

## Invasive Insects (Adventive Pest Insects) in Florida<sup>1</sup>

J. H. Frank and M. C. Thomas<sup>2</sup>

### What is an Invasive Insect?

The term 'invasive species' is defined as 'non-native species which threaten ecosystems, habitats, or species' by the European Environment Agency (2004). It is widely used by the news media and it has become a bureaucratese expression. This is the definition we accept here, except that for several reasons we prefer the word **adventive** (meaning **they arrived**) to non-native. So, 'invasive insects' in Florida are by definition a subset (those that are **pests**) of the species that have arrived from abroad (**adventive species** = non-native species = nonindigenous species). We need to know which insect species are adventive and, of those, which are pests.

### How to Know That a Species is Adventive

In Florida, 500 years ago, nobody identified and made lists of insect species present. So there is a lot of detective work, and many guesses by insect taxonomists, in knowing which ones were present then (are native), and which arrived since then (are **adventive**). Recent arrivals are a lesser problem because we now have lists. There still are problems

because the lists are incomplete. The lists do not include some of the more obscure native species, which still are unrecorded; they do not include some of the adventive species that have not yet been detected and/or identified; and they do not specify the origin (native or adventive) of many species.

### How to Recognize a Pest

A value judgment must be made: among all adventive species in a defined area (Florida, for example), which ones are **pests**? We can classify the more prominent examples, but cannot easily decide whether the vast bulk of them are 'invasive' (= pests) or not, for lack of evidence. To classify them all into pests and non-pests we must draw a line somewhere in a continuum ranging from important pests through those that are uncommon and feed on nothing of consequence to humans, to those that are beneficial.

Florida has at least 12,500 insect species. They all eat something. Whether humans call them pests depends partly on their abundance, partly on whether humans value or denigrate what these insects eat, and partly upon extraneous concepts. There is no rule about what people call a pest. After all, by Federal law, any insect that eats plants is a 'plant pest' –

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  2. J. H. Frank, professor, Entomology and Nematology Department, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL and M. C. Thomas, Florida State Collection of Arthropods, Division of Plant Industry, Gainesville, FL.

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although some insects that eat plants are caterpillars of 'endangered species' of butterflies under Federal law. Even Federal laws are inconsistent.

Because we had no easy means of deciding all that are pests, we avoided the issue by selecting 100 important adventive pest insects ('invasive insects'). We list them (Table 1) by order, and then by family, genus and species, all alphabetical.

For each species, we give the date of detection in Florida, accurately for fairly recent arrivals, or approximately for older arrivals if we found any information, but for a few of them we found no information and simply leave the year of arrival with a question mark. We do not really know whether they are the 100 worst, but we guess they may be, or many of them potentially were at the time of their arrival, although accurate economic data are not available. We give the common name if there is one.

## Conclusion

Insects have been arriving in Florida for thousands of years, in fact ever since the peninsula was last exposed by dropping sea levels. But it has only been in the last 30 years or so that the rate of insect immigration into Florida has been documented (Frank and McCoy 1992; Thomas 2004). During the decades since 1971 exotic insects have been arriving and becoming established on Florida's shores at a rate of about 10 species per year. In other words, Florida's insect fauna increases by one species every five weeks. This is counting only those species for which there is evidence that the species are breeding in Florida; it does not count port interceptions; it does not count the few insects introduced/established for biocontrol of pests.

**Table 1.** A hundred important invasive insects in Florida.

<b>BLATTARIA: BLATTELLIDAE</b>
<i>Blattella asahinai</i> Mizukubo, Asian cockroach, from Asia, a pest of ornamental plants and crops. 1986.
<i>Blattella germanica</i> (L.), German cockroach, from Europe, a household pest. 19 <sup>th</sup> century.
<b>BLATTARIA: PERIPLANETIDAE</b>
<i>Periplaneta americana</i> (L.), American cockroach, from Africa, a household pest. 17 <sup>th</sup> century.
<i>Periplaneta australiae</i> (F), Australian cockroach, from Africa, a household pest. 1877.
<b>COLEOPTERA: CHRYSOMELIDAE</b>
<i>Chelymorpha cribraria</i> (F.), no common name, from the American tropics, a pest of native <i>Ipomoea</i> plants. 1993.
<i>Diabrotica balteata</i> LeConte, banded cucumber beetle, from the southwestern USA, Mexico, and Central America, a pest of cucurbits and some other vegetables. Early 20 <sup>th</sup> century.
<i>Leptinotarsa decemlineata</i> (Say), Colorado potato beetle, from the western USA, a pest of potato. 1920.
<b>COLEOPTERA: COCCINELLIDAE</b>
<i>Epilachna varivestis</i> Mulsant, Mexican bean beetle, from Central America, a pest of beans. 1920.
<b>COLEOPTERA: CURCULIONIDAE</b>
<i>Anthonomus grandis</i> Boheman, boll weevil, from southern Mexico, a pest of cotton. 1920.
<i>Anthonomus eugenii</i> Cano, pepper weevil, from Mexico, a pest of sweet pepper. 1935.
<i>Asynonychus godmanni</i> Crotch, Fuller rose weevil, from South America, a pest of citrus and ornamental plants. 1870.
<i>Cylas formicarius</i> (F.), sweetpotato weevil, from Asia, a pest of sweet potatoes. 1878
<i>Diaprepes abbreviatus</i> (L.), sugarcane rootstock weevil borer, or Apopka weevil, from the West Indies, a pest of citrus, sugarcane, and many other plants. 1960.
<i>Hypera postica</i> (Gyllenhal), alfalfa weevil, from Europe, a pest of alfalfa. 1970.
<i>Metamasius callizona</i> (Chevrolat), Mexican bromeliad weevil, from Mexico, a pest of native and cultivated bromeliads. 1989.
<i>Metamasius hemipterus</i> (L.), silky sugarcane weevil, from the Neotropics, a pest of sugarcane, ornamental palms, and rarely of pineapple fruits. 1984.
<b>COLEOPTERA: NITIDULIDAE</b>
<i>Aethina tumida</i> Murray, small hive beetle, from Africa, a pest of honey bees. 1998.

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<b>DIPTERA: BIBIONIDAE</b>
<i>Plecia nearctica</i> Hardy, lovebug, from Central America, damages radiators and paint of cars. 1949.
<b>DIPTERA: BRAULIDAE</b>
<i>Braula coeca</i> Nitzsch, beelouse, from Europe, a pest of honey bee. 1983.
<b>DIPTERA: CALLIPHORIDAE</b>
<i>Cochliomyia hominivorax</i> (Coquerel), New World screwworm, from the Neotropics, a pest of cattle and other vertebrates including humans. 1933. Eradicated by use of the sterile-male technique.
<b>DIPTERA: CULICIDAE</b>
<i>Aedes aegypti</i> (L.), yellow fever mosquito, from Africa, a vector of yellow fever and dengue. Before 1850.
<i>Aedes albopictus</i> (Skuse), Asian tiger mosquito, from eastern Asia, a vector of dengue. 1986.
<b>DIPTERA: MUSCIDAE</b>
<i>Haematobia irritans</i> (L.), horn fly, from Africa, a pest of cattle. 1890.
<i>Musca domestica</i> L., house fly, from Africa, a pest of humans and livestock. Before 1850.
<i>Stomoxys calcitrans</i> (L.), stable fly, from Africa, a pest of livestock and humans. 1900.
<b>DIPTERA: OESTRIDAE</b>
<i>Gasterophilus haemorrhoidalis</i> L., nose botfly, from Europe, a pest of horses. Before 19 <sup>th</sup> century.
<i>Gasterophilus intestinalis</i> (DeGeer), horse botfly, from Europe, a pest of horses. Before 19 <sup>th</sup> century.
<i>Gasterophilus nasalis</i> (L.), throat botfly, from Europe, a pest of horses. Before 19 <sup>th</sup> century.
<i>Hypoderma bovis</i> (L.), northern cattle grub, from Europe, a pest of cattle. Before 19 <sup>th</sup> century.
<i>Hypoderma lineatum</i> (Villers), common cattle grub, from Europe, a pest of cattle. Before 19 <sup>th</sup> century.
<i>Oestrus ovis</i> (L.), sheep botfly, from Europe, a pest of sheep. Before 19 <sup>th</sup> century.
<b>DIPTERA: TEPHRITIDAE</b>
<i>Anastrepha suspensa</i> (Loew), Caribbean fruit fly, from the West Indies, a pest of cultivated fruits. 1931.
<i>Ceratitis capitata</i> (Wiedemann), Mediterranean fruit fly, from subsaharan Africa, a pest of fruits. Detected several times, beginning in 1929, and eradicated at great expense each time.
<i>Toxotrypana curvicauda</i> Gerstaecker, papaya fruit fly, from the Neotropical region, a pest of papaya. 1905.
<b>HEMIPTERA: PENTATOMIDAE</b>
<i>Euschistus quadrador</i> Rolston, a brown stink bug, from Mexico, has supplanted other stink bugs in cotton, soybean, citrus, and other crops. Early 1990s.
<i>Nezara viridula</i> (L.), southern green stinkbug, from Africa, a pest of vegetables. Before 1850.
<b>HEMIPTERA: TINGIDAE</b>
<i>Leptodictya tabida</i> (Herrich-Schaeffer), sugarcane lace bug, from the Neotropics, a pest of sugarcane. 1990.
<b>HOMOPTERA: ALEYRODIDAE</b>
<i>Aleurocanthus woglumi</i> Ashby, citrus blackfly, from Asia, a pest of citrus. 1930 (eradicated) and 1976.
<i>Aleurodicus dispersus</i> Russell, spiralling whitefly, from the Neotropics, a pest of citrus and coconut. 1950.
<i>Aleurodicus dugesii</i> Cockerell, giant whitefly, from Mexico, a pest of numerous ornamental plants. 1996.
<i>Bemisia argentifolii</i> Bellows & Perring, silverleaf whitefly, perhaps from the Middle East, a pest of ornamental plants, tomatoes, and cucurbits. 1986.
<i>Bemisia tabaci</i> Gennadius, sweetpotato whitefly, from Asia, a pest of field crops and ornamental plants. 1890.
<i>Dialeurodes citri</i> (Ashmead), citrus whitefly, from Asia, a pest of citrus. 1870.
<i>Singhiella citrifolii</i> (Morgan), cloudywinged whitefly, from Asia, a pest of citrus and some ornamental plants. 1900.
<b>HOMOPTERA: APHIDIDAE</b>
<i>Aphis gossypii</i> Glover, melon or cotton aphid, from Eurasia, a pest of cucurbits, cotton, and many other plants, and a vector of virus. Year?

**Table 1.** A hundred important invasive insects in Florida.

<i>Aphis spiraecola</i> Patch, spirea (or spiraea) aphid, from Asia, a pest of citrus, other fruit and ornamental trees, and many other plants. 1920.
<i>Melanaphis sacchari</i> (Zehnter), sugarcane aphid, from Asia, a pest of sugarcane. 1977.
<i>Myzus persicae</i> (Sulzer), green peach aphid, from Asia, a pest of tree fruits and many other plants, and an important virus vector. Year?
<i>Therioaphis trifolii</i> (Monell), spotted alfalfa aphid, from Eurasia, a pest of alfalfa and clover. 1960.
<i>Toxoptera aurantii</i> (Fonscolombe), black citrus aphid, from Asia, a pest of citrus. 1914.
<i>Toxoptera citricida</i> (Kirkaldy), brown citrus aphid, from Asia, a pest of citrus. 1995.
<b>HOMOPTERA: COCCIDAE</b>
<i>Ceroplastes cirripediformis</i> Comstock, barnacle scale, from Asia, a pest of citrus and ornamental plants. 1880.
<i>Coccus hesperidum</i> L., brown soft scale, from Asia, a pest of citrus. 1870.
<i>Saissetia neglecta</i> DeLotto, Caribbean black scale, from the Caribbean, a pest of citrus. 1921.
<b>HOMOPTERA: DELPHACIDAE</b>
<i>Perkinsiella saccharicida</i> Kirkaldy, sugarcane delphacid, from Australia, a pest of sugarcane. 1980.
<i>Saccharosydne saccharivora</i> (Westwood), West Indian sugarcane delphacid (called canefly in the English-speaking Caribbean) from the Caribbean, a pest of sugarcane. Year?
<b>HOMOPTERA: DIASPIDIDAE</b>
<i>Aonidiella aurantii</i> (Maskell), California red scale, from Asia, a pest of citrus. 1890.
<i>Aspidiotus destructor</i> Signoret, coconut scale, from Asia, a pest of coconut palm. 1920.
<i>Aulacaspis yasumatsui</i> Takagi, cycad aulacaspis scale, from Asia, a pest of cycads. 1996.
<i>Chrysomphalus aonidum</i> (L.), Florida red scale, from Asia, a pest of citrus. 1880.
<i>Fiorinia theae</i> Green, tea scale, from Asia, a pest of camellia, holly, and other ornamental plants. 1898.
<i>Lepidosaphes beckii</i> (Newman), purple scale, from Asia, a pest of citrus. 1859.
<i>Pseudaulacaspis cockerelli</i> (Cooley), false oleander scale, from Asia, a pest of oleander, magnolia, mango, dogwood, etc. 1942.
<i>Pseudaulacaspis pentagona</i> (Targioni-Tozzetti), white peach scale, from Asia, a pest of peach and other trees. 1880.
<i>Unaspis citri</i> (Comstock), citrus snow scale, from Asia, a pest of citrus. 1880.
<i>Unaspis euonymi</i> (Comstock), euonymus scale, from Asia, a pest of ornamental plants. 1960.
<b>HOMOPTERA: KERRIIDAE</b>
<i>Paratachardina lobata</i> (Chamberlin), lobate lac scale, from India, a pest of many trees and shrubs. 1999.
<b>HOMOPTERA: PSEUDOCOCCIDAE</b>
<i>Antonina graminis</i> Maskell, Rhodesgrass mealybug, from Asia, a pest of grasses. 1940.
<i>Dysmicoccus boninsis</i> (Kuwana), gray sugarcane mealybug, from Asia, a pest of sugarcane. 1895.
<i>Dysmicoccus brevipes</i> (Cockerell), pineapple mealybug, from the American tropics, a pest of pineapple. 1880.
<i>Maconellicoccus hirsutus</i> (Green), pink hibiscus mealybug, from Asia, a pest of hibiscus and many other ornamental plants. 2002.
<i>Paracoccus marginatus</i> Williams & Granara de Willink, papaya mealybug, from South America, a pest of papaya. 1998.
<i>Planococcus citri</i> (Risso), citrus mealybug, from Asia, a pest of citrus. 1880.
<i>Saccharicoccus sacchari</i> (Cockerell), pink sugarcane mealybug, from Africa, a pest of sugarcane. 1944.
<b>HOMOPTERA: PSYLLIDAE</b>
<i>Diaphorina citri</i> Kuwayama, Asian citrus psyllid, from Asia, a pest of citrus. 1998.
<b>HYMENOPTERA: FORMICIDAE</b>
<i>Linepithema humile</i> (Mayr), Argentine ant, from South America, a household pest. Earliest Florida specimen 1914, but probably was present in the 1890s (Mark Deyrup pers. com.).
<i>Monomorium pharaonis</i> (L.), pharaoh ant, from Africa, a household pest. Earliest Florida specimen 1908, but could have arrived as early as the first European explorers (Mark Deyrup pers. com.).

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<i>Paratrechina longicornis</i> (Latreille), crazy ant, from the Old World tropics, a household pest. First Florida record 1930, but probably was present a century before (Mark Deyrup pers. com.).
<i>Solenopsis invicta</i> Buren, red imported fire ant, from South America, a health risk to humans, pest of “wildlife” and “farm animals” and some cultivated crops, but a useful predator of some pests. First Florida specimens 1948 (Mark Deyrup pers. com.).
<i>Tapinoma melanocephalum</i> (F.), ghost ant, from the Old World tropics, a household pest. First Florida specimens 1930, but probably was present long before that (Mark Deyrup pers. com.).
<i>Technomyrmex albipes</i> (Fr. Smith), whitefooted ant, from Asia, a household pest. 1986.
<b>ISOPTERA: KALOTERMITIDAE</b>
<i>Cryptotermes brevis</i> (Walker), West Indian powderpost drywood termite, from the West Indies (although its true area of origin may be elsewhere), a pest of structures and living trees. Before 1919.
<b>ISOPTERA: RHINOTERMITIDAE</b>
<i>Coptotermes formosanus</i> Shiraki, Formosan subterranean termite, from Asia, a pest of structures. 1980.
<i>Coptotermes gestroi</i> (Wasmann), Asian subterranean termite (until recently, called <i>C. havilandi</i> Holmgren, Haviland's subterranean termite), from southeast Asia, a pest of structures. 1996.
<b>LEPIDOPTERA: GELECHIIDAE</b>
<i>Pectinophora gossypiella</i> (Saunders), pink bollworm, from Asia, a pest of cotton. 1950.
<b>LEPIDOPTERA: GRACILLARIIDAE</b>
<i>Phyllocnistis citrella</i> Stainton, citrus leafminer, from Asia, a pest of citrus. 1993.
<b>LEPIDOPTERA: NOCTUIDAE</b>
<i>Alabama argillacea</i> (Hübner), cotton leafworm, a frequent immigrant from the south, a pest of cotton.
<i>Anticarsia gemmatilis</i> Hübner, velvetbean caterpillar, a frequent immigrant from the south, a pest of soybean and other legumes. 1903.
<i>Pseudoplusia includens</i> (Walker), soybean looper, a frequent immigrant from the south, a pest of soybean.
<b>LEPIDOPTERA: PIERIDAE</b>
<i>Pieris rapae</i> (L.), imported cabbageworm (small white butterfly), from Eurasia, a pest of cole crops. 1886.
<b>LEPIDOPTERA: PYRALIDAE</b>
<i>Cactoblastis cactorum</i> Berg, cactus moth, from South America via the Caribbean, a pest of <i>Opuntia</i> cacti. 1989.
<i>Diatraea saccharalis</i> (F.), sugarcane borer, from the West Indies and Central and South America, a pest of sugarcane. 1860.
<b>LEPIDOPTERA: TINEIDAE</b>
<i>Opogona sacchari</i> (Bojer), banana moth, from the Old World tropics, a pest of many cultivated plants. 1963.
<b>LEPIDOPTERA: YPONOMEUTIDAE</b>
<i>Plutella xylostella</i> (L.), diamondback moth, from Europe or Africa, a pest of cole crops. 1883.
<b>ORTHOPTERA: GRYLLOTALPIDAE</b>
<i>Scapteriscus abbreviatus</i> Scudder, shortwinged mole cricket, from South America, a pest of turf. 1899.
<i>Scapteriscus borellii</i> Giglio-Tos, southern mole cricket, from South America, a pest of turf. 1924.
<i>Scapteriscus vicinus</i> Scudder, tawny mole cricket, from South America via Georgia, a pest of turf- and pasture-grasses and vegetables. 1919.
<b>THYSANOPTERA: THRIPIDAE</b>
<i>Frankliniella occidentalis</i> (Pergande), western flower thrips, from the western USA, a pest of tomato and ornamental plants. 1982.

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<i>Selenothrips rubrocinctus</i> (Giard), redbanded thrips, from Asia or Africa, a pest of tropical/subtropical fruit and ornamental trees. Year?
<i>Thrips palmi</i> Karny, melon thrips, from Asia, a pest of greenhouse crops. 1990.
The list above includes only the species that we judge to be or have been major pests. They are only a small proportion, less than a tenth, of the insect species that arrived in Florida in the last 500 years. We do not include pre-Columbian arrivals because we interpret Federal law as indicating these are to be considered native. Amerindians are naturalized natives under Federal law, so we accord the same status to the human lice and dog fleas which probably arrived with them and have undergone far more generations here than have the Amerindians because they breed several times each year. We did not try to rank these pests in order of importance. One way of doing this would be to evaluate annual losses and costs of control caused by each in dollars. However, that would ignore pests that were historically important, but are now controlled permanently by biological control, such as the major pests of citrus. Without biological control of citrus pests, there would be no Florida citrus industry. Household pests (mainly termites and ants) are now the most costly pests, because biological control for them is difficult to develop inside dwellings, so huge sums are spent on chemical treatments giving no more than temporary control.

Although the rate of immigration seems to have held relatively steady over the past 30 years, the source of the immigrants has been changing. Earlier in that time period, the major source of immigrants was the New World tropics (the Caribbean, Central America, South America). During the 1990s, though, there was a steady increase in species from other parts of the world, especially Asia, so that now immigrant species from the Old World almost equal those from the New World. Given the relaxation of trade barriers and the increasing trade with Asia, it is a trend that promises to continue.

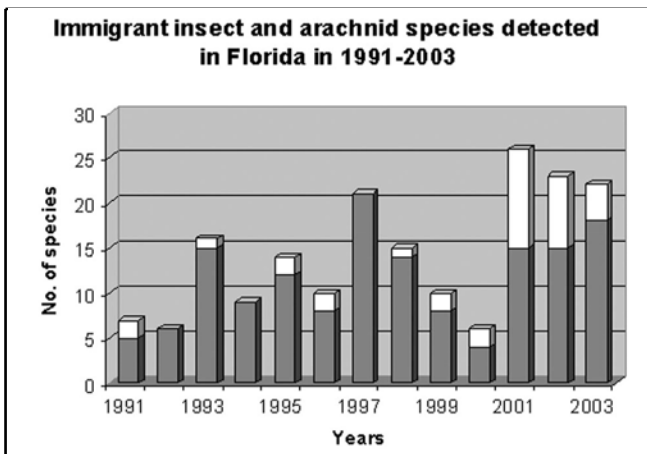
### Explanation of Terms Used Here

There are other definitions of 'invasive species', but the one we found in U.S. law (Executive Order 13112 of 1999) is unacceptable because it limits 'invasive species' to species that 'were **introduced**.' The writers of that definition paid no attention to the way that insects arrive in Florida, and so used the wrong word. That word (**introduced**) is as inappropriate as saying that all the people now in Florida who were not born here 'were introduced': of course they were not introduced – they were immigrants – and so were most of the insects.

This explanation has been given in the literature cited. For those who are familiar with it, there is no need to read on. For those who have never heard it before, it is presented here in the context of recent information.

### How Insects Arrived in Florida

During the 1970s and 1980s, 19 insect species were **introduced** (deliberately) and established in Florida, all as biological control agents (Frank & McCoy 1993). None of them is a pest (invasive species). In approximately the same years, 209 insect species of foreign origin were detected in Florida for the first time. These 209 species were not introduced (nobody introduced them deliberately), so are **immigrants**. All of the pest species (invasive insects) that arrived during those years are immigrant species, not introduced species. They belong to the group of 209 immigrant species, not the group of 19



**Figure 1.** Immigrant insect (dark part of bar) and arachnid (white part of bar) species newly detected in Florida annually in 1991-2003. It is not yet clear how many of these species will prove to be pests ('invasive species'). The totals are 150 insects and 35 arachnids. Source: DPI records/ M.C. Thomas (2004).

introduced species. There were 228 adventive species so far as we can determine, of which 19 (8.3%) were introduced and are not pests. Some people argue that insects that arrive as contaminants of cargoes should be called 'accidentally introduced' and should be included within the group of introduced insects. We do not agree with this concept. Of the 209 immigrant insects in the 1970s and 1980s, we have evidence (Frank and McCoy 1992) that only 8% belong to species that were detected as contaminants of cargoes. We might stretch that 8% to 24% (Frank and McCoy 1992), but still, for most immigrant insects in Florida (at very least 76%), there is no evidence that they arrived with human help; so they flew, or drifted on aerial or marine currents, or rafted, or walked. The maximal percent of introduced species is thus 19 (introduced species) + 50 ('accidentally introduced' species) which together amount to 69 (33% of the adventive species). The remainder (>66%) are immigrants, not 'introduced species' by any reasonable definition).

For those reasons, the US Federal definition of invasive species as being pest species that were 'introduced' is inappropriate for the Florida insect scenario. It may apply to plants and vertebrate animals in Florida, but it does **not** apply to insects. The European Environment Agency (2004) definition works for all organisms, including insects in Florida; it says that invasive species are 'non-native species which threaten ecosystems, habitats, or species', and we think that 'adventive' is better than 'non-native'.

We might add some native species – those that expanded their habitat to human dwellings and imported crops, ornamental plants, and disturbed habitats – to the list of invasive species. They, too, could be called invaders. We desist from doing so only because this would cause further confusion, in an already confused topic.

## Acknowledgments

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