motschulsky, from Italy, released in 1899 against *Ceroplastes ceriripediformis*, became established, attacking not only the target but two other pests, *Ceroplastes floridensis* Comstock and *Saissetia nigra* (Nietner) (Bartlett 1978, Mizell 1990). *

*Spalangia cameroni* Perkins, from Mauritius and from Spain via France, imported in 1983 by P. B. Morgan against *Musca domestica* and *Stomoxys calcitrans*; from France and from Germany via France and from Spain, imported in 1984 by P. B. Morgan; from Zimbabwe, imported in 1986 by R. S. Patterson; from France,

imported in 1987 by R. S. Patterson; from Morocco via France, imported in 1988 by R. S. Patterson; from Mauritius and from Brazil, imported in 1989; this species was reported from Florida by Mitchell et al. (1974); the imported material was used only for laboratory study, without release (AD 1983, 1984, 1986, 1987, 1989, Stange 1986, P. B. Morgan pers. comm.).

*Spalangia endius* Walker, permit issued in 1971 for its importation and release in Florida; from Thailand, imported in 1984 against *Musca domestica* and *Stomoxys calcitrans*; from Mauritius via France and from Australia and from Hungary, imported in 1986; from France and from India via France and from Brazil, imported in 1987 by R. S. Patterson and P. B. Morgan; from Brazil, imported in 1989; this species was reported from Florida by Mitchell et al. (1974); the imported material was used only for laboratory study, without release (Denmark & Porter 1973, AD 1984, 1986, 1987, 1989, P. B. Morgan pers. comm.).

*Spalangia gemina* Bouček, from Brazil, imported in 1987 and 1989 by P. B. Morgan against *Musca domestica*, not released (AD 1987, 1989, P. B. Morgan pers. comm.).

*Spalangia nigra* Latreille, from France, imported in 1987 and 1990 by R. S. Patterson against *Musca domestica*; this species was reported from Florida by Mitchell et al. (1974); the imported material was used only for laboratory study, without release (AD 1987, 1990, P. B. Morgan pers. comm.).

*Spalangia nigroaenea* Curtis, from Zimbabwe, imported in 1986 by R. S. Patterson against *Musca domestica* and *Stomoxys calcitrans*; this species was reported from Florida by Morgan & Patterson (1975); the imported material was used only for laboratory study, without release (AD 1986, P. B. Morgan pers. comm.).

*Spalangia* sp., from Mauritius, imported in 1974 and 1983 by P. B. Morgan, not released (AD 1974, 1983, P. B. Morgan pers. comm.).

HYMENOPTERA: SCELIONIDAE

*Telenomus alecto* (Crawford), from Trinidad via Louisiana, 2,200 adults released against *Diatraea saccharalis* in 1950 at four sites, but no recoveries were made (Gifford 1964, Charpentier 1972, Bennett et al. 1990). ~

*Telenomus remus* Nixon, from Sarawak via Trinidad, imported in 1974-1975 by W. H. Whitcomb against *Spodoptera frugiperda*, released in 1975-1977 in Dade County (AD 1974, 1975, Wojcik et al. 1976, Grissell 1978, Waddill & Whitcomb 1980); from the Cayman Islands, imported by F. D. Bennett in 1987, released in Dade County in 1988-1989, without evidence of establishment; from Puerto Rico, imported in 1987-1988 and 1990 by F. D. Bennett; from Jamaica, imported in 1989 by F. D. Bennett, but not released (AD 1987, 1988, 1989, 1990, Bennett & Capinera in press). ~

*Telenomus* sp., from Colombia, imported in 1986 by R. M. Baranowski and F. D. Bennett (erroneously under the name *T. alsophiliae* Viereck) against *Epimecis detexta*; 330 adults were shipped from quarantine to Homestead (Dade County), but no releases were made (AD 1986, Mizell & Tedders 1990, F. D. Bennett pers. comm., H. B. Glenn pers. comm.).

*Trissolcus basalis* (Wollaston), from Montserrat via Delaware, imported in 1973 by W. H. Whitcomb and N. R. Spencer as a biocontrol agent for *Nezara viridula*, though occurred already in Florida; from Australia, imported in 1974 by N. R. Spencer (AD 1973, 1974, BIRL 1992, F. D. Bennett pers. comm.).

HYMENOPTERA: SERPHIDAE

*Nothoserphus affisae* (Watanabe), from Korea via Delaware, imported in 1990 into quarantine as a potential biocontrol agent for *Epilachna varivestis*, but not released (BIRL 1990, Nong & Bennett in press).

TABLE 2. (Continued)

HYMENOPTERA: SIGNIPHORIDAE

*Signiphora* sp., from Brazil, imported in 1990 by F. D. Bennett together with parasitoids of *Bemisia tabaci*, but probably is a hyperparasitoid and was terminated in quarantine (AD 1990).

HYMENOPTERA: SPHECIDAE

*Larra analis* F., from Louisiana, imported by J. R. Watson in 1941-1942 against *Scapteriscus* spp., though it is a specific natural enemy of *Neocurtilla hexadactyla* (Perty) which does not attack *Scapteriscus*, and though it occurred already in Florida; all but one specimen were dead on arrival (Watson & Thompson 1943).

*Larra bicolor* F., from Pará, Brazil via Puerto Rico, imported by R. I. Sailer, J. L. Castner, and J. A. Reinert in 1981-1983 against *Scapteriscus vicinus*, *S. borellii*, and *S. abbreviatus*, screened in quarantine and released in 1981 in Alachua, Broward, and Hillsborough counties, in 1982 in Alachua, Broward, and Manatee counties, in 1983 in Hillsborough County (AD 1981, 1982, 1983, ROBO 1981, 1982, 1983, Stange 1982), established only in Broward County and there studied by J. L. Castner (Castner 1988), still (1992) with a very localized population in Broward County; from Bolivia, imported [almost certainly together with material of *L. praedatrix*] by F. D. Bennett in 1986-1989 and released in 1988-1989 in Alachua County, without evidence of establishment (AD 1986, 1987, 1988, 1989, F. D. Bennett pers. comm., Frank 1990). *

*Larra godmani* Cameron (under the name *L. braunsii*), from Santa Cruz, Bolivia, imported and released against *Scapteriscus* spp. by F. D. Bennett in 1988-1989 in Alachua County, without evidence of establishment (Frank 1990, F. D. Bennett pers. comm.). ~

*Larra praedatrix* (Strand), see under *L. bicolor*.

*Larra* spp., unidentified or under the names *L. gastrica* (Taschenberg) [synonym of *L. bicolor*] and *L. burmeisterii* (Lynch) [the correct name is *L. burmeisterii* (Holmberg)], from Uruguay, Bolivia, and Brazil, imported in 1984 and 1986 by R. I. Sailer against *Scapteriscus* mole crickets; from Brazil, imported by F. D. Bennett in 1989; all died in quarantine (AD 1984, 1986, 1989).

HYMENOPTERA: TORYMIDAE

*Monodontomerus dentipes* (Dalman), from Europe via North Carolina, imported and released in 1969 by R. C. Wilkinson against *Neodiprion lecontei*, not established (Wilkinson 1969, R. C. Wilkinson pers. comm.).

HYMENOPTERA: TRICHOGRAMMATIDAE

*Brachyufens osborni* (Dozier), from Puerto Rico, imported in 1969 (together with *Testrastichus haitiensis*) against *Diaprepes abbreviatus*, but no attempt was made to culture it because it already was present in Florida as a parasitoid of *Pachnaeus*; imported in 1977 but died during shipping (Sutton et al. 1972, AD 1977, Woodruff 1981).

*Trichogramma evanescens* Westwood, permit issued in 1968 for its importation and release (Denmark & Porter 1973).

*Trichogramma minutum* Riley, permit issued in 1971 for its importation (Denmark & Porter 1973).

*Trichogramma plattneri* Nagarkatti, from California, imported in 1985, reared on *Trichoplusia ni*, 20,000 released in 1985 in Dade County against *Epimecis detexta*, but not established (Mizell & Tedders 1990, H. B. Glenn pers. comm.). ~

*Trichogramma pretiosum* Riley, from Texas, released inundatively in 1976 in Gadsden County against *Helicoverpa zea* and *Trichoplusia ni*, established (Denmark & Porter 1973, Martin et al. 1976, Jansson & Peña 1990). *

LEPIDOPTERA: COLEOPHORIDAE

*Coleophora* sp., from Brazil, imported in 1989 by D. H. Habeck against *Schinus terebinthifolius*, but not reared and not released (AD 1989, D. H. Habeck pers. comm.).

LEPIDOPTERA: NOCTUIDAE

*Spodoptera pectinicornis* (Hampson), from Thailand, imported in 1986-1988 by D. H. Habeck and C. R. Thompson against *Pistia stratiotes*, released in 1990 in Glades, Palm Beach and St. Lucie counties, and in 1991 in Brevard, Broward, Gadsden, Glades, Okeechobee, Putnam, and Sumter counties; it is not yet clear that establishment is permanent (AD 1986, 1987, 1988, Buckingham & Habeck 1990, Dray & Center 1992, D. H. Habeck pers. comm.). ?

LEPIDOPTERA: PYRALIDAE

*Acentria ephemerella* (Denis & Schiffermuller), native to the northern USA, from New York via Maryland, imported in 1975-1976 (under the name *Acentropus niveus*) by N. R. Spencer, and in 1978 by G. R. Buckingham, against *Myriophyllum spicatum*, but died in quarantine (AD 1975, 1976, 1978, G. R. Buckingham pers. comm.).

*Acigona infusella* (Walker), from Argentina, imported in 1974-1975 by N. R. Spencer against *Eichhornia crassipes*, but was not released, and died in quarantine (AD 1974, 1975, N. R. Spencer pers. comm.).

*Parapoynx diminutalis* Snellen, from Asia via Panama, imported in 1980-1982 by G. R. Buckingham against *Hydrilla verticillata*, though by then was established in Florida as an immigrant (AD 1980, 1981, 1982, G. R. Buckingham pers. comm.).

*Parapoynx stratiotata* L., from Italy via Delaware, from Yugoslavia, and from Italy, imported in 1975-1976 by N. R. Spencer as a potential biocontrol agent for *Myriophyllum spicatum*, but was terminated in quarantine (AD 1975, 1976, BIRL 1992, D. H. Habeck pers. comm., N. R. Spencer pers. comm.).

*Sameodes albiguttalis* (Warren), from Argentina, imported in 1975-1976 by N. R. Spencer, released in Broward, Collier Dade, and Pinellas counties in 1977-1979 (numbers not counted) and in 1979-1980 in Alachua County (79,093 in 1979, 19,764 in 1980) against *Eichhornia crassipes*, established by 1979 (AD 1975, 1976, Center & Durden 1981, Center 1984, Buckingham & Habeck 1990). *

*Vogtia malloi* Pastrana, from Argentina, released in 1971-1972 in Alachua, Broward, Duval, Orange and St. Lucie counties against *Alternanthera philoxeroides*, established (Brown & Spencer 1973, Coulson 1977, Buckingham & Habeck 1990). *

LEPIDOPTERA: TORTRICIDAE

*Episimus utilis* Zimmerman, from Brazil, imported in 1989 and 1991 by D. H. Habeck against *Schinus terebinthifolius*, but not released (AD 1989, 1991, D. H. Habeck pers. comm.).

NEUROPTERA: CHRYSOPIDAE

*Chrysoperla carnea* (Stephens), from India, 8,500 eggs were released in 1957 in five fields, and 1,150 were released in 1958 in five fields (from Belle Glade, Palm Beach County) against *Sipha flava*, and others were released from Quincy (Gadsden County) against *Myzus persicae* and *Therioaphis maculata*; not established (Denmark 1964, Charpentier et al. 1972, Jackson 1990, L. A. Stange pers. comm.). ~

STREPSIPTERA: STYLOPIDAE

*Stenocranophilus quadratus* Pierce, from Jamaica via Trinidad and New Jersey, 580 adults and nymphs were released in 1959 at one site from Belle Glade (Palm Beach County) against *Saccharosydne saccharivora*, established (Bennett 1960,

TABLE 2. (Continued)

| |
|---|
| Denmark 1964, Gifford 1964, Simmonds 1969, Charpentier et al. 1972, Bennett et al. 1990, F. D. Bennett pers. comm.). * |
| THYSANOPTERA: PALEOTHRIPIDAE |
| *Amynothrips andersoni* O'Neil, from Argentina, released in 1967-1972 in Alachua, Broward, Clay, Duval, Glades, Orange and Palm Beach counties against *Alternanthera philoxeroides*, established (Coulson 1977, Buckingham & Habeck 1990). * |
| *Liothrips ichinii* Hood, from Brazil, imported into quarantine in 1989-1991 by F. D. Bennett and D. H. Habeck against *Schinus terebinthifolius*, but no releases were made (AD 1989, 1990, 1991, Habeck et al. in press, F. D. Bennett pers. comm.) |

became established and caused severe problems. Control was first attempted by physical methods, which already had been shown to be ineffective in California. In 1899, a new attempt was made to import the biocontrol agent, resulting in completely successful control. A second introduced insect species, *Gromphadorina* sp. (Blattaria: Oxyhydroidae), is a potential pest, but is not yet known to be established (see Table 2). The other introduced pests are plants that have become weeds. They were brought to Florida either as ornamentals [*Eichhornia crassipes* (Martius) Solms (waterhyacinth), *Melaleuca quinquenervia* (Cavanilles) S. T. Blake (melaleuca), *Schinus terebinthifolius* Raddi (Brazilian peppertree)], or by the aquarium trade [*Hydrilla verticillata* (Lf.) Royle (hydrilla), *Myriophyllum spicatum* L. (Eurasian watermilfoil)], and then became feral and difficult to control.

A problem arises with some pests that have been widely distributed for such a long time that their native ranges are not clear to taxonomists. An example among the insects is *Selenothrips rubrocinctus* (Giard) (Thysanoptera: Thripidae), which is widely distributed in the tropics and subtropics around the world. An example among the plants is the aquatic weed *Pistia stratiotes* L. (waterlettuce), which was observed in Florida in the 18th century but yet may not be native. In a few instances, particularly where a specialist pest of an introduced plant is concerned, the pest has been assumed to be an immigrant, from the same part of the world as its host plant; an example is *Chrysomphalus aonidum* (L.) (Homoptera: Diaspididae), which is assumed to be native to Asia, and whose common name "Florida red scale" is thus a misnomer. In other instances, when all the closest relatives of a pest are from one continent, it has been assumed that the pest likewise is from that continent; an example is *Aedes aegypti* (L.) (Diptera: Culicidae), whose closest relatives are African. Counter-examples to both of these assumptions can be found; therefore, we must view any conclusions drawn from the assumptions as tentative.

*Introduced Insects*

We included information, when we had it, on geographical origins, dates of introduction, locations of releases, and the status of each introduced insect (Table 2). The latter kind of information distinguishes among species imported but not released, species released but not established, species released and established, and species whose status is currently unknown. Establishment (see Hall & Ehler 1979, Stiling 1990) was documented by record of subsequent recovery in the field, although this criterion may yield questionable conclusions, for at least three reasons. First, little or no follow-up work has been done for many of the releases. Second, species that establish in the short term may fail to do so in the long term, and species that seem to fail to establish in the short term may eventually do so (a temporal scale problem, which would be reduced if

an appropriate time frame were specified in advance). Third, establishment may be judged to have occurred in one part of the state but not in another (a spatial scale problem, which would be reduced if Florida were not considered the geographical area of interest). We also included additional information, such as on sizes of releases, that we had for some species. Because we did not feel we possessed enough information to do so, we made no particular attempt to draw conclusions about the success (see Hall et al. 1980, Stiling 1993) of releases for biological control in Florida. The cut-off date is 1991 for new importations.

Almost all of the introduced insects that we included in our tabulation were imported deliberately and were deemed beneficial and suitable for release (but see Howarth 1991). Release of the biocontrol agents usually was subject to proof of host-specificity, however. Almost all also were not already established in Florida, although in a few instances, strains (subspecific or infra-subspecific categories) from other areas were imported. We included on the list: (1) a few species shipped unsolicited to the quarantine facility of the Florida Biological Control Laboratory by foreign suppliers, but which were terminated in quarantine, (2) a few unexpected parasitoid species that emerged from their imported hosts in the quarantine facility, and (3) two species imported by members of the public without permit and which are documented to have been released in Florida. We omitted from the list: (4) any pest species imported into the quarantine facility simply as a host for beneficial parasitoids or predators, and which was terminated in the quarantine facility, (5) species imported by the pet trade or by members of the public without permit or other public record, (6) species imported under permit for experimental purposes in secure laboratories, (7) species imported under permit for educational purposes but which were not intended for release (such as exotic butterflies), and (8) beneficial species imported under permit by commercial organizations as biological control agents for pests. Records of the permits for categories (6)-(8) exist, but records of receipt of shipments for categories (7)-(8) are not in the public record. The last category (8) is of insect biocontrol agents produced in insectaries in other states, imported into Florida under permit as biopesticides by commercial companies, but not passed through quarantine; no public record is made of their numbers or places of release, and no special record is made of those among them which are not established already in Florida; such importations could lead to establishment of species which are not already present in Florida. *Icerya purchasi* is not included in out table of importations because it is not a biological control agent and because we discuss its introduction above.

Alternative scientific names have been used in the literature for some of the biological control agents listed in Table 2. Table 3 shows these alternative names, and will help anyone who wants to relate information from Table 2 to the literature.

## Results and Discussion

### *Targets of Classical Biological Control Efforts*

A diverse group of 75 organisms has been targeted for classical biological in Florida (Table 1). Slightly less than half (48%) of the insects belong to the order Homoptera. Other well-represented insect orders are Lepidoptera (24%) and Coleoptera (10%). Two families, Diaspididae and Aphididae, together include half of the species of Homoptera. Single families, Noctuidae and Curculionidae, respectively include nearly half (44%) of the species of Lepidoptera and more than half (57%) of the species of Coleoptera. The distribution of targeted insect pest species among orders is not very similar to the distribution of recent immigrant insect species among orders (see Frank & McCoy 1992). The eight targeted plant pest species are from eight orders.

Most (79% of the insects, 75% of the plants) of the pests targeted for classical

TABLE 3. Alternative scientific names have been used in the literature for several of the biological control agents listed in these pages. Synonyms were used inadvertently in many instances, but in some instances misspellings were used, or misidentifications were made. The list following shows (at left) names that have been used in the literature, and (at right) names that we believe to be correct now for the species in question.

| | |
|---|---|
| for *Acentropus niveus* | see *Acentria ephemerella* |
| for *Adenis variegata* | see *Hippodamia variegata* |
| for *Adonia variegata* | see *Hippodamia variegata* |
| for *Aganaspis daci* | see *Trybliographa daci* |
| for *Agathis stigmatera* (Cresson) | see *Alabagrus stigma* |
| for *Apanteles flavipes* | see *Cotesia flavipes* |
| for *Aphelinus semiflavus* (Howard) | see *Aphelinus asychis* |
| for *Aphis citricola* van der Goot | see *Aphis spiraecola* |
| for *Aphycus helvolus* | see *Metaphycus helvolus* |
| for *Aphycus luteolus* | see *Metaphycus luteolus* |
| for *Aphytis citrinus* (Compere) | see *Aphytis aonidiae* |
| for *Aptesis basizonia* | see *Pleolophus basizonus* |
| for *Aspidiotiphagus* | see *Encarsia* |
| for *Asynonychus godmani* | see *Asynonychus godmanni* |
| for *Azya trinitatis* | see *Pseudoazya trinitatis* |
| for *Bagous pulchellus* Hustache | see *Bagous affinis* |
| for *Bassus stigmaterus* (Cresson) | see *Alabagrus stigma* |
| for *Biosteres longicaudatus* | see *Diachasmimorpha longicaudata* |
| for *Biosteres oophilus* (Fullaway) | see *Biosteres arisanus* |
| for *Bracanastrepha anastrephae* | see *Utetes anastrephae* |
| for *Bracon brevicornis* | see *Habrobracon brevicornis* |
| for *Bracon chinensis* | see *Myosoma chinensis* |
| for *Bracon vesticida* | see *Bracon vestiticida* |
| for *Brumus suturalis* | see *Brumoides suturalis* |
| for *Centeterus alternecoloratus* | see *Aubertillus alternecoloratus* |
| for *Ceromasia sphenophori* | see *Lixophaga sphenophori* |
| for *Chilomenes sexmaculata* | see *Menochilus sexmaculatus* |
| for *Chrysopa carnea* | see *Chrysoperla carnea* |
| for *Coccinella punctata* | see *Coccinella septempumctata* |
| for *Cryptochaetum* | see *Cryptochetum* |
| for *Cryptochetum monophlebi* Skuse | see *C. iceryae* |
| for *Cryptognatha flavescens* | see *Serangium flavescens* |
| for *Cryptognatha simillima* Sicard | see *Cryptognatha gemellata* |
| for *Dasyscapus parvipennis* Gahan | see *Goetheana parvipennis* |
| for *Delphastus sonoricus* Casey | see *Delphastus pusillus* |
| for *Dibrachoides dynastes* (Foerster) | see *Dibrachoides druso* |
| for *Doryctobracon cereum* (Gahan) | see *Doryctobracon areolatus* |
| for *Dusmetia sangwani* | see *Neodusmetia sangwani* |
| for *Encarsia tabacivora* Viggiani | see *Encarsia pergandiella* |
| for *Eocanthecona furcellata* | see *Cantheconidia furcellata* |
| for *Euphasiopteryx depleta* | see *Ormia depleta* |
| for *Goetheana parvipennis* (Gahan) | see *Goetheana shakespearei* |
| for *Gonatopus* sp. | see *Pseudogonatopus variistriatus* |
| for *Ipobracon rimac* | see *Iphiaulax rimac* |
| for *Heterolaccus grandis* | see *Catolaccus grandis* |
| for *Iphiaulax amabilis* | see *Digonogastra amabilis* |

for *Iphiaulax rimac* see *Digonogastra rimac*
for *Larra braunsii* Kohl see *Larra godmani*
for *Leis dimidiata* see *Harmonia dimidiata*
for *Leptomastix abnormis* seee *Leptomastidea abnormis*
for *Litodactylus leucogaster* see *Phytobius leucogaster*
for *Litomastix truncatella* (Dalman) see *Copidosoma floridanum*
for *Lydella grisescens* Robineau-Desvoidy see *Lydella thompsoni*
for *Microbracon vestiticida* see *Bracon vestiticida*
for *Microcharops bimaculata* (Ashm.) see *Microcharops anticarsiae*
for *Microceromasia sphenophori* see *Lixophaga sphenophori*
for *Namangana pectinicornis* see *Spodoptera pectinicornis*
for *Nephaspis amnicola* Wingo see *Nephaspis oculata*
for *Opius anastrephae* see *Utetes anastrephae*
for *Opius concolor* see *Psyttalia concolor*
for *Opius fletcheri* see *Psyttalia fletcheri*
for *Opius incisi* see *Psyttalia incisi*
for *Opius oophilus* Fullaway see *Biosteres arisanus*
for *Opius persulcatus* Silvestri see *Biosteres vandenboschi*
for *Opius trinidadensis* see *Doryctobracon trinidadensis*
for *Opius tryoni* see *Diachasmimorpha tryoni*
for *Opius vandenboschi* see *Biosteres vandenboschi*
for *Pantomorus cervinus* (Boheman) see *Asynonychus godmanni*
for *Pantomorus godmanni* see *Asynonychus godmanni*
for *Parachasma cereum* (Gahan) see *Doryctobracon areolatus*
for *Parachasma crawfordi* see *Doryctobracon crawfordi*
for *Parachasma trinidadense* see *Doryctobracon trinidadense*
for *Paraleptomastix abnormis* see *Leptomastidea abnormis*
for *Phania vittata* see *Evbrissa vittata*
for *Pimpla* sp. see *Coccygomimus* sp.
for *Praon palitans* Muesebeck see *Praon exsoletum*
for *Prospaltella* see *Encarsia*
for *Pseudoarchytopsis* see *Archytas*
for *Pseudococcobius terryi* Fullaway see *Pseudaphycus mundus*
for *Pyrophorus luminosus* see *Ignelater luminosus*
for *Scapteriscus acletus* Rehn & Hebard see *Scapteriscus borellii*
for *Scymus binaeratus* see *Nephus binaevatus*
for *Stethorus atomus* Casey see *Stethorus utilis*
for *Theresia claripalpis* see *Paratheresia claripalpis*
for *Timberlakia europaea* see *Pseudectroma europaea*
for *Triaspis vesticida* see *Triaspis vestiticida*
for *Trioxys utilis* Muesebeck see *Trioxys complanatus*

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biological control in Florida are known to be adventive. Although the adventive insect pests had their geographic origins in many regions of the globe, a large percentage (43%) is native to Asia, and most of these Asian natives attack citrus. These Asian pests are atypical of adventive insects in 1971-present, because most of the latter are of Neotropical origin (Frank & McCoy 1992). However, many of the targeted insect pests were pests of citrus, which is of Asian origin. The targeted adventive plant pests are from South America (50%), Eurasia (33%), and Australia (17%). The early part of the pattern of arrival of targeted pest species in Florida (Fig. 1) may illustrate the linkage of pest exchange with commercial traffic noted by Sailer (1983). The importation of

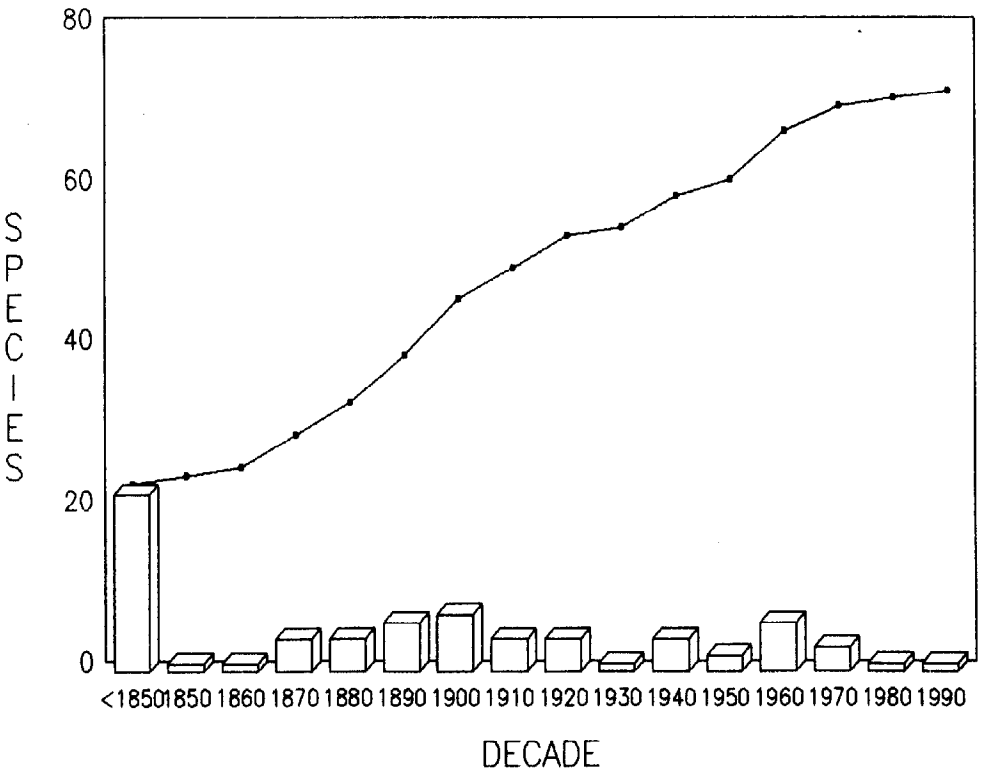


Fig. 1. Arrival of targeted pest species in Florida. Line is the cumulative number of species. Note that one species, *Aleurocanthus woglumi* Ashby, immigrated to Florida twice (Table 1).

several ornamental plants — that later became pests — near the end of the nineteenth century further inflated the number of arrivals at that time.

It is interesting to note that acting under the Plant Pest Act of 1912 and Plant Quarantine Act of 1957, USDA agricultural inspectors have for decades tried to exclude phytophagous insects ("plant pests") from entry into the USA, yet the USDA has encouraged, and itself has taken part in, importation of exotic plants as ornamentals. This incongruity is explicable in terms of trade: sales of exotic terrestrial plants (by the nursery trade), exotic aquatic plants (by the aquarium trade), and exotic animals, especially vertebrates, but also mollusks and anthropods (by the pet trade) provide a profit to importers. Our laws make it acceptable to import potential pests if a profit is to be made, but not to import worthless (i.e., unsalable) potential pests. We are not aware of anything in the laws that requires importers to pay for the control of imported organisms that have become pests, nor even to pay the cost of research toward finding means of control of such pests, although it strikes us as fair that they should do so.

None of the targeted pests known to be native (16% of the insects, 12% of the plants) is precinctive (i.e., occurring only in Florida; see Frank & McCoy (1990) for definition of this term). All have wider distributions, either in the southeastern states generally, or also in the West Indies, with Florida only a part of their native ranges. An example among the insects is *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae), which has a wide distribution in the West Indies, Central and South America; it occurs in the southern USA, but in severe winters it can survive only in the extreme south of

Florida. An example among the plants is *Lantana camara* L. (lantana), which occurs naturally from the southern USA to northern South America.

*Introduced Insects*

Our tabulation of insects introduced into Florida (Table 2) includes 351 taxa (a few species are lumped together). Of these 351 taxa, 32 appear to have occurred already in Florida; 24 apparently are natives and 8 apparently are immigrants. Some of the immigrants, such as *Bathyplectes curculionis* (Thomson) (Hymenoptera: Ichneumonidae), seem to have arrived in Florida by immigration from other states into which they had been imported, while others, such as *Megastigmus transvaalensis* (Hussey) (Hymenoptera: Torymidae) and *Utetes anastrephae* (Viereck) (Hymenoptera: Braconidae), may have arrived directly from abroad by stowing away in cargoes of plants and other materials, probably with their host insects (Frank & McCoy 1992). Another 11 taxa are thought to have been introduced because permits were issued for their importation, but no actual records of importation could be located. Exactly half, 154, of the remaining 308 taxa were released in Florida. Three of the species released are not biological control agents, leaving 151 taxa, of which 139 targeted insect pests and 12 targeted plant pests. Biological control agents have been released in Florida since the 1890s (Fig. 2).

Overall, the proportion of establishment of biological control agents in Florida is 27.8%. If the agents targeting insect and plant pests are considered separately, the

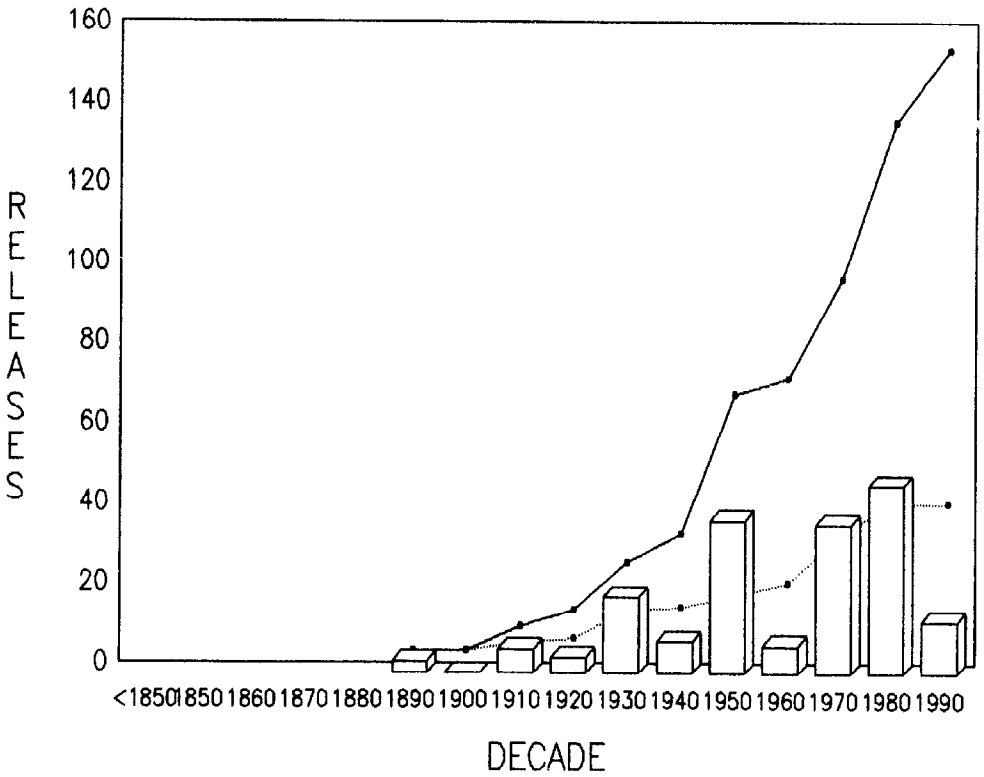


Fig. 2. Release of insect biological control agents in Florida (one release = one agent taxon introduced against one pest taxon in one decade). Upper line is the cumulative number of releases, lower line is the cumulative number of releases that resulted in establishment.

proportions are 24.5% and 66.7%, respectively. If the taxa whose current status is unknown are assumed to establish in the same proportions as the taxa whose status is known, then the overall proportions increase to 27.3% and 91.7%, respectively. Our proportion of establishment for agents targeting insect pests, calculated in either way, loosely matches what Hall & Ehler (1979) refer to as the "often quoted figure of 0.20-0.25" (see Clausen 1956). Our proportion of establishment, however, is less than the worldwide proportions calculated from published lists by Hall & Ehler (1979) (34%) and Stilir g (1990) (35.6% or 43.4%, depending upon how the calculations were made).

It may be significant that the establishment proportion calculated by Hall & Ehler (1979) for California (22%) also seems to be relatively low. They attributed the relatively low proportion in California to that state's efficient documentation of introductions and its role as a "screening ground"; for natural enemies, both of which would result in proportionately more failures being reported. To a certain degree, the same two explanations hold for Florida.

Proportions of establishment may differ in some systematic way among species or among situations, but the factors that correlate with relatively high or relatively low proportions of establishment of biological control agents seem to be complex and poorly understood (Gross & Pair 1986, Stiling 1990; see also Murdoch et al. 1985). Few researchers today would try to predict which species-introductions are likely to succeed, as was common practice at one time (see DeBach 1971, Huffaker et al. 1971, Price 1972). Previous studies have reached several relevant conclusions concerning proportions of establishment of insect agents, however. (These same conclusions often apply equally well to proportions of success.) Proportions are similar for predators and parasitoids (Hall & Ehler 1979); proportions are higher (1) against certain orders of pest than against others (Hall & Ehler 1979, Stiling 1990), (2) against exotic pests than against native ones (Hall & Ehler 1979, Stiling 1990), (3) against exposed pests than against concealed ones (Stiling 1990, Gross 1991; see also Hawkins & Lawton 1987), (4) against monophagous pests than against polyphagous ones (Martin et al. 1981, Stiling 1990), (5) in "stable" habitats than in "unstable" ones (Hall & Ehler 1979, but see Stiling 1990), (6) when agents are adapted to the climatic regimes in which the pests reside than when they are not (Messenger 1971, Stiling 1990), (7) when large numbers of individuals of agents are introduced than when they are not (Beirne 1975, but see Gross & Pair 1986). Proportions of introduced species becoming established in the USA declined over time (Hall & Ehler 1979). Some factors that may interfere with establishment, but that we shall not discuss, are voltinism (van den Bosch & Messenger 1973, Stiling 1990), lack of alternate prey/hosts (van den Bosch & Messenger 1973, Eikenbary & Rogers 1974), lack of foodstuff for adult parasitoids (Hagen et al. 1970, van den Bosch & Messenger 1973), and — most controversially — competition (Ehler & Hall 1982, 1984, Keller 1984, Simberloff 1986, Myers et al. 1989; see example in Schuster & Dean 1976 and *Anagyrus antoninae* Timberlake in Table 2).

Examination of these conclusions with our data set led to some interesting results. The proportions of establishment of insect predators and parasitoids are 26.7% and 23.9%, respectively. These proportions cannot be shown to be different (G-statistic = 0.04, $P > 0.05$), but both are lower than the proportion of establishment of herbivores (66.7%) (G-statistics = 88.02 and 12.34, $P < 0.05$). Most releases were against targets in two orders, Homoptera and Lepidoptera, and the proportions of establishment are different for them: 31.7% and 10.5%, respectively (G-statistic = 6.82, $P < 0.05$). (Numbers of releases against targets in other orders were too few to draw meaningful conclusions.) Although the worldwide proportions of establishment they report for these two orders are substantially higher than ours, Hall & Ehler (1979) and Stiling (1990) both conclude that the proportion of establishment for homopterous targets exceeds the proportion for lepidopterous targets.

We could not examine four of the conclusions with our data set. Because most of the native insect pests are in the order Lepidoptera, and we have just shown pests in this order to be relatively poor candidates for establishment, we could not compare proportions of establishment against native and exotic pests. Likewise, pests in the order Homoptera, which we have shown to be relatively good candidates for establishment, tend to occur in large groups on the surface of one or a few plant taxa, particularly on citrus trees; therefore, because pests in this order make up nearly half of all the targeted insects, we also could not compare proportions of establishment against exposed and concealed pests, against monophagous and polyphagous pests, or in "stable" and unstable" habitats.

We examined the effect of climatic regime in the useful, albeit indirect, way suggested by Stiling (1990). It is necessary to employ an indirect method because direct measures of local climate usually are not available for either the pest's location or the biological control agent's origin (see Stiling 1990). Because Stiling's (1990) method operates on a relatively large spatial scale, any results derived from its use must be considered tentative. Stiling's (1990) results suggest that, for Florida, which we will consider mostly temperate, agents of temperate origin will be more readily established than agents of tropical origin. We could not confirm this tendency for agents targeting insect pests; the establishment proportions are 22.2% and 29.0% for agents probably of temperate and tropical origin, respectively (G-statistic = 0.48, $P > 0.05$). When the regions of origin are grouped as New World, Eurasia, tropical Asia/Australia, Africa, and Hawaii, the resulting establishment proportions range from 20.0% to 33.3%, none of which can be shown to be different from the others (G-statistics = 0.00 to 0.08, $P > 0.05$). Proportions of establishment of agents of island origin (24.2%) are not different from those of agents of mainland origin (27.1%) (G-statistic = 0.06, $P > 0.05$). Agents from India/Pakistan and the West Indies have the highest (36.0%) and lowest (17.6%) proportion of establishment, respectively, for individual regions, but neither proportion can be shown to be different from that of the rest of the globe (G-statistics = 1.42 and 0.64, $P > 0.05$).

Although agents from specific regions cannot be shown to be unusual in proportion of establishment, more detailed examination of the cases of India/Pakistan and the West Indies may reveal patterns that are potentially of interest. Most of the agents acquired from India/Pakistan targeted insects in the order Homoptera, and many of the ones that established targeted more than one pest. These facts may help to explain their relatively high proportion of establishment. The relatively low proportion of establishment for agents acquired from the West Indies is less easily explained, especially as immigration from the West Indies appears to occur regularly (Frank & McCoy 1992). Many of these agents also targeted insects in the order Homoptera, but the lists of targets of agents from India/Pakistan and from the West Indies overlap very little. Perhaps the particular pests targeted by West Indian agents simply are poorer candidates for establishment than those targeted by agents from other regions; but, of course, such a conclusion begs the question.

The mean number of individuals released for agents that established was quite near the mean number released for agents that failed to establish. The mean numbers were 4743 (±7364) individuals and 4332 (±10,979) individuals, respectively, when releases against *Anastrepha suspensa* (Loew) (Dip.: Tephritidae) are excluded. Inclusion of releases of *A. suspensa*, one of which exceeds one million individuals, raises the mean number of individuals released for agents that established to 30,377 (±161,726). The variances are too high to allow meaningful conclusions to be drawn, but even if they were not, we are not sure what a difference in numbers of individuals might mean. If number of individuals released could be shown to be related positively to chance of establishment, the result might mean that raising extremely large numbers of individ-

uals for release could improve the chance of establishment. Release of large numbers of individuals in more locations, targeting more microclimates, could improve chances of success. On the other hand, the result could simply mean that large numbers of individuals are released only when the chance of establishment (and, perhaps, success) is thought to be high in advance. It seems likely to us that releases of large numbers of individuals are warranted sometimes, but that at present we have little way of predicting whether release of large numbers is justifiable.

No decline in proportion of establishment over time was obvious. We did discern an apparent tendency for proportions to be lower for decades in which relatively many releases were made, which we believe indicates that occasional "shotgun"; releases are made, and that many of these releases have relatively little chance of establishment. The tendency indeed is present, but it is not a particularly strong one (Spearman's $r$ = -0.515, $P > 0.05$).

We also looked for patterns in proportions of establishment relative to location of release. Releases were known to have been made in 41 of the 67 counties, and the outcome was known for at least one release in 39 of these counties. Only five counties had proportions of establishment less than 50%: Alachua, Dade, Gadsden, Indian River, and Palm Beach. Coincidentally, four of the five (all but Indian River) were the sites of the largest numbers of releases. We refer to these counties as "donors," where potential agents are released and screened; agents judged to have a high chance of establishment are then released in other counties, which we refer to as "recipients." Because proportions of establishment were greater in Dade (37.0%), Indian River (37.5%), and Palm Beach (41.4%) counties than in Alachua (12.5%) or Gadsden (7.7%) counties, we thought that we might also find greater proportions of establishment in recipient counties in the south or along the coast than in recipient counties in the north or inland. No such correlations were obvious to us, however, but trends might be masked if agents thought in advance to have a high chance of establishment were released preferentially in recipient counties. The generally low proportions of success in the Panhandle region may merit investigation, but sample sizes are too small for us to reach any firm conclusions.

What needs to be done to further our understanding of how insects introduced into Florida react to the environment that they encounter? An analysis of proportions of success is needed, to accompany the analysis of proportions of establishment. Some greater insight into the behavioral ecologies of biological control agents and their targets also is needed. We suggest that closer scrutiny of all of the introductions, including the biologies and ecologies of the organisms involved and, perhaps, the use of multiple comparisons, would prove productive. On a larger scale, in order to determine how Florida fares relative to other regions, two other pieces of information would be valuable: (1) the variation in the way proportions of establishment and success are calculated and reported worldwide and (2) a list of the taxa that were imported but not released worldwide ("failed to establish or succeed in the laboratory"). The latter piece of information might well alter the way in which we think about proportions of establishment and success, although we have not considered all the implications.

## THE SYMPOSIUM

In dealing with the behavioral ecology of immigrant insects as the theme of last year's symposium, we faced two unknowns: we did not know how many individuals of any immigrant species arrived in Florida, nor precisely how these immigrations were distributed in time. This restricted us to dealing with successful immigrations, i.e., immigrant species which were shown to have established populations in Florida.

The theme of this year's symposium is introduced insects. People have introduced

insects into Florida for various reasons, but very nearly all of the introductions that have been documented were for biological control purposes. The Florida Entomological Society had planned a separate symposium on biological control. When it became clear that much of our symposium would be about the behavioral ecology of biological control, we decided to merge the two symposia. Most of the contributions are about the behavioral ecology of insects or nematodes introduced for biological control purposes, but some of the contributions are about related topics that we found interesting.

Practitioners of classical biological control import biological control agents against immigrant pests and sometimes against native pests. These introductions are made when native or previously-introduced biological control agents do not control the pests adequately. Fred Bennett reviews reports of the effect of newly-introduced agents on the previously-occurring natural enemies; he finds that populations of the latter sometimes are reduced, and that aggression of one biological control agent against another has been documented.

Pest ants have been the targets of biological control attempts, especially using pathogens. David Oi and Roberto Pereira review the literature on the behavior of ants afflicted by bacteria, fungi, protozoans, nematodes and trematodes. They document production of secretions, grooming, nest hygiene, avoidance, and dispersal as behaviors displayed by ants of a range of genera against such natural enemies.

Entomopathogenic nematodes have been used as biopesticides, typically are applied at high dosages, and have no residual effect because they do not reproduce in the habitats where they are applied. Patrick Parkman and Howard Frank describe a novel use of an imported nematode species which reproduces in its specific host. They attracted mole crickets to synthetic mole cricket song, there exposed the mole crickets to the nematodes, and then permitted the insects to disperse. Thus, they fomented disease epidemics in mole cricket populations on Florida golf courses.

The theme of use of entomopathogenic nematodes to control insects is continued by Rick Jansson. He examines behavioral characteristics of heterorhabditid and steinernematid nematodes collected in recent surveys of soils. Many of the species were previously unknown taxonomically and behaviorally. He is rightly concerned about their host-range and about potential effects of releasing them in places where they are not native.

Waterhyacinth is one of the most invasive aquatic weeds infesting waterways in the southern USA. Two weevil species of the genus *Neochetina* have been introduced against it, but chemical herbicides are still in use. Kim Haag (manuscript not submitted) shows that the weevils can reduce waterhyacinth populations. When waterhyacinth in a lake was treated experimentally with 2,4-D, weevils aggregated in untreated refugia and there caused significant reduction in plant stature and growth.

*Coccinella septempunctata*, a widely-distributed palearctic ladybird, was released first in the USA in 1956, and further releases were made in 1958-1973. Established populations were found in 1973 in Canada and New Jersey. John Obrycki (manuscript not submitted) examines behavioral characteristics of this insect in attempt to determine why it took so long to become established. He also is concerned with documenting any effects of this species, which is one of the least prey-specific of ladybirds, on the ladybird fauna native to North America.

Under what circumstances is a classical biological control project justifiable economically? Michael Habeck (and two co-authors) are economists who look critically at project cost, length, chance of success, and the time value of money to build a simple mathematical model. By their calculations, the benefits of a biological control project must be predicted to exceed about $62,000 per year before its funding can be justified. Of course there are exceptions, but biological control practitioners need to understand the economic realities when they seek funding for research.

Gypsy moth was introduced into Massachusetts in the last century, escaped from captivity, and became a pest. It has been the target of biological control by introduction of natural enemies from the palearctic region, but these introductions were not reviewed by Jon Allen (and eight co-authors). Instead, these colleagues address the probability of gypsy moth managing to colonize Florida from northern states. They conclude that the moth probably will establish populations in northern Florida, but its behavioral response to mild winters and sparsely-distributed host-trees may not allow it to achieve pest status.

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