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Classical Biological Control of Pest Insects of Trees in the Southern United States: *A Review and Recommendations*



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Forest
Service

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Note to the reader:

Some of the pest species addressed in this paper are also addressed in a related paper, Biological Control of Arthropod Pests of the Northeastern and North Central Forests in the United States: A Review and Recommendations, by Roy G. Van Driesche, Steve Healy, and Richard C. Reardon (FHTET-96-19, Forest Health Technology Enterprise Team, Morgantown, WV; USDA Forest Service, 1996). Information and recommendations for the 16 pests common to the two papers may differ, according to different opinions of the authors. See the paper by Van Driesche et al. regarding the following species: bagworm, balsam woolly adelgid, black turpentine beetle, carpenterworm, cottonwood borer, elm leaf beetle, flatheaded apple tree borer, gypsy moth, hemlock woolly adelgid, introduced pine sawfly, mimosa moth, nantucket pine tip moth, pales weevil, pitch-eating weevil, redheaded pine sawfly, and white pine cone beetle.

Cover Photo:

Chrysoperla rufilabris feeding on early instar of *Orgyia detrita*. Photographed by James L. Castner, University of Florida.

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**Classical Biological Control of Pest Insects
of Trees in the Southern United States:
A Review and Recommendations**

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Classical Biological Control of Pest Insects of Trees in the Southern United States:

A Review and Recommendations

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Classical Biological Control of Pest Insects of Trees in the Southern United States: A Review and Recommendations

by J. Howard Frank and John L. Foltz

Introduction: Almost all North American releases of classical biological control agents of pests of trees either have been made into Canada with subsequent movement into the northern United States, or released directly into the northern United States. Almost all of these have been biological control agents imported from Europe. Releases in the South have been relatively few. Furthermore, there seems to have been far more study of native and adventive (arrived from somewhere else) biological control agents in the North (and especially the Northeast) than in the South, so that distribution of natural enemies in the South is relatively poorly known.

Two kinds of opportunities have been missed. First, biological control agents that were imported from Europe, released in the North, and did not become established, might have established more readily if they were released in the South either against the target pest or against close relatives which also are pests, e.g., the genus *Rhyacionia*. Where such biological control agents **did** become established in the North, it would be expected that eventually their range would spread to include most or all of the range of their hosts. The same should also apply in reverse — that agents established in the South would spread to the limits of their potential range in the North.

Second, some of the southern pests are native not only to the South, but also to the Caribbean, Mexico, Central America, and South America. Few attempts seem to have been made to obtain biological control agents from these areas. One outstanding opportunity is to search for biological control agents of *Graphognatha* in its native range in South America.

Background: This paper gives information on classical biological control of 119 species of pest insects of trees in the Southern United States. Classical biological control is the importation, release, and establishment of specialist natural enemies with the expectation that they will reduce pest insect populations permanently. This paper reviews the resident natural enemies, as well as past attempts and future possibilities for biological control. Almost all of the natural enemies mentioned are insects, and these are predators or parasitoids. A predator is an insect (or other animal) that eats and kills many individual prey during its development. A parasitoid is an insect (or other animal) that consumes and kills no more than one host during its development. A secondary parasitoid, also known as a hyperparasitoid, is a parasitoid that consumes and kills another parasitoid. The word "parasite" is not used in this paper because by definition it is an organism that does not normally kill its host. The words "parasite" and "hyperparasite" are used in many older works where by definition the words "parasitoid" and "hyperparasitoid" would have been appropriate.

In general, possibilities for classical biological control are greater for adventive pests than for native pests, because most or all of the specialist natural enemies of native pests are likely already to be present. However, there may be pests that are considered native to the United States but have disjunct populations in other areas (e.g., the Caribbean and Mexico) where the pest has natural enemies not present in the United States. Also, there may be circumstances when a native pest has a close relative in some other geographical area, and this close relative may have natural enemies that would attack the native pest in the United States and might improve the level of control.

In general, for biological and economic reasons, pests that constantly maintain moderately high populations are better subjects for biological control than those that go through periods of scarcity and occasional sudden outbreaks. Economics is only one factor determining the use of classical biological control because it is virtually impossible to predict the cost and necessary duration (for a satisfactory conclusion) of a classical biological control program. Unless an identical program has been conducted in some other country, each program is an experiment that has never before been conducted. Classical biological control has been touted as an inexpensive alternative to the use of insecticides; this is sometimes true. Furthermore, sometimes biological control is the only feasible means of controlling a given pest; however, other means of managing pest populations should be considered carefully before embarking on a program in classical biological control.

The cost of a successful classical biological control program is unlikely to be less than the cost of one scientist-year, and may cost the equivalent of many years of such research. In some examples, years of research have been expended with no satisfactory solution in sight. The cost of a classical biological control program is necessarily burdened with the cost of testing effects of imported biological control agents on non-target organisms. What should be weighed against this is the indirect cost of control by insecticides, i.e., the cost of their effects on non-target species.

An example of many scientist-years of research conducted without satisfactory solution is research on biological control of the gypsy moth. Millions of dollars have been spent on this program, and gypsy moth is still a problem and continues to spread. However, damage by this pest in Massachusetts declined sevenfold from 1910 to 1930 — a time when there was much introduction and establishment of biological control agents from Europe (Montgomery and Wallner 1988). This suggests that funds spent on biological control in the second decade of the century were an excellent investment.

Another noteworthy example is biological control of winter moth in eastern and western Canada. The Canadian Forestry Service sought biological control agents for this adventive pest of European origin in Europe, and released some of them in eastern Canada. The Canadian program followed the basic tenets of classical biological control, which were based upon art as much as upon science. Meanwhile, life table studies in England suggested that major mortality was not likely to be inflicted by such biological control agents. Nevertheless, two of the six introduced biological control agents were enormously successful. Only when the same agents were introduced into western Canada and were successful there, too, was a reanalysis conducted which showed an interaction of native insect predators and imported parasitoids. The studies conducted in England were not wrong, but they had applied only to low-density

pest populations. This example suggests that life table studies are not necessarily good predictors of likelihood of success of biological control programs, and that it may be more cost-effective to use the basic tenets of classical biological control.

Organization of this paper: This paper summarizes information on classical biological control of 119 pest species of forests in the southern United States. Pest genera are arranged alphabetically, and pest species are arranged alphabetically within each genus. An index at the end of this paper gives vernacular names of the pests and matches these to scientific names in the body of this paper. In the body of the paper the number above the vernacular name corresponds to the left-hand number in the Classification of pests by order and family that beings on page 5.

For each entry (each pest), under its correct scientific name, is given its family, its vernacular name or names, scientific synonyms that have been used recently, its origin (native, and currently recorded distribution; or adventive and its probable origin), and its currently recorded distribution in the South. For distribution, we use postal abbreviations for the southern states, Puerto Rico, and the United States Virgin Islands.

AL	Alabama	LA	Louisiana	TN	Tennessee
AR	Arkansas	MS	Mississippi	TX	Texas
FL	Florida	NC	North Carolina	VA	Virginia
GA	Georgia	OK	Oklahoma	PR	Puerto Rico
KY	Kentucky	SC	South Carolina	VI	Virgin Islands

Under **Resident natural enemies** we give the names of natural enemies that have been recorded to kill the pest, with their distribution. Under **Biological control attempts** we give a condensed history of attempts to import classical biological control agents. Finally, under **Biological control possibilities**, we suggest where natural enemies for classical biological control might be sought. Apart from the names of the insects, with which we had no choice, we have avoided the use of almost all terms that would not be encountered in a large English dictionary. We defined our use of the term "adventive" in the Introduction, and of "parasitoid," "hyperparasitoid" and "secondary parasitoid" in the Background. Where we use the word "immigrant" we are applying the word to insects just as it is normally applied to humans. Immigrant insects are those that arrived by some means other than deliberate introduction. Thus, adventive insects (those that came from somewhere else) include those that immigrated and those that were introduced.

Sources of information: The 119 species of pests were selected from the much larger number named in the forestry literature. Primary selection was based on their frequent mention in the USDA Forest Service publications "Forest Insect and Disease Conditions in the United States," "Forest Insect and Disease Conditions in the South," and "Insect and Disease Conditions - Puerto Rico and the United States Virgin Islands." Additions to the list were based on "Insects of Eastern Forests" (Drooz 1985), "Insects of Puerto Rico" (Wolcott 1950, 1951) and, especially for ornamental trees, on publications of the Florida Department of Agriculture and Consumer Services. Further literature sources were located by computerized searching of CAB Abstracts, the Agricola database, and the bibliographies of the publications that were consulted. Natural enemies and biological control agents of the pests selected were listed from the above sources, from Clausen (1978), from the Commonwealth Agricultural Bureaux predator/prey and host/

parasite catalogs, and from catalogs of Hymenoptera (Krombein et al. 1979) and Tachinidae (Arnaud 1975) of the United States.

An effort was made to list the distribution by state of the pests and of their natural enemies. Success in this task ranged from high for all states for Coccinellidae (using Gordon 1985) and for most of the pests, through moderate for Florida alone for Tachinidae (using Patton 1958), to low when the literature did not provide precise statements about distribution. The distributions given in this paper vary accordingly. They range from a listing of all states in the South in which a species occurs, through listing of a few states from which records were obtained, to general statements. Some of the general statements are "GA and North," "not in South," "not in South?," "states not named," and "United States and Canada." Only the first provides clear evidence of a record from a southern state. The second and third suggest that the species does not occur in the South, though with differing levels of certainty. The fourth and fifth suggest only that the species exists somewhere in the United States.

Many of the scientific names of the insects mentioned were verified in taxonomic publications on Coleoptera, Hemiptera, Homoptera, Hymenoptera, and Lepidoptera; by additional sources provided by taxonomists J.B. Heppner, A.B. Hamon, S.B. Halbert, M.C. Thomas, and G.J. Steck of the Division of Plant Industry, Florida Department of Agriculture and Consumer Services; G.F. Evans and V.K. Gupta of the University of Florida; and D.B. Wahl of the American Entomological Institute, and by computerized searching of Zoological Record. Vernacular names preferentially follow the "Common Names of Insects" list of the Entomological Society of America (Stoetzel 1989) but, when no name was found there, one was taken from the forestry literature.

Classification of the pests by order and family

The sequential numbers on the left are referenced in the body of the paper above the vernacular name for each insect.

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119. Texas leafcutting ant, <i>Atta texana</i>	13

Pests and their biological control

9

Adelges piceae (Ratzeburg)

balsam woolly adelgid

Adelgidae

Adventive (Eurasia) ca. 1908: NC, VA and North and West. The area infested in the southern Appalachians is much smaller than in the North, and the race of the pest there may be different (Amman 1966, Dull et al. 1988).

Resident natural enemies: **Coccinellidae:** *Aphidecta oblitterata* (L.) NC; *Scymnus impexus* (Mulsant) not in South; neither of these exerts much control.

Biological control attempts: **Coccinellidae:** *Aphidecta oblitterata* (L.) — introduced from Europe into NC in 1960-1963, became established, but maintains only a small population; *Scymnus impexus* (Mulsant) — imported from Europe into Canada and subsequently released in NC, but not yet known to be established there, though it became established in Oregon.

Derodontidae: *Laricobius erichsonii* (Rosenhauer) — imported from Europe into Canada and subsequently released in NC, not certainly established. **Chamaemyiidae:** *Cremifania nigrocellulata* Czerny — imported from Europe into Canada; *Leucopis obscura* Haliday — imported from Europe into Canada and subsequently released in NC. **Cecidomyiidae:** *Aphidoletes thompsoni* Möhn — imported from Europe into Canada and subsequently released in NC.

Biological control possibilities: As a whole, the established predators present little promise that they will contribute any appreciable economic benefit in checking the pest according to Balch (1960), who emphasized the need for finding additional natural enemies that are more efficient at low host densities. It is now time to search for parasitoids of *A. piceae* and its relatives in Eurasia; according to Van Driesche et al. (1997) the appropriate places to search are the Caucasus Mountains and northeastern Turkey.

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Adelges tsugae Annand

hemlock woolly adelgid

Adelgidae (*Adelges funitectus* Dreyfus may be the correct name for this species.)

Adventive (Asia) ca. 1927: NC, VA and North and West.

Resident natural enemies: See McClure (1987).

Biological control attempts: M.S. McClure (Connecticut Agricultural Experiment Station) and M.E. Montgomery (US Forestry Service, Hamden, CT) are currently studying coccinellids imported from Japan and China, and the problem in general.

Biological control possibilities: The coccinellid beetle, *Pseudoscymnus tsugae* Sasaji and McClure (Coleoptera: Coccinellidae) shows the most promise of five hemlock woolly adelgid predators identified in Japan (McClure et al 1996). Another coccinellid, *Scymnus* sp., collected in China is also being tested to determine its value for control (Van Driesche et al 1997).

Agrilus arcuatus Say ssp. *torquatus* LeConte

hickory spiral borer

Buprestidae

Native: GA, KY, MS, NC, VA, WV and North.**Resident natural enemies: Ichneumonidae:** *Labena grallator* (Say) — FL and North and West.**Eulophidae:** *Baryscapus rugglesi* (Rohwer) (= *Tetrastichus rugglesi*) — WV and North.**Biological control attempts:** None known.**Biological control possibilities:** Investigating natural enemies of many neotropical species of *Agrilus* (especially in the southernmost latitudes) may yield information on species that could be employed as biological control agents of *A. arcuatus*. Even though *Agrilus hyperici* (Creutzer) was imported into California and Canada as a natural enemy of *Hypericum perforatum* L., it was killed by cold in Canada and has been largely displaced in California by *Chrysolina* spp. Therefore, there is no need to protect it should it prove to be an alternate host of biological control agents investigated.*Alsophila pometaria* (Harris)

fall cankerworm

Geometridae

Native: FL, GA, NC, SC, TX, VA.**Resident natural enemies: Tachinidae:** *Blondelia eufitchiae* (Townsend) — not in South?; *Ictericophyto spinosa* (Coquillett) — not in South?; *Omotoma fumiferanae* (Tothill) — not in South?; *Phryxe pecosensis* (Townsend) — not in South?; *P. vulgaris* (Fallén) — not in South?; *Pseudotachinomyia slossonae* (Townsend) — not in South?; *Tachinomyia nigricans* Webber — not in South?; *Winthemyia rufopicta* (Bigot) — FL, LA, NC, TN, VA. **Braconidae:** *Apanteles nemoriae* Ashmead — TN and North; *A. paleacrita* Riley — GA and North; *Meteorus autographae* Muesebeck — FL, LA and North; *M. hyphantriae* Riley — United States and Canada; *Rogas stigmator* (Say) — not in South. **Ichneumonidae:** *Phobocampe flavipes* (Provancher) — SC and North and West; *P. geometrae* (Ashmead) — AL, GA and West; *Richtichneumon residuus* (Say) — not in South; **Chalcididae:** *Spilochalcis albifrons* (Walsh) — FL and North and West, also acts as a hyperparasitoid by attacking *Apanteles*, *Bathyplectes*, and *Gelis*. **Eulophidae:** *Eulophus orgyiae* (Fitch) — MS, NC and North and West; *E. smerinthis* (Ashmead) — not in South. **Scelionidae:** *Telenomus alsophilae* Viereck — NC, VA and North, a parasitoid of the eggs, is a major factor in the decline of fall cankerworm populations (Drooz 1985).**Biological control attempts:** None known.**Biological control possibilities:** Natural enemies of *Alsophila aescularia* (Schiffermüller) (march moth) in Europe and *A. japonensis* Warren (pear fall cankerworm) in Japan, should be sought, imported, and researched as potential biological control agents. Lack of knowledge of population dynamics of fall cankerworm may be a barrier to implementation of biological control.

Anisota virginiensis (Drury)

pinkstriped oakworm

Saturniidae

Native: AR, FL, NC and throughout the eastern half of the United States.

Resident natural enemies: **Tachinidae:** *Compsilura concinnata* (Meigen) — not in South, introduced from Europe in 1906 as a biological control agent for *Lymantria dispar*; *Lespesia datanarum* (Townsend) — not in South?; *L. frenchii* (Williston) — MS, NC, TX, WV; *Pacidianus* sp. — FL. **Ichneumonidae:** *Hyposoter fugitivus* (Say) — FL, LA, TX and North and West.

Biological control attempts: None known.

Biological control possibilities: A search for natural enemies of *A. assimilis* Druce, *A. dissimilis* Boisduval, *A. kendallorum* Lemaire, and *A. punctata* Riotte and Peigler in Mexico may possibly yield potential biological control agents for use against *A. virginiensis*.

Apate monacha (Fabricius)

el caculo taladrador

Bostrichidae

Adventive (Africa): PR, and Cuba.

Resident natural enemies: None reported.

Biological control attempts: None known.

Biological control possibilities: This insect is also a pest of walnut in Israel; current biological control projects in Israel may yield information on natural enemies that could be used in PR as biological control agents.

Aphrophora parallela (Say)

pine spittlebug

Cercopidae

Native: AL, AR, FL, NC and most of the eastern states.

Resident natural enemies: A fungus causes high mortality (Drooz 1985).

Biological control attempts: None known.

Biological control possibilities: Related species in Europe (*A. corticea* Germar, *A. forneri* Haupt) and Japan (*A. harimaensis* Matsumura, *A. vittata* Matsumura) offer hope for the detection of natural enemies that might be used as biological control agents for *A. parallela*.

Archips argyrospila (Walker)

fruittree leafroller

Tortricidae

Native: FL, NC and throughout the United States.

Resident natural enemies: **Tachinidae:** *Actia interrupta* Curran — not in South?; *Aplomya caesar* (Aldrich) — not in South?; *Carcelia malacosomae* Sellers — not in South?; *Compsilura concinnata* (Meigen) — not in South, introduced from Europe in 1906 as a biological control agent for *Lymantria dispar*; *Eusisyropa blanda* (Osten Sacken) — FL, NC, Cuba and North; *Hemisturmia tortricis* (Coquillett) — AR and North; *Nemorilla pyste* (Walker) — FL, GA, MS, LA, NC, SC, TX, PR, VI, Cuba, Dominican Republic, and North; *Paralispe infernalis* (Townsend) — SC, VA and North; *Phryxe pecosensis* (Townsend) — not in South?; *P. vulgaris* (Fallén) — not in South?; *Pseudoperichaeta erecta* (Coquillett) — FL, GA, TX. **Braconidae:** *Apanteles cacoeciae* Riley — not in South; *A. clavatus* (Provancher) — AR, SC and North; *A. gillettei* Baker — not in South; *A. polychrosidis* Viereck — FL and North; *Bracon gelechia* Ashmead — AR, GA, SC and West Indies (which, in turn, is attacked by *Baryscapus coerulescens* (Ashmead) (= *Tetrastichus coerulescens* Ashmead (Eulophidae))); *Macrocentrus cerasivoranae* Viereck — United States; *M. iridescens* French — not in South; *Meteorus argyrotaeniae* Johansen — not in South; *M. trachynotus* Viereck — United States and Canada; *Microgaster canadensis* Muesebeck — not in South; *M. epagoges* Gahan — SC and North; *M. peroneae* Walley — not in South. **Ichneumonidae:** *Acropimpla alboricta* (Cresson) — SC and North and West; *Apophua simplicipes* (Cresson) — TX and North and West; *Campoplex atridens* Townes — not in South; *Enytus eureka* (Ashmead) — not in South; *Exochus nigripalpus tectum* Townes — NC and North and West; *Glypta erratica* Cresson (= *G. inversa*) — not in South; *Ischnus inquisitorius atricollaris* (Walsh) — NC and North and West; *Itoplectis conquisitor* (Say) — AR, FL, GA, LA, SC, VA and North and West is an important parasitoid but can act as a hyperparasitoid of *Hyposoter fugitivus*, *Phobocampe clisiocampe*, *P. pallipes*, and *Rogas stigmator*; *I. quadricingulata* (Provancher) — not in South; *Parania badia* (Schmid) — not in South; *Phaeogenes cacoeciae* Viereck — not in South; *Phytodietus vulgaris* Cresson — not in South; *Pimpla pedalis* Cresson (= *Coccygomimus pedalis*) — VA and North and West; *Tranosema rostrale* (Brischke) — not in South; *Triclistus emarginalus* (Say) — FL and North and West; **Torymidae:** *Monodontomerus aereus* Walker — not in South, acts also as a hyperparasitoid by attacking *Compsilura concinnata*, *Carcelia laxifrons*, and *Blepharipa pratensis*, was introduced to North America in 1906-1910 as a biological control agent for gypsy moth and browntail moth. **Chalcididae:** *Brachymeria ovata* (Say) — throughout the South and northward is a primary parasitoid; *B. hammeri* (Crawford) — FL, AR, TX and North and West is a primary parasitoid of the larvae (Burks 1960); *Spilochalcis albifrons* (Walsh) — FL and North and West, also acts as a hyperparasitoid by attacking *Apanteles*, *Bathyleptes*, and *Gelis*. **Eulophidae:** *Elachertus cacoeciae* Howard — VA and North and West.

Biological control attempts: None known.

Biological control possibilities: Mey (1987) investigated natural enemies of *Archips rosana* (L.), European leafroller, in Germany. Among its primary parasitoids he found 4 tachinids, 9 ichneumonids, 2 braconids, and 1 eulophid (and 2 pteromalids which are hyperparasitoids). The most important were *Itoplectis maculator* (F.) and *Phytodietus segmentator* (Gravenhorst) auct. (Ichneumonidae). Although the total percent parasitoidism did not exceed 29.8%,

some of these parasitoids may have a more severe effect on *Archips argyrospila* than on *A. rosana* and, even if not, may be able to add to the mortality inflicted on *A. argyrospila*. Two other *Archips* species, *A. crataegana* (Hübner) and *A. podana* (Scopoli), both in Europe and Asia, may likewise yield useful parasitoids.

Aspidiotus destructor Signoret

coconut scale

Diaspididae

Adventive (Asia) before 1895 in PR, ca. 1910 in continental United States: FL, GA, NC, PR, VI.

Resident natural enemies: **Coccinellidae:** *Cryptognatha nodiceps* Marshall — FL, PR; *Pseudazya trinitatis* (Marshall) — PR. **Aphelinidae:** *Aphytis chrysomphali* Mercet — PR; *A. proclia* (Walker) — cosmopolitan; *Encarsia citrina* (Craw) — cosmopolitan; *E. lounsburyi* Berlese and Paoli — PR. **Signiphoridae:** *Signiphora borinquensis* Quezada, DeBach and Rosen — PR (Quezada et al. 1973). Aphelinid parasitoids seem to have adapted to attack the scale in FL and PR, and their action apparently is important. Populations generally are now under control, and outbreaks are only occasional.

Biological control attempts: Several species of predatory Coccinellidae were imported into PR and thence into FL in the 1930s from Trinidad. Of these, *Cryptognatha nodiceps* Marshall became established in both places, though populations are now very low in southern Florida and probably have little effect on coconut scale. In PR, but not in Florida, *Pseudazya trinitatis* (Marshall) became established.

Biological control possibilities: Control of coconut scale was achieved in Bali, Indonesia, by importation and release of *Encarsia citrina* (Voute 1937). This parasitoid is a "common endemic wasp" in Puerto Rico (Wolcott 1951) and may have contributed to the decline of *Aspidiotus destructor*. Further distribution of *Encarsia citrina* may solve remaining problems. *Comperiella unifasciata* Ishii (Encyrtidae) was introduced into eastern Pacific islands against the pest and likewise might be valuable.

Atta texana (Buckley)

Texas leafcutting ant

Formicidae

Native: LA, TX.

Resident natural enemies: Apparently none reported.

Biological control attempts: None known.

Biological control possibilities: Not good. There have been numerous studies of control of neotropical species of *Atta*, thus far without development of a useful biological control mechanism. Baits are used successfully in the United States.

Aulacaspis yasumatsui Takagi

a scale

Diaspididae

Adventive: FL.**Resident natural enemies:** None known.**Biological control attempts:** None.

Biological control possibilities: Good. This scale, which was described from Thailand (Nakao et al. 1977), has recently caused major problems for cycads in southern Florida. There is a high possibility that its natural enemies in southeast Asia will prove to be useful as biological control agents. R.M. Baranowski (University of Florida) is exploring for natural enemies in Thailand. The Division of Plant Industry, Florida Department of Agriculture and Consumer Services, seems to be committed to a biological control solution as the least expensive means of control.

Bucculatrix ainsliella Murtfeldt

oak skeletonizer

Bucculatricidae (Lyonetiidae)

Native: MS, NC and northward.

Resident natural enemies: **Braconidae:** *Apanteles ornigis* Weed — AR, VA and North; *Bucculatriplex bucculatricis* (Ashmead) — FL and North. **Chalcididae:** *Haltichella xanticles* (Walker) — FL, OK, TX and North. **Eulophidae:** *Cirrospilus cinctithorax* (Girault) — not in South; *C. flavicinctus* Riley — not in South; *Pnigalio maculipes* (Crawford) VA and North.

Biological control attempts: None known.

Biological control possibilities: The genus *Bucculatrix* has over 220 species named, from all continents except Antarctica. About 100 species occur in the U.S., 67 in Europe, and so far 14 are known from South America. Natural enemies of some of the European species may attack *B. ainsliella* and might be useful as potential biological control agents for it.

Caliroa liturata MacGillivray = *lineata* MacGillivray

pin oak sawfly

Tenthredinidae

Native: NC and northward.**Resident natural enemies:** **Ichneumonidae:** *Hyperallus caliroae* Viereck — LA, VA and North.**Biological control attempts:** None known.

Biological control possibilities: Find, import, and research natural enemies of *Caliroa annulipes* (Klug), called oak slugworm, in Europe.

Chrysobothris femorata (Olivier)

flatheaded apple tree borer

Buprestidae

Native: FL, NC and transcontinental in United States.**Resident natural enemies: Braconidae:** *Atanycolus tranquebaricae* Shenefelt — FL and Bahamas;**Ichneumonidae:** *Labena grallator* (Say) — FL and North and West. **Chalcididae:***Phasgonophora sulcata* Westwood — FL and North and West; *Trigonura californica* Rohwer — not in South; *T. elegans* (Provancher) — AR, WV and North. **Eupelmidae:** *Metapelma spectabile* Westwood — FL, TX and North. **Eulophidae:** *Baryscapus holbeini* (Girault) (=*Tetrastichus holbeini*) — WV and West; *Baryscapus rugglesi* (Rohwer) (= *Tetrastichus rugglesi*) — WV and North; *Horismenus carolinensis* Burks — NC, but may be a hyperparasitoid.**Philanthidae:** *Cerceris californica* Cresson — TX and West; *C. fumipennis* Say — FL and North.**Biological control attempts:** None known.**Biological control possibilities:** Investigation of species of *Chrysobothris* from Mexico, Europe, Asia, and East Africa, may yield information on natural enemies that could be employed as biological control agents of *C. femorata*. However, damage is most severe to stressed trees and to young, newly transplanted trees. The latter can be protected by wrapping trunks with paper or burlap to prevent oviposition (Baerg and Isely 1938, Solomon 1995). Consequently, biological control attempts may not be justified economically.*Chrysobothris tranquebarica* (Gmelin)

Australian pine borer

Buprestidae (This pest attacks Australian pines [*Casuarina* spp.], not *Pinus*.)**Native:** FL, PR, Bahamas.**Resident natural enemies: Braconidae:** *Atanycolus charus* Shenefelt — not in South; *A.**rugosiventris* (Ashmead) — FL and North and West; *Spathius floridanus* Ashmead — FL, TX and North. **Ichneumonidae:** *Labena grallator* (Say) — FL and North and West; *Xorides neoclyti*

(Rohwer) — not in South.

Biological control attempts: None known.**Biological control possibilities:** Though Australian pines (*Casuarina* spp.) were once considered to be useful species in Florida, two of them (*C. glauca* and *C. cunninghamiana*) are now classed as invasive weeds by the Florida Exotic Pest Plant Council because they infest 374,000 acres (Schmitz 1994). Attempts to protect them must now be considered inappropriate.

Chrysomphalus aonidum (Linnaeus)

Florida red scale

Diaspididae

Adventive (Asia) ca. 1880: FL, NC, TX, PR and other southern states.

Resident natural enemies: **Phlaeothripidae:** *Aleurodothrips fasciapennis* Franklin. **Chrysopidae:** *Chrysoperla* spp. **Coccinellidae:** *Chilocorus stigma* (Say) — all southern states; *Microweisia coccidivora* (Ashmead) — southern FL north to southeast SC. **Encyrtidae:** *Comperiella bifasciata* Howard — FL and West; *Pseudhomalopoda prima* Girault — FL, TX. **Aphelinidae:** *Ablerus perspicuosus* Girault — not in South; *Aphytis chrysomphali* (Mercet) — FL and North and West; *A. holoxanthus* DeBach — FL west to CA, introduced; *A. proclia* (Walker) — cosmopolitan; *Encarsia citrina* (Craw) — cosmopolitan; *E. elongata* Dozier — FL, LA, TX and West; *E. lounsburyi* (Berlese and Paoli) — FL. **Signiphoridae:** *Signiphora aleyrodis* Ashmead — TX and North; *Thysanus niger* (Ashmead) — FL and North and West.

Biological control attempts: *Encarsia elongata* and *Pseudhomalopoda prima*, collected in FL, were released in TX in 1955 and both reportedly became established. Introduction of *Aphytis holoxanthus* from Israel into Texas in 1959 and Florida in 1960 gave greatly improved control. Introduction of *A. holoxanthus* into other countries has yielded similar benefits.

Biological control possibilities: Biological control campaigns using *A. holoxanthus* were conducted for the benefit of the citrus industry. The parasitoid was found to spread rapidly, so should be able to locate populations of the scale in citrus-growing areas. Isolated populations of the scale remote from citrus-growing areas may not yet have populations of *A. holoxanthus*, so releases of that parasitoid should be the first line of attack. Another aphelinid parasitoid, *Pteroptrix smithi* (Compere), was imported from Hong Kong into Israel about 1960, and became established. It persists at very low population densities and “may be contributing to the maintenance of the scale at subeconomic levels along the coastal plain” (Rosen and DeBach 1978 p. 104). It should be considered for importation into localities (if there are any) in the South where attempts to use *A. holoxanthus* have failed.

Cinara strobil (Fitch) syn. *Eriosoma strobil*

white pine aphid

Aphididae

Native: AR, NC, SC, VA.

Resident natural enemies: **Aphidiidae:** *Pauesia bicolor* (Ashmead) — FL and North; *P. xanthothera* (Smith) — AL, AR, NC, OK, SC and North.

Biological control attempts: None known.

Biological control possibilities: Natural enemies of *Cinara pinea* Mordvilkov (black pine aphid) could be sought in China and tested for their potential as biological control agents of *C. strobil*. However, other species of *Cinara* in Africa are very important pests (Allard and Day 1994), suggesting that damage levels caused by *C. strobil* are very minor, that little improvement might be obtained by establishment of additional natural enemies, and that costs of biological control studies might be difficult to justify.

Clostera inclusa (Hübner) syn. *Ichthyura inclusa*

poplar tentmaker

Notodontidae

Native: FL, GA, NC, TX and northward.

Resident natural enemies: **Braconidae:** *Apanteles sarrothripae* Weed — VA and North; *Rogas scrutator* (Say) — states not named; **Ichneumonidae:** *Agrypon anale* (Say) — AL and North; **Pteromalidae:** *Psychophagus omnivorus* (Walker) — not in South, a primary and secondary parasitoid; **Scelionidae:** *Telenomus ichthyurae* Ashmead — MS, OK, TX and North.

Biological control attempts: None known.

Biological control possibilities: The genus occurs not only in the U.S. but also in Europe and Asia. Four species (*C. anachoreta* Denis and Schiffermüller, *C. anastomosis* L., *C. curtula* L., and *C. pigra* Hufnagel) in France might have natural enemies that could be evaluated as potential biological control agents for *C. inclusa*.

Cnemerachis vandinei Smyth syn. *Phyllophaga vandinei*

a white grub

Scarabaeidae

Native: PR.

Resident natural enemies: *Cryptomeigenia aurifacies* Walton and *Eutrixoides jonesii* Walton (Tachinidae) attack adult scarabs in moister parts of PR, but parasitize only a trivial percentage of them even in favorable environments (Wolcott 1951). See also *Phyllophaga portoricensis*.

Biological control attempts: *Bufo marinus* (Bufonidae) was introduced into Puerto Rico in the 1920s as a biological control agent for this species and for *Phyllophaga portoricensis*, and the problem caused by these species was stated to have been solved (Wolcott 1933).

Biological control possibilities: See comments under *Phyllophaga portoricensis*.

Coleophora laticornella Clemens

pecan cigar casebearer

Coleophoridae

Native: FL, TX and northward.

Resident natural enemies: **Braconidae:** *Orgilus lateralis* (Cresson) — FL, TX and North and West; *Parahormius trilineatus* (Ashmead) — VA.

Biological control attempts: None known.

Biological control possibilities: Hymenopterous parasitoids of *Coleophora fuscadinella* Zeller, the birch casebearer, and of *L. laricella* (Hübner), the larch casebearer, have been imported and

established in Canada and the northern United States (Raske 1978, Clausen 1978). It is unlikely these would attack *C. laticornella*, but parasitoids of other Eurasian species of *Coleophora* might do so and could be tested in quarantine.

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Compsus maricao Wolcott

a weevil

Curculionidae

Native: PR.

Resident natural enemies: None known.

Biological control attempts: None known.

Biological control possibilities: *Tetrastichus compsivorus* Crawford (Eulophidae) is recorded as a parasitoid of *Compsus auricephalus* (Say), its only reported host, in MS, OK, TX; its importation into quarantine in PR for investigation of its behavior toward *C. maricao* might be worthwhile.

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Conophthorus coniperda (Schwarz)

white pine cone beetle

Scolytidae

Native: NC, VA and North.

Resident natural enemies: **Braconidae:** *Spathius aphenges* Matthews — not in South; **Bethylidae:** *Cephalonomyia hyalinipennis* Ashmead — FL and North and West.

Biological control attempts: None known.

Biological control possibilities: Natural enemies of *C. ponderosae* Hopkins, which occurs from southwestern Canada to Durango and Michoacan in Mexico, might be evaluated for their potential as biological control agents of *C. coniperda* in the South. If useful natural enemies are not found, then it would be worthwhile looking at natural enemies of the closely related genera *Pityophthorus*, *Gnatholeptus*, and *Pityotrichus*. The large genus *Pityophthorus* (over 300 species worldwide) is very closely related, and its various species are distributed not only from Alaska to Argentina, but also in temperate Europe and Asia, and Africa. See also *Dendroctonus frontalis* and *Ips calligraphus*.

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Copturus floridanus (Fall)

mahogany notcher

Curculionidae

Native: FL, Bahamas, Cuba.

Resident natural enemies: None recorded.

Biological control attempts: None recorded.

Biological control possibilities: The major part of the range of this species is in Cuba and the Bahamas, where natural enemies should be sought as potential biological control agents.

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Corthylyus columbianus Hopkins
Scolytidae

Columbian timber beetle

Native: AR, FL, GA, NC, TN, VA, WV.

Resident natural enemies: None known.

Biological control attempts: None known.

Biological control possibilities: In Central and South America there are numerous species of this genus whose natural enemies should be investigated for potential biological control agents for *C. columbianus*. See also comments under *Dendroctonus frontalis* and *Ips calligraphus*.

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Corythucha arcuata (Say)
Tingidae

oak lace bug

Native: AL, GA, MS, NC, SC, TX, VA and North.

Resident natural enemies: None reported.

Biological control attempts: None known.

Biological control possibilities: The genus has several species in North, Central, and South America, but no other species seems to be reported from oak. Prospects for biological control, therefore, do not seem high.

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Corythucha ciliata (Say)
Tingidae

sycamore lace bug

Native: AL, FL, GA, NC, OK, TN, TX, VA and North.

Resident natural enemies: Not reported.

Biological control attempts: None known.

Biological control possibilities: The genus has several species in North, Central, and South America. One species, *C. salicata* Gibson, which is reported from the Pacific Northwest, has been recorded from sycamore. Any specialist natural enemies of *C. salicata* from California might be useful as biological control agents for *C. ciliata* in the South.

Cossula magnifica (Strecker)

pecan carpenterworm

Cossidae

Native: Southern states.**Resident natural enemies: Tachinidae:** *Phorocera comstocki* Williston — NC, TX and North; *Phorocera signata* Aldrich and Webber — SC, TN.**Biological control attempts:** None known.**Biological control possibilities:** European and Asian parasitoids of *Cossus* (a related genus) and other members of Cossidae might prove useful as biological control agents of *Cossula* and *Prionoxystus*.*Curculio caryae* (Horn)

pecan weevil

Curculionidae

Native: AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, TX, VA, WV.**Resident natural enemies: Tachinidae:** *Myiophasia harpi* Reinhard — TX (Harp and Van Cleave 1976). **Formicidae:** *Solenopsis* spp. — FL and other southern states (R.F. Mizell, pers. comm.). Other North American *Curculio* spp. are attacked by **Tachinidae:** *Clausicella neomexicana* (Townsend), *Elfia melissopodis* (Coquillett), *Myiophasia nigrifrons* (Townsend), and *Winthemia quadripustulata* (F.) and by **Braconidae:** one species of *Triaspis* and at least eight species of *Urosigalphus*.**Biological control attempts:** None known.**Biological control possibilities:** The presence of several *Curculio* spp. in Mexico, including *C. pseudocaryae* Gibson, suggests possibilities of discovering a suitable parasitoid there for use as a classical biological control agent in the South. Studies are in progress in Chihuahua, northern Mexico.*Cydia ingens* (Heinrich) syn. *Laspeyresia ingens*

longleaf pine seedworm

Tortricidae

Native: AL, FL, GA, MS, SC, and others.**Resident natural enemies: Braconidae:** *Agathis acrobasis* (Cushman) — AR, FL, GA, LA, MS, SC, TX and North; *Phanerotoma fasciata* Provancher — FL, TX and North, formerly misidentified as *P. tibialis*. *Phanerotoma* sp. may destroy a high percentage of larvae of the related *Cydia caryana* (Fitch) (= *Laspeyresia caryana*).**Biological control attempts:** None known.

Biological control possibilities: Release of *Ascogaster quadridentata* (Wesmael) (Braconidae), a European parasitoid of *Cydia pomonella* (codling moth), against *Cydia strobilella* (L.) (= *Laspeyresia youngana* (Kearfott)), spruce seed moth, in Ontario was unsuccessful because the parasitoid did not attack this host. However, search in Eurasia for natural enemies of *Cydia strobilella* could produce biological control agents not only for it but also for *Cydia ingens*; both pests attack conifers.

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Datana integerrima Grote and Robinson

walnut caterpillar

Notodontidae

Native: FL, NC and throughout the East.

Resident natural enemies: Tachinidae: *Archytas metallicus* (Robineau-Desvoidy) — GA and North; *Archytas* spp. — AR; *Belvosia bifasciata* (F.) — FL, GA, NC, PR and North; *Blepharipa pratensis* (Meigen) [= *B. scutellata* (Robineau-Desvoidy) according to Sabrosky and Reardon (1976)] — not in South?; *Carcelia malacosomae* Sellers — not in South?; *Compsilura concinnata* (Meigen) — not in South, introduced from Europe in 1906 as a biological control agent for *Lymantria dispar*; *Euphorocera claripennis* (Macquart) — AL, FL, KY, LA, MS, NC, SC, OK, TN, TX, VA, WV and North; *E. edwardsii* (Williston) — WV and North; *E. floridensis* Townsend — FL, GA, MS, NC, SC; *Exorista mella* (Walker) — FL, GA, MS, NC, TX and North; *Lespesia datanarum* (Townsend) — not in South?; *L. frenchii* (Williston) — MS, NC, TX, WV; *Mericia ampelus* (Walker) — not in South?; *Winthemia datanae* (Townsend) — FL, GA and North. **Braconidae:** *Meteorus datanae* Muesebeck — NC and North. **Ichneumonidae:** *Heteropelma datanae* Riley — GA, LA and North; *Hyposoter fugitivus* (Say) — FL, LA, TX and North and West. **Scelionidae:** *Telenomus ichthyurae* Ashmead — MS, OK, TX and North.

Biological control attempts: None known.

Biological control possibilities: There are 13 species of *Datana* in the U.S., and more in Mexico and Central America. Species in Mexico and Central America are perhaps the most likely to yield natural enemies that could be investigated as potential biological control agents for *D. integerrima* in the South.

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Dendroctonus frontalis Zimmermann

southern pine beetle

Scolytidae

Native: AL, AR, FL, GA, KY, LA, MS, NC, SC, TN, VA, WV, eastern OK and TX, and parts of Mexico and Honduras.

Resident natural enemies: Anthocoridae: *Scoloposcelis mississippiensis* Drake and Harris — NC. **Cleridae:** *Thanasimus dubius* (F.) — GA, LA, MS, NC, TX (with hyperparasitoid *Baryscapus thanasimi* (Ashmead)). **Braconidae:** *Atanycolus comosifrons* Shenefelt — FL, LA, MS, NC, TX and North; *Cenocoelius nigrisoma* (Rohwer) — GA, LA, MS, NC, SC, TX; *Coeloides pissodis* (Ashmead) — GA, LA, MS, NC, TX and North; *Dendrosoter sulcatus* Muesebeck — FL, GA, NC, TX and North; *Doryctes anatolokus* Marsh — FL and North; *Ecphylyus schwarzii* (Ashmead) — NC and North; *Meteorus hypophloeae* Cushman — FL, GA, LA, MS, NC, TX and

West; *Spathius canadensis* Ashmead — NC, VA, and North; *S. pallidus* Ashmead — GA, LA, MS, NC, TX and North; *Vipio rugator* (Say) — FL, TX and North. **Ichneumonidae:** *Cremastus* sp. — NC. **Torymidae:** *Roptrocerus xylophagorum* (Ratzeburg) (= *R. eccoptogastris*) — GA, LA, MS, NC, TX, VA, WV and North and West. **Pteromalidae:** *Dinotiscus dendroctoni* (Ashmead) (= *Cecidostiba dendroctoni*) — GA, NC, TX, VA, WV, and West; *Heydenia unica* Cook and Davis — GA, AL, NC, VA, WV and North and West. **Eurytomidae:** *Eurytoma cleri* (Ashmead) — GA, NC, VA, WV and West; *E. conica* Provancher — not in South; *E. tomici* Ashmead — GA, LA, MS, TX, VA. **Scelionidae:** *Gryon* sp. — LA; *Idris* sp. — LA; *Leptoteleia* sp. — NC; *Probarryconus heidemanni* Ashmead — GA, TX, VA.

Biological control attempts: *Thanasimus formicarius* (L.) (Cleridae) from Germany was released in WV (2,200 individuals) in 1892-1894, but was not recovered (Hopkins 1893). Some 200 individuals of the same species, from the USSR, were released in MS in 1980, and again was not recovered (Miller et al. 1987). Individuals of *Rhizophagus grandis* Gyllenhal (Rhizophagidae) from Europe were imported into the United States in 1976-1977, but were not released (Miller et al. 1987). These few North American attempts to establish biological control agents of foreign origin were trivial in view of the importance of *D. frontalis* as a pest. Westward spread of *Dendroctonus micans* (Kugelann) in Europe led to programs in several western European countries to culture, release, and establish *Rhizophagus grandis* Gyllenhal from farther east in the pest's range (Evans and King 1989, Grégoire et al. 1989). Preliminary analysis of the results in reports of the British Forestry Commission is encouraging (e.g., Fielding 1992).

Biological control possibilities: *Rhizophagus grandis* (see under *Dendroctonus terebrans*) offers some possibilities. Natural enemies of *D. frontalis* in the disjunct parts of its range in Mexico (e.g., Tejada and Patton 1979) and Central America are too poorly known to determine whether any of them might serve as a biological control agent for importation into the South. The literature shows a general problem in documentation of natural enemies of scolytids (*Conophthorus*, *Corthylus*, *Dendroctonus*, *Ips*, *Scolytus*, *Xylosandrus*, and *Xyleborus*). Part of the problem was caused by inadequacy of systematics of scolytids and of their natural enemies when work was begun many decades ago. Consequently, there are no records of natural enemies for some species, whereas for other species there are long lists of records, some of them of questionable validity.

Another part of the problem was caused by recording of some organisms as natural enemies simply because they were discovered "in association" with scolytids, whereas they may inflict little or no mortality on scolytids. For this reason, it is necessary to set aside all early records that cannot be substantiated by existing voucher specimens of both the pest and its natural enemy (either parasitoid or predator) accompanied by adequate documentation. Consequently, we did not bother to copy all the records of natural enemies that we found in the literature. To resolve the problem we recommend (a) collecting voucher specimens of natural enemies of scolytids (accompanied by the scolytid specimen which was the host of a parasitoid or the prey of a predator) from every state, and (b) compiling a computerized database of records. Specimens of organisms that were collected "in association" with a scolytid would also be housed, and data about them would be entered into the database. One of the fields in the database would be reserved for direct evidence of causation of mortality, and another would be reserved for estimates of proportion of mortality inflicted on a pest population by the organism in question at numerous geographical locations. Data accompanying voucher specimens now housed in the U.S. National Museum of Natural History could be integrated into the database after reexamination of the specimens.

These recommendations would be inexpensive to carry out because they should take only a small part of the time of one professional entomologist who has an interest in systematics.

Until these actions are taken, the predator-prey and host-parasitoid associations will remain unclear, and the potential for classical biological control will remain obscure.

Collaboration with forestry services in Canada and Mexico in constructing the database, in sharing taxonomic expertise, and in exchanging voucher specimens, is highly desirable. *Dendroctonus frontalis* is a prime example. There may be natural enemies in Mexico or Central America that could become useful as biological control agents for the South, but knowledge of the natural enemy complex in the South is fuzzy, and knowledge of the natural enemy complex in Mexico and Central America is almost nonexistent.

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Dendroctonus terebrans (Olivier)

black turpentine beetle

Scolytidae

Native: AL, AR, FL, GA, LA, MS, NC, OK, TX, VA, WV.

Resident natural enemies: We found no publications on specific enemies of *D. terebrans*.

Biological control attempts: Small numbers of *Rhizophagus grandis* Gyllenhal, imported from Belgium, were released in LA in 1988 as a biological control agent for *D. terebrans* (Moser 1989).

Biological control possibilities: *Rhizophagus grandis* is claimed to be a major mortality factor of *D. micans* in Eurasia and may be exceptional among *Rhizophagus* species, in that others may be fungivores rather than predators. *R. grandis* is attracted not only to volatile chemicals present in larval frass of *D. micans*, but also in that of the U.S. species *D. frontalis* and *D. terebrans* (Miller et al. 1987). Miller et al. (1987) suggested introducing *R. grandis* into the United States as a biological control agent mainly for *D. terebrans*, and with lesser possibilities for the control of *D. frontalis*, whose larvae are not gregarious, unlike those of *D. micans* and *D. terebrans*. A policy of waiting for analysis of results of European programs using this predator may have been fiscally conservative, but it seems the time has now come to plan an investment in a rearing, release, and evaluation program against *D. frontalis* and *D. terebrans* jointly, in several southern states. Such a strategy appears to be the most likely one in classical biological control to succeed. Techniques for rearing *R. grandis* and for monitoring populations of *D. frontalis* and *D. terebrans* have been devised. Dahlsten and Whitmore (1989) give arguments for and against biological control of bark beetles.

22

Dialeurodes citri (Ashmead)

citrus whitefly

Aleyrodidae

Adventive (Asia) ca. 1870: AL, FL, GA, LA, MS, NC, SC, TX.

Resident natural enemies: **Phlaeothripidae:** *Aleurodothrips fasciapennis* Franklin. **Aphelinidae:** *Encarsia lahorensis* (Howard) — AL, FL, NC, SC.

Biological control attempts: *Encarsia lahorensis* (Howard) was imported into Florida in 1977, released, and established for the first time, providing much-improved control of citrus whitefly (Sailer et al. 1984). It was released in AL, TX, and then in NC in 1982-1989 and found its way to SC.

Biological control possibilities: This whitefly is now largely under control. Occasional outbreaks probably are attributable to presence of the whitefly in areas where *E. lahorensis* is not established (e.g., Nalepa 1996). Distribution of this parasitoid to those areas is expected to solve the problem.

Diapheromera femorata (Say)

a walkingstick

Heteronemiidae

Native: NC, TX and throughout most of the eastern United States.

Resident natural enemies: **Tachinidae:** *Euhaliidaya genalis* (Coquillett) (= *Biomyia genalis*) — GA, VA, parasitizes nymphs and adults; *Phasmophaga antennalis* Townsend — TX, attacks nymphs and adults; *Phasmophaga meridionalis* Townsend — FL, where its host is recorded as *Anisomorpha buprestoides* (Stoll) (Pseudophasmatidae), another walkingstick, without evidence that it may also attack *Diapheromera femorata*. **Chrysididae:** *Mesitiopterus kahlii* Ashmead — NC and North, attacks eggs but does not seem to provide control; *M. floridensis* Krombein was described from FL, but its host is not recorded — perhaps it, too, attacks eggs of walkingsticks.

Biological control attempts: None known.

Biological control possibilities: Further basic studies are required before a strategy can be assigned. The studies should be directed to determining the most closely related genera to *Diapheromera* (studies in phylogeny), the natural enemies of these genera wherever they occur, and which of these natural enemies might be most adaptable to existence in the South (due to climatic similarity). Only thereafter should host-range trials be conducted for such natural enemies.

Diaprepes abbreviatus (L.)

la vaquita, Apopka weevil,

Curculionidae

West Indian sugarcane rootstock borer weevil

Native in PR, and Barbados, Dominica, Dominican Republic, Guadeloupe, Haiti, Martinique, Montserrat, St. Lucia, St. Vincent; **Adventive** in Florida.

Resident natural enemies: **Eulophidae:** *Aprostocetus gala* (Walker) (= *Tetrastichus gala*) — FL, Jamaica and some other West Indian islands where it is a parasitoid of *Exophthalmus vittatus* (L.); *Quadrastichus haitiensis* (Gahan) (= *Tetrastichus haitiensis*) FL, PR.

Biological control attempts: *Aprostocetus gala* was shipped from Dominica to St. Lucia in 1938, but is not known to have become established (Cock 1985). *Quadrastichus haitiensis* was introduced from PR into FL in 1969 and released, and had become established by 1978 (Beavers et al. 1980). *Platystasius citri* (Nixon) (= *Fidiobia citri*) (Platygastridae), a parasitoid of eggs of *Exophthalmus vittatus* (L.), was imported into FL from Jamaica in 1989 in the hope that it would attack eggs of *D. abbreviatus*, but releases have not yet been made (Frank and McCoy 1993).

Biological control possibilities: *D. abbreviatus* is a pest not only in FL but also in PR, though *Quadrastichus haitiensis* now exists in both areas. Presence of additional parasitoids of *Diaprepes* and perhaps of the related genus *Exophthalmus* in other Caribbean islands (Wolcott 1950, 1951; Cock 1985) seems to offer a source of biological control agents, and there is current effort by D. Hall and R. Nguyen to import them to Florida. Two parasitoids associated with *D. abbreviatus* are *Horismenus* sp. (Eulophidae) PR, a parasitoid of *Quadrastichus haitiensis*, and *Brachyufens osborni* (Dozier) (Trichogrammatidae), perhaps a parasitoid of *Quadrastichus haitiensis*, FL, PR and West Indies (Wolcott 1951). Care should be taken not to assume these are primary parasitoids of *D. abbreviatus*. Species of *Diaprepes* and *Exophthalmus* occur not only in the West Indies, but also in continental areas of the neotropical region, offering additional possibilities for the discovery of natural enemies.

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Dioryctria amatella (Hulst)

southern pine coneworm

Pyalidae

Native: AR, FL, NC, TX, VA and other southeastern states (Ebel 1965).

Resident natural enemies: **Tachinidae:** *Phrynofrontina* sp. — FL; *Xanthophyto* sp. — FL, GA.

Braconidae: *Agathis acrobasis* (Cushman) — AR, FL, GA, LA, MS, SC, TX and North;

Macrocentrus dioryctriae Muesebeck — AR, FL, LA, MS and North. **Ichneumonidae:**

Campoplex conocola (Rohwer) — AR, FL, and North and West; *Exochus turgidus* Holmgren —

AR, FL, LA, NC and North and West; *Exeristes comstockii* (Cresson) — AR, FL, GA, LA, SC,

VA and North and West. **Eulophidae:** *Hyssopus rhyacioniae* Gahan — AR, FL, TX and North.

Biological control attempts: None known.

Biological control possibilities: A survey of parasitoids of three *Dioryctria* species in India (Chacko 1979) yielded information on potential biological control agents for use against *Dioryctria* spp. in the South.

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Dioryctria clarioralis (Walker)

blister coneworm

Pyalidae

Native: AR, FL, NC, TX and other southeastern states and northward.

Resident natural enemies: **Tachinidae:** *Phrynofrontina* spp. — FL. **Braconidae:** *Apanteles*

bushnelli Muesebeck — FL, NC and West; *Macrocentrus dioryctriae* Muesebeck — AR, FL, MS

and North; **Ichneumonidae:** *Campoplex conocola* (Rohwer) — AR, FL, and North and West;

Exeristes comstockii (Cresson) — FL, GA, SC, VA and North and West.

Biological control attempts: None known.

Biological control possibilities: See *D. amatella*. The information on natural enemies of the several *Dioryctria* spp. mentioned in this report is not great. It would be worthwhile to construct a collection of voucher specimens and a computerized database for this information as recommended under *Dendroctonus frontalis*.

Dioryctria ebeli Mutuura and Munroe
Pyalidae

southern coastal coneworm

Native: AL, FL, GA, LA, SC and other southeastern states.

Resident natural enemies: Various species of *Dioryctria* were separated by Mutuura and Munroe (1979), but their specific natural enemies have not yet been separated.

Biological control attempts: Not known.

Biological control possibilities: See comments under *Dioryctria amatella*.

Dioryctria merkei Mutuura and Munroe
Pyalidae

loblolly pine coneworm

Native: FL, GA, LA, MS, NC, SC, TX, VA, WV and other southeastern states.

Resident natural enemies: Various species of *Dioryctria* were separated by Mutuura and Munroe (1979), but their specific natural enemies have not yet been separated.

Biological control attempts: None known.

Biological control possibilities: See comments under *Dioryctria amatella*.

Dioryctria pygmaeella Ragonot
Pyalidae

baldcypress coneworm

Native: AR, FL, TX, VA and other southeastern states.

Resident natural enemies: **Braconidae:** *Macrocentrus delicatus* Cresson — FL, TX and North; *M. dioryctriae* Muesebeck — AR, FL, MS and North; **Ichneumonidae:** *Calliephialtes grapholithae* (Cresson) — FL, TX and North. **Chalcididae:** *Brachymeria molestae* Burks — FL, MS, SC, TN and North.

Biological control attempts: None known.

Biological control possibilities: See comments under *Dioryctria amatella*.

Dioryctria yatesi Mutuura and Munroe
Pyalidae

mountain pine coneworm

Native: GA, NC, VA and northward.

Biological control possibilities: *D. abbreviatus* is a pest not only in FL but also in PR, though *Quadrastichus haitiensis* now exists in both areas. Presence of additional parasitoids of *Diaprepes* and perhaps of the related genus *Exophthalmus* in other Caribbean islands (Wolcott 1950, 1951; Cock 1985) seems to offer a source of biological control agents, and there is current effort by D. Hall and R. Nguyen to import them to Florida. Two parasitoids associated with *D. abbreviatus* are *Horismenus* sp. (Eulophidae) PR, a parasitoid of *Quadrastichus haitiensis*, and *Brachyufens osborni* (Dozier) (Trichogrammatidae), perhaps a parasitoid of *Quadrastichus haitiensis*, FL, PR and West Indies (Wolcott 1951). Care should be taken not to assume these are primary parasitoids of *D. abbreviatus*. Species of *Diaprepes* and *Exophthalmus* occur not only in the West Indies, but also in continental areas of the neotropical region, offering additional possibilities for the discovery of natural enemies.

94

Dioryctria amatella (Hulst)

southern pine coneworm

Pyalidae

Native: AR, FL, NC, TX, VA and other southeastern states (Ebel 1965).

Resident natural enemies: **Tachinidae:** *Phrynofrontina* sp. — FL; *Xanthophyto* sp. — FL, GA.

Braconidae: *Agathis acrobasis* (Cushman) — AR, FL, GA, LA, MS, SC, TX and North;

Macrocentrus dioryctriae Muesebeck — AR, FL, LA, MS and North. **Ichneumonidae:**

Campoplex conocola (Rohwer) — AR, FL, and North and West; *Exochus turgidus* Holmgren —

AR, FL, LA, NC and North and West; *Exeristes comstockii* (Cresson) — AR, FL, GA, LA, SC,

VA and North and West. **Eulophidae:** *Hyssopus rhyacioniae* Gahan — AR, FL, TX and North.

Biological control attempts: None known.

Biological control possibilities: A survey of parasitoids of three *Dioryctria* species in India (Chacko 1979) yielded information on potential biological control agents for use against *Dioryctria* spp. in the South.

86

Dioryctria clarioralis (Walker)

blister coneworm

Pyalidae

Native: AR, FL, NC, TX and other southeastern states and northward.

Resident natural enemies: **Tachinidae:** *Phrynofrontina* spp. — FL. **Braconidae:** *Apanteles*

bushnelli Muesebeck — FL, NC and West; *Macrocentrus dioryctriae* Muesebeck — AR, FL, MS

and North; **Ichneumonidae:** *Campoplex conocola* (Rohwer) — AR, FL, and North and West;

Exeristes comstockii (Cresson) — FL, GA, SC, VA and North and West.

Biological control attempts: None known.

Biological control possibilities: See *D. amatella*. The information on natural enemies of the several *Dioryctria* spp. mentioned in this report is not great. It would be worthwhile to construct a collection of voucher specimens and a computerized database for this information as recommended under *Dendroctonus frontalis*.

Dioryctria ebeli Mutuura and Munroe

southern coastal coneworm

Pyralidae

Native: AL, FL, GA, LA, SC and other southeastern states.

Resident natural enemies: Various species of *Dioryctria* were separated by Mutuura and Munroe (1979), but their specific natural enemies have not yet been separated.

Biological control attempts: Not known.

Biological control possibilities: See comments under *Dioryctria amatella*.

Dioryctria merkei Mutuura and Munroe

loblolly pine coneworm

Pyralidae

Native: FL, GA, LA, MS, NC, SC, TX, VA, WV and other southeastern states.

Resident natural enemies: Various species of *Dioryctria* were separated by Mutuura and Munroe (1979), but their specific natural enemies have not yet been separated.

Biological control attempts: None known.

Biological control possibilities: See comments under *Dioryctria amatella*.

Dioryctria pygmaeella Ragonot

baldcypress coneworm

Pyralidae

Native: AR, FL, TX, VA and other southeastern states.

Resident natural enemies: **Braconidae:** *Macrocentrus delicatus* Cresson — FL, TX and North; *M. dioryctriae* Muesebeck — AR, FL, MS and North; **Ichneumonidae:** *Calliephialtes grapholithae* (Cresson) — FL, TX and North. **Chalcididae:** *Brachymeria molestae* Burks — FL, MS, SC, TN and North.

Biological control attempts: None known.

Biological control possibilities: See comments under *Dioryctria amatella*.

Dioryctria yatesi Mutuura and Munroe

mountain pine coneworm

Pyralidae

Native: GA, NC, VA and northward.

Resident natural enemies: Various species of *Dioryctria* were separated by Mutuura and Munroe (1979), but their specific natural enemies have not yet been separated.

Biological control attempts: None known.

Biological control possibilities: See comments under *Dioryctria amatella*.

Diprion similis (Hartig)

introduced pine sawfly

Diprionidae

Adventive (Europe) ca. 1914: NC, TN, VA and North.

Resident natural enemies: **Tachinidae:** *Compsilura concinnata* (Meigen) — not in South, introduced from Europe in 1906 as a biological control agent for *Lymantria dispar*; *Diplostichus lophyri* (Townsend) (= *hamatus* (Aldrich and Webber)) — AR, FL, VA and North; *Euphorocera claripennis* (Macquart) — AL, FL, KY, LA, MS, NC, OK, SC, TN, TX, VA, WV and North; *E.* (= *Neophorocera*) *edwardsii* (Williston) — WV and North; *Palexorista bohémica* (Mesnil) (variously listed in publications of the 1930s as *Drino bohémica*, and by error as *Drino* (= *Palexorista*) *inconspicua* (Meigen) and *Sturmia inconspicua*) — released in 1943-1951 in eastern Canada against European spruce sawfly, and established, but not in South?; *Winthemia quadripustulata* (F.) — FL, MS, NC, VA, WV, PR and North. **Ichneumonidae:** *Agrothereutes lophyri* (Norton) — AL, FL, VA and North; *Bathythrix triangularis* (Cresson) — AL and North, functions also as a hyperparasitoid, attacking *Cotesia melanoscela*, *Meteorus versicolor*, and *Phobocampe geometriae*; *Delomerista japonica* Cushman ssp. *diprionis* Cushman — NC and North; *D. novita* (Cresson) — VA and North and West; *Exenterus amictorius* (Panzer) — WV and North, introduced from Europe for biological control of *Gilpinia hercyniae* in the 1930s; *Gelis tenellus* (Say) — GA and North and West, also attacks beneficial insects including *Chrysopa*, *Chrysoperla*, *Bracon*, *Meteorus*, *Microplitis*, *Enicospilus*, *Hyposoter*, and *Phobocampe*; *Itopectis conquisitor* (Say) — AR, FL, GA, LA, SC, VA and North and West can act as a hyperparasitoid, attacking *Hyposoter fugitivus*, *Phobocampe clisiocampe*, *P. pallipes*, and *Rogas stigmator*. **Torymidae:** *Monodontomerus dentipes* (Dalman) — NC and North, functions also as a hyperparasitoid, attacking *Rogas unicolor*, was introduced in 1938 as a biological control agent of *Gilpinia hercyniae*, but may already have been present as an immigrant accompanying its host, and occasionally is very effective in controlling *Diprion similis*. **Pteromalidae:** *Dibrachys cavus* (Walker) — FL and North and West [this species is extremely polyphagous and frequently is a hyperparasitoid, and it, in turn has a parasitoid: *Baryscapus coerulescens* (Ashmead) (= *Tetrastichus coerulescens* Ashmead) (Eulophidae)]; *Mesopolobus verditer* (Norton) — not in South, also functions as a hyperparasitoid, attacking *Itopectis conquisitor*; *Tritneptis diprionis* Gahan — not in South; **Eupelmidae:** *Eupelmus spongipartus* Foerster — not in South, of European origin, acts also as a hyperparasitoid, attacking *Cotesia melanoscela*, *Microcentrus ancyliivorus*, and *Meteorus versicolor*. **Eulophidae:** *Dahlbominus fuscipennis* (Zetterstedt) — NC, VA and North, introduced into Canada from Europe as a biological control agent for *Gilpinia hercyniae* in 1933 and, after establishment in the North, introduced into NC as a biological control agent for *Diprion similis*.

Biological control attempts: Classical biological control programs have been conducted against two other sawflies of European origin — *Gilpinia hercyniae* (Hartig) and *Neodiprion sertifer* (Geoffroy) — both mainly in eastern Canada, and each with a relatively minor U.S. component. Although European parasitoids of these pests were established, and some of

them attacked other native sawflies, it was the fortuitous establishment of a nuclear polyhedrosis virus that proved to be most useful (Clausen 1978). Augmentative releases of *Monodontomerus dentipes* suppressed *Diprion similis* in NC in 1982 (Drooz 1985).

Biological control possibilities: The biological control agents thus far introduced into the South were introduced originally into Canada, became established there, and then were secondarily introduced into the South. If the extent of damage in NC, TN and VA justifies further attempts, efforts should be made to acquire Eurasian parasitoids of *Diprion similis* and of *Neodiprion* species other than *N. sertifer* for evaluation in quarantine, before direct release in the South. Biological notes on some of the European species (Morris et al. 1937) will provide a partial background, provided that misidentifications (Reeks 1952) and later changes in nomenclature are recognized.

27

Dysmicoccus morrisoni (Hollinger)

a mealybug

Pseudococcidae

Native: AL, GA, LA, MS and North.

Resident natural enemies: Apparently none reported.

Biological control attempts: None known.

Biological control possibilities: The genus *Dysmicoccus* has about 30 species reported from North America, 20 from Central America and Asia, 24 from Australia, and 12 from the tropical South Pacific. Some of the natural enemies of species from other countries might adapt to *D. morrisoni* and should be investigated as potential biological control agents.

95

Ennomos subsignarius Hübner

elm spanworm

Geometridae

Native: TX and throughout the East to southern Canada.

Resident natural enemies: **Carabidae:** *Calosoma scrutator* (F.) — AL, FL, GA, KY, NC, SC, TX, VA and North, and also in Central and South America. **Sarcophagidae:** *Sarcophaga houghi* Aldrich — AL, VA and North. **Braconidae:** *Apanteles murtfeldtae* Ashmead — NC and North; *Macrocentrus iridescens* French — not in South. **Ichneumonidae:** *Apophua simplicipes* (Cresson) — not in South; *Diadromus mellinus* (Provancher) — not in South. *Itopectis conquisitor* (Say) — FL and North; *Theronia atalantae fulvescens* (Cresson) — VA and North. **Pteromalidae:** *Dibrachys cavus* (Walker) — FL and North. **Encyrtidae:** *Ooencyrtus ennomophagus* Yoshimoto — not in South. **Scelionidae:** *Telenomus droози* Muesebeck — GA, NC, SC and North.

Biological control attempts: None known.

Biological control possibilities: Elm spanworm is a poor candidate for biological control because it occurs at low population levels with only occasional damaging outbreaks. Nevertheless, the genus *Ennomos* also occurs in Europe where natural enemies might be

sought for biological control. *Ooencyrtus ennemophagus* is known only from Connecticut, and may thus may be a recent immigrant (Drooz 1980); if so, its release in other states may be useful.

15

Eriokermes gillettei (Tinsley) syn. *Eriococcus gillettei*

Gillette eriococcin

Kermesidae

(see Miller and Miller 1993)

Native: FL, VA and North and West.

Resident natural enemies: Apparently none reported.

Biological control attempts: None known.

Biological control possibilities: Natural enemies of the two other members of this genus, *E. juniperi* (Goux) in southern France and *E. juniperinus* (DeLotto) in northeastern Africa, may perhaps yield potential biological control agents for *E. gillettei*.

17

Eucalymnatus tessellatus (Signoret)

tessellated scale

Coccidae

Native: AL, AR, FL, LA, MS, SC, TN, TX, PR, VI, Cuba, Dominican Republic.

Resident natural enemies: **Aphelinidae:** *Coccophagus ceroplastae* (Howard) (= *Aneristus ceroplastae*) — LA and West, PR, Jamaica, and Asian tropics. **Encyrtidae:** *Metaphycus stanleyi* Compere — not in South.

Biological control attempts: None known.

Biological control possibilities: The 12 other described species of this genus seem to occur only in the neotropical region, this one alone having a wider distribution. It is thus the neotropical region that should be explored for natural enemies suitable for use as biological control agents.

2

Gnophothrips fuscus (Morgan)

slash pine flower thrips

Phlaeothripidae

Native: FL, GA.

Resident natural enemies: Apparently none reported.

Biological control attempts: None known.

Biological control possibilities: Poor in the immediate future, because knowledge of natural enemies of this species, its relatives, and of thrips in general is lacking.

Adventive (South America) ca. 1935: (1) AL, FL, GA, LA, MS, NC, SC, TN, VA; (2) AL, AR, FL, GA, KY, LA, MS, NC, SC, TN, TX, VA; (3) AL, FL; (4) AL, AR, FL, GA, LA, MS, NC, SC, TN, VA.

Resident natural enemies: Mortality has been inflicted on white-fringed beetles in the United States by naturally occurring entomopathogenic nematodes (*Steinernema* spp.), the entomopathogenic fungus *Metarhizium anisopliae* (Metschnikoff), and several nonspecific predatory insects. Naturally occurring entomopathogenic nematodes (*Heterorhabditis* spp.) have been shown to kill the beetles in Australia and these may yet be demonstrated to do so in the United States.

Biological control attempts: None known.

Biological control possibilities: Various entomopathogenic nematodes, fungi, or both probably could be employed as bioinsecticides where economics allow such action. Insect classical biological control agents should be sought in the South American homelands of these pests.

Native: FL, GA, LA, NC, OK, TX and other eastern states.

Resident natural enemies: **Tachinidae:** *Argyrophylax* spp. — states not named; *Compsilura concinnata* (Meigen) — not in South, introduced from Europe in 1906 as a biological control agent for *Lymantria dispar*; *Drino incompta* (Wulp) — FL, GA, KY, NC and North; *Leschenaultia fulvipes* (Bigot) — TX and western states; *Lespesia aletiae* (Riley) — AL, FL, GA, LA, MS, NC, OK, TN, TX, VA, PR and North. **Braconidae:** *Apanteles hemileucae* Riley — FL and North; *Meteorus hyphanthiae* Riley — United States and Canada; **Ichneumonidae:** *Hyposoter fugitivus* (Say) — FL, LA, TX and North and West.

Biological control attempts: None known.

Biological control possibilities: Of the 22 species in this North American genus, about 5 are exclusively Mexican. Larvae of two species feed on oak and are uncommon: *H. grotei* Grote and Robinson in TX and New Mexico, and *H. diana* Packard in Arizona, Colorado and TX. These oak-feeding species outside the range of *H. maia* should be examined for natural enemies that could be useful as potential biological control agents for *H. maia*.

Hexeris enhydris Grote

seagrape borer

Thyrididae

Native: FL, PR, and West Indies.**Resident natural enemies:** None known.**Biological control attempts:** None known.**Biological control possibilities:** Perhaps searching in West Indian islands other than PR may lead to the discovery of natural enemies of *H. enhydris* that could be used as biological control agents in FL and PR. The genus *Hexeris* has no other described species, so related species with similar habits are not known to exist.*Homadaula anisocentra* Meyrick

mimosa webworm

Urodidae

Adventive (China) ca. 1940: AL, FL, MS, NC, TX and northward.**Resident natural enemies:** **Braconidae:** *Agathis cincta* (Cresson) — FL and North; *Apanteles hyphantriae* Riley — United States and Canada and Europe. **Ichneumonidae:** *Enytus obliteratus* (Cresson) — FL and North; *Ophonellus foutsii* (Cushman) — not in South; *Parania geniculata* (Holmgren) — GA and North and West. **Eulophidae:** *Baryscapus dolosus* (Gahan) (= *Tetrastichus dolosus*) — AR, LA, VA and West, acts also as a hyperparasitoid by attacking *Euplectrus comstocki* and *E. plathypenae*; *Elasmus albizziae* Burks — VA and North; *Paraolinx canadensis* Miller — FL and North. Parasitism as high as 39-47% was reported for *E. albizziae* in Iowa (Bastian and Hart 1989).**Biological control attempts:** None known.**Biological control possibilities:** The species is known from China, Japan, and Taiwan, where natural enemies should be sought. Possibilities are good.*Homaledra sabalella* (Chambers)

palm leaf skeletonizer

Coleophoridae

Native: FL, MS, NC, SC, TX, PR and Dominican Republic, Haiti, Cuba.**Resident natural enemies:** **Carabidae:** *Plochionus amandus* Newman — AL, FL, GA (Creighton 1937). **Braconidae:** *Agathis difficilis* (Muesebeck) (= *Bassus difficilis*) — AR, FL, GA, LA, MS, NC, TX; *Apanteles* sp. — NC, TX; *Macrocentrus dioryctriae* Muesebeck — AR, FL, MS and

North; *Macrocentrus instabilis* Muesebeck — FL, SC, TX and North. **Ichneumonidae:** *Lyneon orbis* (Say) (= *Cryptieropsis orbis*) — FL, LA, TX and North, acts also as a hyperparasitoid by attacking *Hyposoter fugitivus* and other primary parasitoids. **Chalcididae:** *Brachymeria incerta* (Cresson) — FL, PR and West Indies, is a primary and secondary parasitoid of several Lepidoptera including *Megalopyge krugii* and *Homaledra sabalella* in PR (Wolcott 1951); *Spilochalcis cocois* Wolcott and *C. homaledrae* Wolcott — PR (Wolcott 1951). **Eupelmidae:** *Eupelmus limneriae* Howard — FL and North, acts also as a hyperparasitoid by attacking *Campoplex validus* and *Macrocentrus ancyliivorus*. **Eulophidae:** *Horismenus ignotus* Burks — FL; *Horismenus microgaster* (Ashmead) — NC, TX, is a secondary parasitoid, attacking *Apanteles* in *Homaledra*.

Biological control attempts: None known.

Biological control possibilities: The only two known species of this genus occur in Florida. Search for natural enemies in Hispaniola and Cuba may lead to the discovery of currently unreported natural enemies that could be used as biological control agents in the southern United States.

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Hylobius aliradicis Warner

southern pine root weevil

Curculionidae

Native: FL, GA, NC, TX, and Bahamas.

Resident natural enemies: Apparently none reported; see *H. pales*.

Biological control attempts: None known.

Biological control possibilities: Natural enemies of two South American species, *H. capra* F. and *H. capreolatus* Boheman, might prove useful as biological control agents.

45

Hylobius pales (Herbst)

pales weevil

Curculionidae

Native: AL, AR, FL, GA, LA, MS, NC, OK, SC, VA, TX, WV and North; **Adventive:** PR.

Resident natural enemies: **Braconidae:** *Microctonus pachylobii* Muesebeck — has been reared from adult *H. pales* in Wisconsin (Rieske et al. 1989). **Braconidae:** *Bracon radialis* Shenefelt — in North (not in South), attacks other *Hylobius* spp. **Ichneumonidae:** *Dolichomitus tuberculatus* (Geoffroy) — in North and in Eurasia (not in South) attacks other *Hylobius* spp.

Biological control attempts: None known.

Biological control possibilities: Natural enemies of three western European species — *H. abietis* L., *H. fatuus* Rossi, and *H. pinastri* Gyllenhal — might prove useful as biological control agents. However, populations of the weevil can be managed by making tree stumps unavailable for its breeding by destroying them mechanically, by applying chemical insecticide to them, or by keeping them alive (Corneil and Wilson 1984).

Hyphantria cunea (Drury)

fall webworm

Arctiidae

Native: FL, TX and northward.

Resident natural enemies: **Tachinidae:** *Archytas aterrimus* (Robineau-Desvoidy) — AL, FL, NC and North; *Blondelia eufitchiae* (Townsend) — not in South?; *B. hyphantriae* (Tothill) — not in South?; *Bombyliopsis abrupta* (Wiedemann) — states not named; *Carcelia malacosomae* Sellers — not in South?; *C. protuberans* (Aldrich and Webber) — states not named; *Ceromasia auricaudata* Townsend — not in South?; *Compsilura concinnata* (Meigen) — not in South, introduced from Europe in 1906 as a biological control agent for *Lymantria dispar*; *Euphorocera claripennis* (Macquart) — AL, FL, KY, LA, MS, NC, SC, OK, TN, TX, VA, WV and North; *E. floridensis* Townsend — FL, GA, MS, NC, SC; *Eusisyropa blanda* (Osten Sacken) — FL, NC, Cuba and North; *E. boarmiae* (Coquillett) — AR, MS, NC, TX and North; *E. virilis* (Aldrich and Webber) — VA, WV and North and West; *Hyphantrophaga hyphantriae* (Townsend) — FL, GA, NC, OK, TN, TX and West; *Lespesia aletiae* (Riley) — AL, FL, GA, LA, MS, NC, OK, TN, TX, VA, PR and North; *L. frenchii* (Williston) — MS, NC, TX, WV; *Mericia ampelus* (Walker) — not in South?; *M. arcuata* (Tothill) — in western Canada; *M. johnsoni* (Tothill) — states not named; *Winthemia* spp. — states not named. **Braconidae:** *Apanteles diacrisiae* Gahan — LA, SC and North; *A. hyphantriae* Riley — United States and Canada and Europe; *Dolichogenidea lacteicolor* (Viereck) (= *Apanteles lacteicolor*) — is primarily a parasitoid of the brown-tail moth, was introduced from Europe to the northeastern United States in 1908 and became established, was again introduced from Europe in 1963-1977 against gypsy moth, not in South; *Meteorus acronyctae* Muesebeck — not in South; *M. bakeri* Cook and Davis — not in South; *M. hyphantriae* Riley — United States and Canada; *Microplitis hyphantriae* Ashmead — AR, FL, TX and North; *Rogas hyphantriae* Gahan — not in South. **Ichneumonidae:** *Casinaria genuina* (Norton) — TX and North; *C. limenitidis* (Howard) — TX and North; *Coccygomimus disparis* (Viereck) — which was introduced to NC, VA and WV and North in 1974-1979 from Asia against *Lymantria dispar* and is established in some states, has been shown also to attack *Hyphantria cunea* (Schaefer et al. 1989); *Coelichneumon navus* (Say) (= *Ichneumon navus*) — FL, TX and North; *Enicospilus glabratus* (Say) — FL, PR, and North, Dominican Republic, and Jamaica; *Hyposoter fugitivus* (Say) — FL, LA, TX and North and West; *H. rivalis* (Cresson) — AL, TX and North; *Itopectis conquisitor* (Say) — AR, FL, GA, LA, SC, VA and North and West, can act as a hyperparasitoid of *Hyposoter fugitivus*, *Phobocampe clisiocampe*, *P. pallipes*, and *Rogas stigmator*; *Sinophorus validus* (Cresson) — not in South; *Therion morio* (F.) — FL and North; *T. sassacus* Viereck — not in South; *Vulgichneumon brevicincter* (Say) — FL, TX and North and West; *V. subcyaneus* (Cresson) — GA and North and West. **Pteromalidae:** *Dibrachys cavus* (Walker) — FL and North and West is extremely polyphagous and frequently is a hyperparasitoid, and it, in turn has a parasitoid: *Baryscapus coerulescens* (Ashmead) (= *Tetrastichus coerulescens* Ashmead) (Eulophidae). **Eulophidae:** *Aprostocetus esurus* (Riley) (= *Syntomosphyrum esurus*) — GA, TX and North; *Elachertus cacoeciae* Howard — VA and North and West; *E. hyphantriae* Crawford — AR, TX and North; *E. marylandicus* Girault — not in South. **Trichogrammatidae:** *Trichogrammatomyia tortricis* Girault — not in South. **Scelionidae:** *Telenomus bifidus* Riley — not in South. **Bethylidae:** *Goniozus platynotae* Ashmead — FL, LA, PR and North and West, is parasitized in turn by *Perilampus fulvicornis* Ashmead (Pteromalidae) FL, SC and North and West, which has additional hosts.

Biological control attempts: The fall webworm invaded eastern Europe about 1940, and North American parasitoids were released there from the early 1950s to early 1960s (Clausen 1978). There seems to have been no attempt to import natural enemies into North America.

Biological control possibilities: If any Eastern European parasitoids have adapted to this pest, they should be evaluated for importation to the United States. A thesis (Oliver, A.D. 1963. An ecological study of the fall webworm, *Hyphantria cunea* (Drury), in Louisiana. PhD Thesis, Louisiana State Univ.) has not been available to the compilers of this report; it probably contains information additional to that presented here.

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Hypsipyla grandella (Zeller)

mahogany shoot borer

Pyralidae

Adventive: FL, PR and West Indies.

Resident natural enemies: Ichneumonidae: *Calliephialtes ferrugineus* Cushman — FL, PR and Cuba (Wolcott 1951).

Biological control attempts: In the African and Asian tropics, *Hypsipyla robusta* (Moore) is an ecological homolog of *H. grandella*, and likewise is a pest of trees of the family Meliaceae. Following suggestions by Rao and Bennett (1969) and documentation of at least 46 insect parasitoids of *H. robusta*, attempts were made to import some of these parasitoids into Trinidad for distribution to countries of the Commonwealth Caribbean in 1968-1982. Success was very limited, but only a few of the parasitoid species were sent from India.

Biological control possibilities: Mahogany shoot borer is a major pest of trees of the family Meliaceae in its home range (e.g., Yamazaki et al. 1992), though several parasitoids have been reported (Cock 1985). The best hope for biological control still is to import natural enemies of the related *Hypsipyla robusta* from the Old World (Rao and Bennett 1969).

63

Ips avulsus (Eichhoff)

small southern pine engraver

Scolytidae

Native: AL, AR, FL, GA, LA, MS, NC, OK, SC, TX, VA, WV, Bahamas.

Resident natural enemies: Braconidae: *Dendrosoter sulcatus* Muesebeck — FL, TX and North; *Spathius pallidus* Ashmead — GA, TX and North; Pteromalidae: *Heydenia unica* Cook and Davis — GA, AL, NC, VA, WV and North and West.

Biological control attempts: None known.

Biological control possibilities: See comments under *Dendroctonus frontalis* and *Ips calligraphus*.

Ips calligraphus (Germar)

sixspined ips, six-spined engraver

Scolytidae

Native: AL, AR, FL, GA, LA, NC, OK, TN, TX, VA, WV, and North, and Bahamas, Dominican Republic, and Jamaica.

Resident natural enemies: **Braconidae:** *Coeloides pissodes* (Ashmead) — GA, TX and North; **Torymidae:** *Roptrocercus xylophagorum* (Ratzeburg) — GA, LA, MS, NC, TX, VA, WV and North and West; **Pteromalidae:** *Tomicobia tibialis* Ashmead not in South. Much information on natural enemies in the Gulf Coast states was reviewed by Kulhavy et al. (1989), and shows variation in the natural enemy complex among places and host tree species. The review does not specify the level of mortality inflicted on each of the three *Ips* species by each of the presumed predators and parasitoids listed, but gives the relative abundance of the presumed natural enemies. Perhaps some of the presumed natural enemies attack the three *Ips* species indiscriminately, but this is not known. Some of the natural enemies have not even been proven to attack *Ips*. For example, there is a widespread assumption that staphylinid beetles are predatory, and some authors list all staphylinid beetles (for which they are able to obtain identification) as predators, based on this assumption. Though some staphylinids are, indeed, obligate predators, others are strict fungivores or detritivores, and others are facultative predators. The quantitative effect of each staphylinid species that occurs frequently or infrequently under pine bark on named *Ips* species apparently has not been evaluated anywhere in North America. Staphylinidae are a prime example of this problem because their taxonomy in North America has lagged behind other families, so that identification has been uncertain; consequently, forest entomologists avoided working with them or assumed they are predatory. The same is true to a lesser extent of other families of presumed natural enemies.

Biological control attempts: None known.

Biological control possibilities: See comments under *Dendroctonus frontalis*.

Ips grandicollis (Eichhoff)

eastern fivespined ips, southern pine engraver

Scolytidae

Native: AL, AR, FL, GA, MS, NC, OK, SC, TX, VA, WV, Bahamas, Dominican Republic, Cuba.

Resident natural enemies: **Braconidae:** *Dendrosoter sulcatus* Muesebeck — FL, TX and North; *Coeloides pissodes* (Ashmead) — GA, TX and North; *Spathius pallidus* Ashmead — GA, TX and North. **Torymidae:** *Roptrocercus xylophagorum* (Ratzeburg) — GA, LA, MS, NC, TX, VA, WV and North and West. **Pteromalidae:** *Dinotiscus dendroctoni* (Ashmead) — GA, NC, TX, VA, WV, and West; *Tomicobia tibialis* Ashmead — not in South.

Biological control attempts: *Ips grandicollis* was detected in Australia in 1934 and became the target of a biological control program in 1981 using parasitoids and predators from GA and California; of these *R. xylophagorum* has been established, and *Thanasimus dubius* may be established (Berisford and Dahlsten 1989). Knowledge to be gained from this project in

Australia will add much to what is already known about the natural enemies of *Ips grandicollis* in the South.

Biological control possibilities: See comments under *Dendroctonus frontalis* and *Ips calligraphus*.

37

Knulliana cincta (Drury)
Cerambycidae

banded hickory borer

Native: AL, AR, FL, GA, LA, MS, NC, OK, SC, TX, VA.

Resident natural enemies: Ichneumonidae: *Labena grallator* (Say) FL and North and West.

Biological control attempts: None known.

Biological control possibilities: The genus *Knulliana* has no other species. The closest relative appears to be the genus *Purpuriscenus*, which occurs not only in North America, but also in the Old World. Natural enemies of *Purpuriscenus* from other continents should be evaluated as potential biological control agents for *K. cincta*.

4

Leptoglossus corculus (Say)
Coreidae

leaffooted pine seedbug

Native: AL, AR, FL, GA, MS, NC, SC, TN, TX, VA.

Resident natural enemies: Encyrtidae: *Ooencyrtus leptoglossi* Yoshimoto — GA, attacks eggs (Yoshimoto 1977).

Biological control attempts: None known.

Biological control possibilities: *Hylomya chilensis* Macquart (Tachinidae) is reported to attack *Leptoglossus chilensis* (Spinola) in Chile. It should be investigated as a potential biological control agent for *L. corculus*.

105

Lochmaeus manteo Doubleday syn. *Heterocampa manteo* **variable oakleaf caterpillar**
Notodontidae

Native: FL, NC, TX and eastern United States.

Resident natural enemies: Tachinidae: *Lespesia aletiae* (Riley) — AL, FL, GA, LA, MS, NC, OK, TN, TX, VA, and North and PR. Braconidae: *Hypermicrogaster schizurae* (Muesebeck) — AR and North. Ichneumonidae: *Cratichneumon paratus* (Say) — FL and North. *Diradops bethunei* (Cresson) — GA and North, all others of this large genus are neotropical. Eulophidae: *Eulophus brevicapitatus* (Cook and Davis) — LA and North.

Biological control attempts: None known.

Biological control possibilities: *L. manteo* is one of only two North American species. The closely related North American genus *Heterocampa*, has over 20 species, some of them ranging southward through Central America, and their natural enemies could be investigated as potential biological control agents for *L. manteo*.

103

Lymantria dispar (L.)

gypsy moth

Lymantriidae

Adventive (Europe) ca. 1868: an infestation began in Massachusetts when moths imported by Leopold Trouvelot, an astronomer, escaped (Liebhold et al. 1989). The area infested increased, and most recently this species invaded the southeastern United States (Allen et al. 1993). Biological control research in the northeastern United States began decades ago and the account will not be repeated here because it is given at length by Van Driesche et al. (1997) and because the pest is still far more important in the northeastern United States than in the South.

24

Magicicada septendecim (L.)

periodical cicada

Cicadidae

Native: AL, AR, GA, KY, LA, MS, NC, OK, SC, TN, VA.

Resident natural enemies: **Tachinidae:** *Tachina* sp. — states not named, record questionable.
Trichogrammatidae: *Giraultia fidae* (Ashmead) — VA and North.

Biological control attempts: None known.

Biological control possibilities: Possibilities are obscure in absence of a detailed study of phylogenetics of cicadas to identify the most closely related genera elsewhere, and in absence of knowledge of natural enemies of related genera.

99

Malacosoma americanum (Fabricius)

eastern tent caterpillar

Lasiocampidae

Native: FL, NC, TX and eastern half of the United States.

Resident natural enemies: **Sarcophagidae:** *Agria housei* Shewell — not in South; *Sarcophaga aldrichi* Parker — not in South; *S. houghi* Aldrich — AL, WV and North. **Tachinidae:** *Archytas aterrimus* (Robineau-Desvoidy) — AL, FL, NC and North; *A. lateralis* (Macquart) — FL and West; *Blepharipa pratensis* (Meigen) [= *B. scutellata* (Robineau-Desvoidy) according to Sabrosky and Reardon (1976)] — not in South?; *Carcelia laxifrons* Villeneuve — not in South; *C. malacosomae* Sellers — not in South; *C. protuberans* (Aldrich and Webber) — not in South; *Cartocometes io* Aldrich — not in South; *Chetogena floridensis* (Townsend) — FL (Foltz and Dixon unpubl.); *Compsilura concinnata* (Meigen) — not in South, introduced from Europe in

1906 as a biological control agent for *Lymantria dispar*; *Diplostichus lophyri* (Townsend) — AR, FL, VA and North; *Euexorista futilis* (Osten Sacken) — WV and North; *Euphorocera claripennis* (Macquart) — AL, FL, KY, LA, MS, NC, SC, OK, TN, TX, VA, WV and North; *E. edwardsii* (Williston) — WV and North; *E. tachinomoides* Townsend — OK, TX and West; *Exorista mella* (Walker) — FL, GA, MS, NC, TX and North; *Hyphantrophaga hyphantriae* (Townsend) — FL, GA, NC, OK, TN, TX and West; *Leschenaultia exul* (Townsend) — not in South; *Lespesia aletiae* (Riley) — AL, FL, GA, LA, MS, NC, OK, TN, TX, VA, PR and North; *L. archippivora* (Riley) — NC, OK, TX, PR and North and West; *L. ciliata* (Macquart) — not in South; *L. frenchii* (Williston) — FL, MS, NC, TX, WV; *L. schizurae* (Townsend) — FL and North; *Mericia ampelus* (Walker) — not in South; *Palexorista bohémica* (Mesnil) (variously listed in publications of the 1930s as *Drino bohémica*, and by error as *Drino* (= *Palexorista*) *inconspicua* (Meigen) and *Sturmia inconspicua*) — released in 1943-1951 in eastern Canada against European spruce sawfly, and established, but not in South?; *Parasitigena silvestris* (Robineau-Desvoidy) (= *P. agilis* (Robineau-Desvoidy)) — VA and North; *Pilatea arator* (Aldrich) — not in South; **Braconidae**: *Apanteles clisiocampae* Ashmead — not in South; *Meteorus communis* (Cresson) — not in South; *M. hyphantriae* Riley — United States and Canada; *Rogas stigmator* (Say) — not in South; **Ichneumonidae**: *Agrypon anale* (Say) — AL and North; *Apophua simplicipes* (Cresson) — TX and North and West; *Casinarina limenitidis* (Howard) — TX and North; *Coccygomimus disparis* (Viereck) — introduced into NC, VA and WV and North in 1974-1979 from Asia against *Lymantria dispar* and is established in some states, has been shown also to attack *Malacosoma americanum* (Schaefer et al. 1989); *Gambrus canadensis* (Provancher) ssp. *canadensis* — not in South; *Hyposoter fugitivus* (Say) — FL, LA, TX and North and West; *Iseropus coelebs* (Walsh) — FL, TX and North; *Itopectis conquisitor* (Say) — AR, FL, GA, LA, SC, VA and North and West, can act as a hyperparasitoid of *Hyposoter fugitivus*, *Phobocampe clisiocampe*, *P. pallipes*, and *Rogas stigmator*; *Phobocampe clisiocampe* (Weed) — AR and North; *Pimpla pedalis* Cresson (= *Coccygomimus pedalis*) — VA and North and West; *Theronia atalantae* (Poda) ssp. *fulvescens* (Cresson) — AL, VA and North and West, acts also as a hyperparasitoid by attacking *Enicospilus americanus*, *Hyposoter fugitivus* and *Itopectis conquisitor*. **Torymidae**: *Monodontomerus aereus* Walker — not in South, acts also as a hyperparasitoid by attacking *Compsilura concinnata*, *Carcelia laxifrons*, and *Blepharipa pratensis* (Meigen), was introduced to North America in 1906-1910 as a biological control agent for gypsy moth and browntail moth; *M. minor* (Ratzeburg) — VA and North and West, acts also as a hyperparasitoid by attacking *Gambrus extrematis*. **Pteromalidae**: *Dibrachys cavus* (Walker) — FL and North and West, extremely polyphagous and frequently a hyperparasitoid, and it, in turn has a parasitoid: *Baryscapus coerulescens* (Ashmead) (= *Tetrastichus coerulescens* Ashmead) (Eulophidae); *Habrocytus thyridopterigis* Howard — AR, NC, SC and North; *Psychophagus omnivorus* (Walker) — not in South, a primary and secondary parasitoid which attacks *Compsilura concinnata* and *Itopectis conquisitor*; *Pteromalus puparum* (L.) — FL and North and West, an immigrant from Europe in the 19th century. **Encyrtidae**: *Aphycoideus io* Williams — not in South; *Ooencyrtus clisiocampae* (Ashmead) — cosmopolitan. **Aphelinidae**: *Ablerus clisiocampae* (Ashmead) (= *Centrodorus clisiocampae*) — AL, FL, LA, WV and North. **Eulophidae**: *Baryscapus malacosomae* (Girault) (= *Tetrastichus malacosomae*) — AR, NC and North; *Tetrastichomyia clisiocampae* (Ashmead) (= *Syntomosphyrum clisiocampae*) — SC, TX and North; **Scelionidae**: *Telenomus clisiocampae* Riley — WV and North. During most years, the eastern tent caterpillar is said to be controlled satisfactorily by its natural enemies.

Biological control attempts: None known.

Biological control possibilities: Natural enemies of the European *Malacosoma neustria* L. in England called lackey moth and related species could be investigated as potential biological control agents. Investigation should be in conjunction with a program on biological control

of *M. disstria*. These European natural enemies include, at very least, representatives of the genera *Ceranthia*, *Ernestia*, *Eumea*, *Frontina*, *Histochoeta*, *Nemosturmia*, *Pales*, *Paraphorocera*, *Phorcida*, *Tachina*, *Winthemia*, and *Zenillia* (Tachinidae). They also include *Telenomus laeviusculus* (Ratzeburg) (Hymenoptera: Scelionidae), which has been noted to parasitize as many as 80-90% of eggs in some locations (Romanova and Lozinskii 1958). However, bioinsecticides such as *Bacillus thuringiensis* provide a viable method for controlling occasional damage to ornamental trees by *M. americanum*.

Malacosoma disstria Hübner

forest tent caterpillar

Lasiocampidae

Native: AL, FL, KY, LA, MS, NC, SC, VA and most of the United States.

Resident natural enemies: **Sarcophagidae:** *Agria housei* Shewell — not in South; *Helicobia rapax* (Walker) (= *Sarcophaga rapax*) — AL and North; *Sarcophaga aldrichi* Parker — not in South; *S. houghi* Aldrich — AL, WV and North; *S. sarracenioides* Aldrich — AL and North. **Tachinidae:** *Archytas aterrimus* (Robineau-Desvoidy) — AL, FL, NC and North; *Blepharipa pratensis* (Meigen) [= *B. scutellata* (Robineau-Desvoidy) according to Sabrosky and Reardon (1976)] — not in South?; *Carcelia laxifrons* Villeneuve — not in South; *C. malacosomae* Sellers — not in South; *C. protuberans* (Aldrich and Webber) — not in South; *Cartocometes io* Aldrich — not in South; *Compsilura concinnata* (Meigen) — not in South; *Euexorista futilis* (Osten Sacken) — WV and North; *Euphorocera claripennis* (Macquart) — AL, FL, KY, LA, MS, NC, SC, OK, TN, TX, VA, WV and North; *E. edwardsii* (Williston) — WV and North; *Exorista mella* (Walker) — FL, GA, MS, NC, TX and North; *Hyphantrophaga euchaetiae* (Sellers) — AL; *H. virilis* (Aldrich and Webber) — FL (Foltz and Dixon unpubl.); *Leschenaultia americana* (Brauer and Bergenstamm) — not in South; *L. exul* (Townsend) — not in South; *L. leucophrys* (Wiedemann) — PR and North; *Lespesia archippivora* (Riley) — NC, OK, TX, PR and North and West; *L. frenchii* (Williston) — MS, NC, TX, WV; *L. melalophae* (Allen) — MS, NC and North; *Madremyia saundersii* (Williston) — WV and North and West; *Mericia ampelus* (Walker) — not in South; *Palexorista bohemia* (Mesnil) (variously listed in publications of the 1930s as *Drino bohemia*, and by error as *Drino* (= *Palexorista*) *inconspicua* (Meigen) and *Sturmia inconspicua*) — released in 1943-1951 in eastern Canada against European spruce sawfly, and established, but not in South?; *Patelloa pachypyga* — not in South; *Tachinomyia nigricans* Webber not in South; *T. panaeticus* (Walker) — not in South; *T. similis* (Williston) — not in South; *Winthemia datanae* (Townsend) — FL, GA and North. **Braconidae:** *Bracon xanthonotus* Ashmead — VA and North and West; *Meteorus hyphantriae* Riley — United States and Canada. **Ichneumonidae:** *Agrypon anale* (Say) — AL and North; *Casinaria forcipata* Walley — TX and North and West; *Dusona vitticollis* (Norton) — AL, GA and North and West; *Gambrus canadensis* (Provancher) ssp. *canadensis* — not in South; *Glypta erratica* Cresson (= *G. inversa*) — not in South; *Hyposoter fugitivus* (Say) — FL, LA, TX and North and West; *H. fuscitarsis* (Viereck) — not in South; *Ischnus inquisitorius atricollaris* (Walsh) — NC and North and West; *Iseropus coelebs* (Walsh) — FL, TX and North; *I. stercorator* (F.) ssp. *orgyiae* (Ashmead) — not in South; *Itopectis conquisitor* (Say) — AR, FL, GA, LA, SC, VA and North and West can act as a hyperparasitoid of *Hyposoter fugitivus*, *Phobocampe clisiocampe*, *P. pallipes*, and *Rogas stigmator*; *I. quadricingulata* (Provancher) — not in South; *I. viduata* (Gravenhorst) — not in South; *Meringopus genatus* (Pratt) — not in South; *Phobocampe clisiocampe* (Weed) — AR and North; *Pimpla maura* Cresson (= *Coccygomimus maurus*) — AL, FL, GA, NC, TX and North; *Scambus hispae* (Harris) — AL, KY and North and West, acts also as a hyperparasitoid

attacking *Hyposoter fugitivus*; *Pimpla pedalis* Cresson (= *Coccygomimus pedalis*) — VA and North and West; *Theronia atalantae* (Poda) ssp. *fulvescens* (Cresson) — AL, VA and North and West, acts also as a hyperparasitoid by attacking *Enicospilus americanus*, *Hyposoter fugitivus* and *Itopectis conquisitor*. **Pteromalidae**: *Dibrachys cavus* (Walker) — FL and North and West is extremely polyphagous and frequently is a hyperparasitoid, and it, in turn has a parasitoid: *Baryscapus coerulescens* (Ashmead) (= *Tetrastichus coerulescens* Ashmead) (Eulophidae); *Perilampus hyalinus* Say — AL, FL and North and West, also acts as a hyperparasitoid by attacking several dipterous and hymenopterous parasitoids; *Psychophagus omnivorus* (Walker) — not in South, a primary and secondary parasitoid which attacks *Compsilura concinnata* and *Itopectis conquisitor*; *Pteromalus vanessae* Howard — FL and North and West; **Eupelmidae**: *Eupelmella vesicularis* (Retzius) — not in South, an immigrant from Europe ca. 1915, acts also as a hyperparasitoid by attacking *Cotesia melanoscela*, and *Dahlbominus fuscipennis*. **Encyrtidae**: *Ooencyrtus clisiocampae* (Ashmead) — cosmopolitan; **Aphelinidae**: *Ablerus clisiocampae* (Ashmead) (= *Centrodorus clisiocampae*) — AL, FL, LA, WV and North. **Eulophidae**: *Aprostocetus esurus* (Riley) (= *Syntomosphyrum esurus*) — GA, TX and North; *A. silvaticus* (Gahan) (= *Tetrastichus silvaticus*) — not in South; *Baryscapus malacosomae* (Girault) (= *Tetrastichus malacosomae*) — AR, NC and North. **Chalcididae**: *Brachymeria ovata* (Say) — throughout the South and northward is a primary parasitoid; *B. compsilurae* (Crawford) — NC, TN is a parasitoid of *Compsilura concinnata* in at least some lepidopterous hosts; **Scelionidae**: *Telenomus clisiocampae* Riley — WV and North. In the North, *Sarcophaga aldrichi* Parker (Sarcophagidae), *Carcelia protuberans* (Aldrich and Webber) (= *Zenilla protuberans*) and *Compsilura concinnata* Meigen (Tachinidae).

Biological control attempts: None known.

Biological control possibilities: See comments under *M. americanum*. This species is a more important pest of forest trees than is *M. americanum* and its control by bioinsecticides would require aerial application over areas that sometimes are large. Use of *Bacillus thuringiensis* under these circumstances could have an important negative effect on nontarget caterpillars. Therefore, rationally, efforts to develop a more specific bioinsecticide (for example, a nuclear polyhedrosis virus) would be justified. However, the commercial acceptance of such a bioinsecticide is questionable because such a bioinsecticide developed for use against gypsy moth is not a commercial success. Recent evidence suggests that avian predation on the caterpillars is important at all population densities, but that the current suite of parasitoids (at least in Alberta, Canada) may not be capable of controlling low densities of the caterpillars (Parry et al. 1997).

Megalopyge krugii (Dewitz)

Megalopygidae

la plumilla

Native: PR.

Resident natural enemies: **Tachinidae**: *Carcelia lagoae* Sellers (reported by error as *C. flavirostris* (Wulp)), which in turn is parasitized by *Brachymeria incerta* (Wolcott 1951). **Chalcididae**: *Brachymeria incerta* (Cresson) FL, PR and West Indies is a hyperparasitoid, attacking *Carcelia lagoae*; *B. robusta* (Cresson) (= *robustella* Wolcott) FL, PR and West Indies is a primary parasitoid only.

Biological control attempts: None known.

Biological control possibilities: *Archytas vernalis* Curran, *Belvosia weyenberghiana* (Wulp), *Euphorocera eurotae* Blanchard, *E. caridei* (Brèthes), and *Macromya crocata* Reinhard (Tachinidae) are reported as natural enemies of *Megalopyge* spp. in South America, and they should be investigated as potential biological control agents for *M. krugii*.

Megalopyge opercularis (J.E. Smith)

puss caterpillar

Megalopygidae

Native: FL, NC, TX and other eastern states.

Resident natural enemies: Tachinidae: *Carcelia amplexa* (Coquillett) — FL, GA, MS, NC, and North, and PR; *C. lagoae* (Townsend) — FL, MS, TX, sometimes quite abundant in TX (but is attacked in LA by *Tachinobia repanda*, see Eulophidae below); *Euphorocera claripennis* (Macquart) — AL, FL, KY, LA, MS, NC, SC, OK, TN, TX, VA, WV and North; *Lespesia aletiae* (Riley) — AL, FL, GA, LA, MS, NC, OK, TN, TX, VA, PR and North; *Winthemia* sp. — LA; *Zenillia* sp. — state not named. **Ichneumonidae:** *Calliephialtes grapholithae* (Cresson) — FL, TX and North; *Hyposoter fugitivus* (Say) — FL, LA, TX and North and West (Khalaf 1977); *Lanugo retentor* (Brullé) — FL, LA, TX, VA and North (Khalaf 1981); *Lymeon orbus* (Say) (= *Cryptieropsis orbus*) — FL, LA, TX and North, acts as a hyperparasitoid by attacking *Lanugo retentor* (Khalaf 1980). **Chalcididae:** *Brachymeria robusta* (Cresson) (= *robustella* Wolcott) — FL, PR and West Indies is a primary parasitoid only. **Eulophidae:** *Tachinobia repanda* Bouček — LA and Cuba is a secondary parasitoid of Asian origin which attacks *Carcelia lagoae*.

Biological control attempts: None known.

Biological control possibilities: *Archytas vernalis* Curran, *Belvosia weyenberghiana* (Wulp), *Euphorocera eurotae* Blanchard, *E. caridei* (Brèthes), and *Macromya crocata* Reinhard (Tachinidae) are reported as natural enemies of *Megalopyge* spp. in South America, and they should be investigated as potential biological control agents for *M. opercularis*.

Metamasius hemipterus (L.)

cane weevil

Curculionidae

Adventive in FL (neotropical region) ca. 1984; **Native** in PR and VI, Antigua, Barbados, Dominica, Grenada, Guadeloupe, Jamaica, Martinique, Montserrat, St. Kitts, St. Vincent, Central America and South America.

Resident natural enemies: Apparently none reported.

Biological control attempts: None known.

Biological control possibilities: Obscure due to lack of information. A survey should be conducted in the neotropical region for suitable natural enemies for use as biological control agents. Although this insect is widely known as a relatively minor pest of sugarcane, its attacks on ornamental palm trees in southern Florida have proven costly.

Monocesta coryli (Say)

larger elm leaf beetle

Chrysomelidae

Native: AL, FL, GA, NC, SC, WV.**Resident natural enemies:** Apparently none reported.**Biological control attempts:** None known.**Biological control possibilities:** Several species of this genus occur in the neotropics, and may yield natural enemies suitable for use as biological control agents against *M. coryli*.*Myrmelachista ambigua* Forel ssp. *ramulorum* Wheeler

hormiguilla

Formicidae

Native: PR.**Resident natural enemies:** *Iridomyrmex melleus* Wheeler, a competitor, and lizards and birds (Wolcott 1951).**Biological control attempts:** None known.**Biological control possibilities:** Very poor for classical biological control. The best possibilities are for the use of suitable baits poisoned with chemicals or with pathogens.*Neodiprion excitans* (Rohwer)

blackheaded pine sawfly

Diprionidae

Native: AR, FL, NC, TX, VA and North, and Central America.**Resident natural enemies:** **Pentatomidae:** *Podisus fretus* Olsen. **Reduviidae:** *Arilus cristatus* (L.).**Bombyliidae:** *Villa sinuosa* (Wiedemann) — AR, FL, NC, VA and North. **Tachinidae:***Diplostichus lophyri* (Townsend) — AR, FL, VA and North; *Phorocera* sp. — FL; *Spathimeigenia aurifrons* Curran — not in South; *Spathimeigenia spinigera* Townsend — AL, AR, FL, TX, VA and North; *Spathimeigenia* sp. — FL. **Ichneumonidae:** *Agrothereutes lophyri* (Norton) — AL, FL, VA and North; *Endasys subclavatus* (Say) — AR, FL, VA and North and West; *Exenterus canadensis* Provancher — AR, FL, LA, VA and North; *E. nigrifrons* Rohwer — FL, TX and North; *Lamachus contortionis* Davis — AR, FL and North. **Pteromalidae:** *Dibrachys cavus* (Walker) — FL and North and West, extremely polyphagous and frequently ahyperparasitoid, and it, in turn has a parasitoid: *Baryscapus coerulescens* (Ashmead) (= *Tetrastichus coerulescens* Ashmead) (Eulophidae); *Perilampus carolinensis* Smulyan - FL.**Chalcididae:** *Hockeria unipunctatipennis* (Girault) — FL and North and West. **Eulophidae:** *Closterocerus cinctipennis* Ashmead — FL, VA and North. A polyhedral virus disease and several parasitoids and predators apparently are highly effective in bringing outbreaks to an

early end.

Biological control attempts: Parasitoids of an adventive sawfly, *N. sertifer* (Geoffroy), were imported from Europe via Canada in the late 1930s and early 1940s and became established in New Jersey but did not give adequate control; a European polyhedrosis virus also was received from Canada and has proven effective as a bioinsecticide. The tachinid was *Palexorista bohémica* (Mesnil), which has been tested in the laboratory against various *Neodiprion* spp. but apparently is not reported from them in the field. *P. bohémica* has been confused in literature with *P. inconspicua*, which also was imported.

Biological control possibilities: Parasitoids of *N. excitans* in Belize were listed by Wilkinson and Drooz (1979). They concluded that the two principal parasitoids (after *Closterocerus cinctipennis*) in Belize are facultative parasitoids or hyperparasitoids already represented in Florida by the same or very closely related species. In fact, only one parasitoid, *Closterocerus cinctipennis*, was identified to species level. Other parasitoids found belonged to unidentified *Perilampus*, *Dibrachys*, *Eupelmus*, and *Brachymeria*, which **might** have been able to contribute to biological control of *N. excitans* in the South. Though it may have been disappointing to Wilkinson and Drooz (1979) that no parasitoid of a radically different taxon was discovered in Belize, dismissal of the parasitoids discovered there was premature.

Neodiprion lecontei (Fitch)

redheaded pine sawfly

Diprionidae

Native: AR, FL, LA, NC, TX and North.

Resident natural enemies: Bombyliidae: *Villa sinuosa* (Wiedemann) — AR, FL, NC, VA and North. **Tachinidae:** *Bessa harveyi* (Townsend) — not in South?; *B. selecta* (Meigen) — not in South?; *Diplostichus lophyri* (Townsend) (= *Phorocera hamata* Aldrich and Webber) — AR, FL, VA and North; *Eribella* sp. nr. *exilis* (Coquillett) — VA; *Euphorocera claripennis* (Macquart) — AL, FL, KY, LA, MS, NC, SC, OK, TN, TX, VA, WV and North; *E. edwardsii* (Williston) — WV and North; *Phorocera* sp. — AL; *Palexorista bohémica* (Mesnil) (variously listed in publications of the 1930s as *Drino bohémica*, and by error as *Drino* (= *Palexorista*) *inconspicua* (Meigen) and *Sturmia inconspicua*) — released in 1943-1951 in eastern Canada against European spruce sawfly, and established, but not in South?; *Spathimeigenia aurifrons* Curran — not in South; *S. erecta* — Aldrich not in South?; *S. hylotomae* (Coquillett) — FL, VA and North; *Spathimeigenia spinigera* Townsend — AL, AR, FL, TX, VA and North; *Spathimeigenia* sp. — FL. **Ichneumonidae:** *Agrothereutes abbreviator* (F.) ssp. *iridescent* (Cresson) — LA, NC and North; *A. lophyri* (Norton) — AL, FL, VA and North; *Delomerista japonica* Cushman ssp. *diprionis* Cushman — NC and North; *Endasys subclavatus* (Say) — AR, FL, VA and North and West; *Exenterus abruptorius* (Thunberg) — not in South, introduced for biological control of *Gilpinia hercyniae* in the 1930s, from Eurasia; *E. amictorius* (Panzer) — WV and North, introduced for biological control of *Gilpinia hercyniae* in the 1930s, from Europe; *E. canadensis* Provancher — AR, FL, LA, VA and North; *E. nigrifrons* Rohwer — FL, TX and North; *Lamachus contortionis* Davis — AR, FL and North; *L. virginianus* (Rohwer) — NC, VA and North, probably not distinct from *L. contortionis*; *Olesicampe lophyri* (Riley) — FL and North; *Pleolophus basizonus* (Gravenhorst) — not in South, introduced for biological control of *Gilpinia hercyniae* in the 1930s, from Europe; *P. indistinctus* (Provancher) — not in South. **Pteromalidae:** *Dibrachys cavus* (Walker) — FL and North and West, extremely polyphagous and frequently a hyperparasitoid, and it, in turn has a parasitoid: *Baryscapus coerulescens* (Ashmead) (= *Tetrastichus coerulescens* Ashmead) (Eulophidae); *Mesopolobus verditer* (Norton) — not in South, also functions as a hyperparasitoid, attacking *Itoplectus conquisitor*. *Perilampus hyalinus*

Say — AL, FL and North and West, also acts as a hyperparasitoid by attacking several dipterous and hymenopterous parasitoids; *Psychophagus omnivorus* (Walker) — not in South, a primary and secondary parasitoid; *Tritneptis diprionis* Gahan — not in South. **Eupelmidae:** *Eupelmella vesicularis* (Retzius) — not in South, an immigrant from Europe ca. 1915, acts also as a hyperparasitoid by attacking *Cotesia melanoscela*, and *Dahlbominus fuscipennis*.

Eulophidae: *Closterocerus cinctipennis* Ashmead — FL, VA and North; *Dahlbominus fuscipennis* (Zetterstedt) — NC, VA and North, introduced from Europe as a biological control agent for *Gilpinia hercyniae* in 1933 and, after establishment in the North, introduced into NC as a biological control agent for *Diprion similis*.

Biological control attempts: Four parasitoids of *Gilpinia hercyniae* (Hartig) imported from Europe and released in North Carolina, were shipped to Florida in 1969 for release against *Neodiprion lecontei*: (1) *Dahlbominus fuscipennis* (Zetterstedt) (Eulophidae) NC, VA and North, introduced into North America as a biological control agent for *Gilpinia hercyniae* in 1933 and, after establishment in the North, introduced into NC as a biological control agent for *Diprion similis*; (2) *Exenterus amictorius* (Panzer) (Ichneumonidae) WV and North, introduced for biological control of *Gilpinia hercyniae* in the 1930s, from Europe; (3) *Pleolophus* (= *Aptesis*) *basizonus* (Gravenhorst) (Ichneumonidae) not in South, introduced for biological control of *Gilpinia hercyniae* in the 1930s, from Europe; (4) *Monodontomerus dentipes* (Dalman) (Torymidae) NC and North, introduced into North America as a biological control agent of *Gilpinia hercyniae*, but may already have been present as an immigrant accompanying its host, and occasionally is very effective in controlling *Diprion similis*. There is no evidence that any of these four became established in Florida following release there (Frank and McCoy 1993).

Biological control possibilities: Damage caused by *N. lecontei* has been too little to justify production and marketing of a nuclear polyhedrosis virus (LeConte virus) even though this is an effective bioinsecticide (Cunningham and de Groot 1984, Cunningham et al. 1986). The classical biological control alternative is a thorough evaluation of Eurasian parasitoids of *Diprion similis* and of *Neodiprion* species other than *N. sertifer*, and for release and evaluation of laboratory-tested candidates directly in the South. Thus far, Canada has taken the lead in biological control attempts, with the northern United States a distant second. *Palexorista inconspicua* (Meigen) from Europe [not to be confused with *P. bohémica*] was released in Canada in 1934-1942, and in NC, VA, and some northern states in 1972-1973, but is not known to be established; its release farther south might lead to establishment.

Neodiprion merkei Ross

slash pine sawfly

Diprionidae

Native: FL, GA, MS and Bahamas.

Resident natural enemies: **Bombyliidae:** *Villa sinuosa* (Wiedemann) — AR, FL, NC, VA and North. **Tachinidae:** *Spathimeigenia spinigera* Townsend — AL, AR, FL, TX, VA and North; *Spathimeigenia* sp. — FL. **Ichneumonidae:** *Endasys subclavatus* (Say) — AR, FL, VA and North and West.

Biological control attempts: None known.

Biological control possibilities: See comments under *Diprion similis* and *Neodiprion lecontei*.

Neodiprion pratti (Dyar) ssp. *pratti* (Dyar) sand pine sawfly or Virginia pine sawfly
Diprionidae

Native: KY, NC, VA and North.

Resident natural enemies: **Bombyliidae:** *Villa sinuosa* (Wiedemann) — AR, FL, NC, VA and North. **Tachinidae:** *Diplostichus lophyri* (Townsend) — AR, FL, VA and North; *Palexorista bohemica* (Mesnil) (variously listed in publications of the 1930s as *Drino bohemica*, and by error as *Drino* (= *Palexorista*) *inconspicua* (Meigen) and *Sturmia inconspicua*) — released in 1943-1951 in eastern Canada against European spruce sawfly, and established, but not in South? **Ichneumonidae:** *Agrothereutes lophyri* (Norton) — AL, FL, VA and North; *Endasys subclavatus* (Say) — AR, FL, VA and North and West; *Exenterus canadensis* Provancher — AR, FL, LA, VA and North; *E. nigrifrons* Rohwer — FL, TX and North; *Mastrus aciculatus* (Provancher) (= *M. argeae*) — AR, VA and North and West. **Pteromalidae:** *Perilampus hyalinus* Say — AL, FL and North and West, also acts as a hyperparasitoid by attacking several dipterous and hymenopterous parasitoids; *Tritneptis diprionis* Gahan — not in South. **Eulophidae:** *Dahlbominus fuscipennis* (Zetterstedt) — NC, VA and North, introduced into North America from Europe as a biological control agent for *Gilpinia hercyniae* in 1933 and established in the North, then introduced into NC as a biological control agent for *Diprion similis* and spread to VA by 1959, but in 1959-1961, 953,000 reared individuals were released there without important effect (Morris et. al 1963). **Formicidae:** *Aphaenogaster rudis* Emery — FL, NC, VA and North; *Crematogaster lineolata* (Say) — FL, TX, VA and North; *Tapinoma sessile* (Say) — FL, VA and North and West. *Exenterus nigrifrons* (stated erroneously to be *E. canadensis*), *Agrothereutes lophyri* and *Dahlbominus fuscipennis* showed inverse density dependency by killing a greater percentage of hosts as the host population declined from 1962-1964 (Bobb 1965): they are thus more efficient at low host population densities.

Biological control attempts: None known.

Biological control possibilities: As with *Neodiprion lecontei* there are possibilities for development of a nuclear polyhedrosis virus as a bioinsecticide (McIntyre and Dutky 1961). Again, however, production and marketing of the insecticide are very unlikely to be justifiable economically due to the small market. See also comments under *Diprion similis* and *Neodiprion lecontei*.

Neodiprion taedae Ross ssp. *linearis* Ross
Diprionidae

loblolly pine sawfly

Native: AR, LA, SC, TX and North.

Resident natural enemies: **Bombyliidae:** *Villa catulina* (Coquillett) (= *Anthrax catulina*) — AR accounted for 36% mortality of cocooned larvae in 1948; *Villa sinuosa* (Wiedemann) — AR, FL, NC, VA and North. **Tachinidae:** *Diplostichus lophyri* (Townsend) (= *Phorocera hamata*) — AR, FL, VA and North; *Spathimeigenia spinigera* Townsend — AL, AR, FL, TX, VA and North.

Ichneumonidae: *Endasys subclavatus* (Say) — AR, FL, VA and North and West; *Spathimeigenia* sp. — AR; *Exenterus canadensis* Provancher — AR, FL, LA, VA and North; *Exenterus nigrifrons* Rohwer — FL, TX and North; *Lamachus contortionis* Davis — AR, FL and North; *Mastrus aciculatus* (Provancher) (= *M. argeae*) — AR, VA and North and West.

Biological control attempts: None known.

Biological control possibilities: See comments under *Diprion similis* and *Neodiprion lecontei*.

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Neodiprion warreni Ross

a sawfly

Diprionidae

Native: AR, FL, LA.

Resident natural enemies: Apparently none reported.

Biological control attempts: None known.

Biological control possibilities: See comments under *Diprion similis* and *Neodiprion lecontei*.

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Oceanaspidiotus araucariae (Adachi and Fullaway) syn. *Octaspidiotus araucariae* a scale
Diaspididae

Adventive: FL, PR.

Resident natural enemies: None reported.

Biological control attempts: None known.

Biological control possibilities: This species is believed native to the southwestern Pacific where natural enemies should be sought as potential biological control agents.

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Odontopus calceatus (Say)

yellow poplar weevil

Curculionidae

Native: AL, FL, GA, KY, LA, MS, NC, SC, TN, VA, WV.

Resident natural enemies: **Ichneumonidae:** *Scambus hispae* (Harris) — AL, GA, KY, VA and North and West, acts also as a hyperparasitoid attacking *Hyposoter fugitivus*. **Pteromalidae:** *Catolaccus hunteri* Crawford — AL, AR, GA, KY, MS, NC, SC, TX, VA; *Habrocytus piercei* Crawford — KY, LA, TX, WV. **Eulophidae:** *Baryscapus prionomeri* (Girault) (= *Syntomosphyrum prionomeri*) — LA, TN; *Horismenus fraternus* (Fitch) — FL, KY and North; *Zagrammosoma multilineatum* (Ashmead) — FL, KY, LA, SC, WV. Parasitoids have destroyed up to 50% of the pupae in certain areas of KY (Burns and Gibson 1968).

Biological control attempts: None known.

Biological control possibilities: *O. calceatus* is the only North American representative of this neotropical genus (12 other species occur from Mexico to Panama), and it is in the neotropics that natural enemies should be sought as potential biological control agents of *O. calceatus*.

Oracella acuta (Lobdell)

loblolly mealybug

Pseudococcidae

Native: FL, GA, LA, MS, NC, SC, TX, VA.

Resident natural enemies: **Cecidomyiidae:** *Coccidomyia* sp. — GA; *Dicrodiphosis* sp. — GA.

Encyrtidae: *Acerophagus coccois* E. Smith — GA and North. **Signiphoridae:** *Chartocerus* sp. — GA. **Platygastridae:** *Allotropa* sp. — GA (Clarke et al. 1990).

Biological control attempts: None known.

Biological control possibilities: The genus *Oracella* has no other species, so there are no close relatives from which natural enemies might be obtained.

Orgyia leucostigma (J.E. Smith)

white-marked tussock moth

Lymantriidae

Native: FL, TX and eastern United States.

Resident natural enemies: **Tachinidae:** *Bessa selecta* (Meigen) — not in South?; *Carcelia amplexa* (Coquillett) — FL, GA, MS, NC, PR and North; *C. perplexa* Sellers — states not named; *C. yalensis* Sellers — states not named; *Compsilura concinnata* (Meigen) — not in South, introduced from Europe in 1906 as a biological control agent for *Lymantria dispar*; *Drino inconspicua* (Meigen) — not in South?; *Euphorocera claripennis* (Macquart) — AL, FL, KY, LA, MS, NC, SC, OK, TN, TX, VA, WV and North; *E. edwardsii* (Williston) — WV and North; *Exorista lobeliae* Coquillett — FL, VA and North; *E. mella* (Walker) — FL, GA, MS, NC, TX and North; *Leschenaultia* sp. — states not named; *Lespesia aletiae* (Riley) — AL, FL, GA, LA, MS, NC, OK, TN, TX, VA, PR and North; *L. frenchii* (Williston) — MS, NC, TX, WV; *Patelloa leucaniae* (Coquillett) — AR, MS, NC, TN and North; *Phorocera* sp. — not in South?; *Sisyropa* sp. — not in South?; *Winthemia datanae* (Townsend) — FL, GA and North; *W. quadripustulata* (F.) — FL, MS, NC, VA, WV, PR and North. **Braconidae:** *Apanteles acronyctae* (Riley) — not in South; *A. diacrisiae* Gahan — LA, SC and North; *A. delicatus* Howard — not in South; *A. hyphantriae* Riley — United States and Canada and Europe; *Bracon xanthonotus* Ashmead — VA and North and West; *Meteorus autographae* Muesebeck — FL, LA and North; *M. hyphantriae* Riley — United States and Canada; *M. versicolor* (Wesmael) — primarily a parasitoid of brown-tail and satin moths, not in South, introduced from Europe as a biological control agent for *Lymantria dispar*. **Ichneumonidae:** *Agrypon anale* (Say) — AL and North; *Apechthis annulicornis* Cresson (= *Ephialtes annulicornis*) ssp. *componotus* (Davis) — not in South; *Casinaria limenitidis* (Howard) TX and North; *Cratichneumon unifasciatus* (Say) — FL and North; *Gambrus canadensis* Provancher ssp. *burkei* (Viereck) — not in South; *Iseropus coelebs* (Walsh) — FL, TX and North; *I. stercorator* (F.) ssp. *orgyiae* (Ashmead) — not in South; *Itoplectis conquisitor* (Say) — AR, FL, GA, LA, SC, VA and North and West can act as a hyperparasitoid of *Hyposoter fugitivus*, *Phobocampe clisiocampe*, *P. pallipes*, and *Rogas stigmator*;

Orgichneumon calcatorius (Thunberg) — SC, TX and North and Europe; *Phobocampe pallipes* (Provancher) — NC and North and West; *Pimpla maura* Cresson (= *Coccygomimus maurus*) — AL, FL, GA, NC, TX and North; *P. pedalis* Cresson (= *Coccygomimus pedalis*) — VA and North and West; *Scambus nigrifrons* (Viereck) — not in South; *Theronia atalantae* (Poda) ssp. *fulvescens* (Cresson) — AL, VA and North and West, acts also as a hyperparasitoid by attacking *Enicospilus americanus*, *Hyposoter fugitivus* and *Itopectis conquisitor*. **Torymidae:** *Monodontomerus aereus* Walker — not in South, acts also as a hyperparasitoid by attacking *Compsilura concinnata*, *Carcelia laxifrons*, *Blepharipa pratensis*, was introduced to North America in 1906-1910 as a biological control agent for gypsy moth and browntail moth. **Pteromalidae:** *Dibrachys cavus* (Walker) — FL and North and West, is extremely polyphagous and frequently is a hyperparasitoid, and it, in turn has a parasitoid: *Baryscapus coerulescens* (Ashmead) (= *Tetrastichus coerulescens* Ashmead) (Eulophidae); *Habrocytus thyridopterigis* Howard — AR, NC, SC and North; *Psychophagus omnivorus* (Walker) — not in South, a primary and secondary parasitoid which attacks *Compsilura concinnata* and *Itopectis conquisitor*; *Pteromalus coeruleiventris* (Ashmead) — not in South; *Tritneptis hemerocampae* Viereck VA and North and West; **Chalcididae:** *Brachymeria ovata* (Say) (= *Blepharipa ovata*) — throughout the South and northward, is a primary parasitoid of the pupae; *Spilochalcis albifrons* (Walsh) — FL and North and West, also acts as a hyperparasitoid by attacking *Apanteles*, *Bathyleptes*, and *Gelis*. **Eulophidae:** *Aprostocetus esurus* (Riley) (= *Syntomosphyrum esurus*) — GA, TX and North; *Eulophus orgyiae* (Fitch) — MS, NC and North and West; *Tetrastichomyia clisiocampae* (Ashmead) (= *Syntomosphyrum orgyiazele* Burks = *Tetrastichomyia orgyiae* Girault = *Syntomosphyrum orgyiae* Ashmead) — not in South; **Scelionidae:** *Telenomus dalmani* (Ratzeburg) — not in South. Eggs of *Hyposoter* spp. (*H. exiguae* (Viereck), *H. fugitivus*, *H. rivalis*) (Ichneumonidae) are encapsulated and destroyed by *Orgyia leucostigma* haemocytes unless the host contains a larva of *Cotesia* (= *Apanteles*) (Braconidae) as a parasitoid (Guzo and Stoltz 1985). Thus, *Hyposoter* spp. will be unsuccessful in this host unless it contains immature *Cotesia*. This principle may be broader than has been demonstrated.

Biological control attempts: None known.

Biological control possibilities: In England, the genera *Carcelia*, *Eumea*, *Tachina*, and *Zenillia* (Tachinidae) are some of the natural enemies that have been reported as parasitoids of *Orgyia* spp. For some reason, nobody yet seems to have capitalized on this source of potential biological control agents.

Pachylobius picivorus (Germar)

pitch-eating weevil

Curculionidae

Native: AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TX, VA.

Resident natural enemies: **Braconidae:** *Microctonus pachylobii* Muesebeck AR, FL, GA, LA.

Biological control attempts: None known.

Biological control possibilities: The genus *Pachylobius* is closely related to *Hylobius* and to *Rhineilipus* and *Heilipes*, both of which have numerous species in Central and South America, whose natural enemies (seemingly uninvestigated) may provide useful biological control agents for *P. picivorus*. As with *Hylobius pales*, however, removal or treatment of stumps, and chemical treatment of seedlings, can be used to manage populations.

Paleacrita vernata (Peck)

spring cankerworm

Geometridae

Native: NC, SC, TX, VA.

Resident natural enemies: **Braconidae:** *Apanteles paleacritae* Riley — GA and North; *Meteorus hyphantriae* Riley — United States and Canada; *Rogas geometrae* Ashmead — not in South; **Ichneumonidae:** *Hyposoter fuscitarsis* (Viereck) — not in South; *Phobocampe geometrae* (Ashmead) — AL, GA and West.

Biological control attempts: None known using insects. According to Holland (1903 p. 325) the English sparrow was brought to the United States "to effect the destruction" of *P. vernata*. Laycock (1966), however, recounts that bird's importation by the Brooklyn Institute in 1850 without stating any specific purpose, and notes problems that it causes.

Biological control possibilities: The genus has two other North American species. Widely distributed in Eurasia is *Erannis defoliaria* (Clerck) of a closely related genus with larvae that feed on oak and several other trees. Natural enemies of *E. defoliaria* should be worth investigation as potential biological control agents for *P. vernata*. Temporary control on fruit trees and ornamental trees may be obtainable by *Bacillus thuringiensis*.

Paranthrene dollii (Neumoegen)

poplar clearwing borer

Sesiidae

Native: FL, TX and the Southeast.

Resident natural enemies: **Braconidae:** *Apanteles paranthrenidis* Muesebeck — FL, MS, TX and North.

Biological control attempts: None known.

Biological control possibilities: The European species *P. tabaniformis* Rottemburg (= *Sciaapteron tabaniformis*) is an ecological homolog in that it attacks poplars. The fact that it is a rare species in southern England suggests that it may be controlled by natural enemies. At all events, such natural enemies as it has may prove to be useful biological control agents for *P. dollii*.

Paranthrene simulans (Grote)

golden oak borer

Sesiidae

Native: FL, MS, TX and eastern two thirds of the United States.

Resident natural enemies: **Ichneumonidae:** *Ichneumon saucius* Cresson (= *Pterocormus saucius*) NC and North.

Biological control attempts: None known.

Biological control possibilities: The European species *Aegeria vespiformis* (L.) is an ecological homolog, feeding on oak and elm, and its natural enemies may prove useful as biological control agents for *P. simulans*.

Pectinophora gossypiella (Saunders)

pink bollworm

Gelechiidae

Adventive (Asia) ca. 1912 to VI, 1917 to TX, 1920 to PR: AR, FL, GA, LA, OK, SC, TX and southeastern United States, PR, VI.

Resident natural enemies: **Coccinellidae:** *Hippodamia convergens* Guérin-Ménéville - all southern states. **Melyridae:** *Collops vittatus* (Say). **Tachinidae:** *Erynnia tortricis* (Coquillett) — VA, WV and North. **Braconidae:** *Bracon gelechiae* Ashmead — AR, GA, SC and West Indies; *B. mellitor* Say — AR, GA, SC, VA; *B. platynotae* (Cushman) — GA, LA, TX and West; *Chelonus gossypicola* McComb — TX. **Ichneumonidae:** *Calliephialtes ferrugineus* Cushman — FL, PR and Cuba; *Gambrus ultimus* (Cresson) — FL, TX and North and West; **Pteromalidae:** *Dibrachys cavus* (Walker) — FL and North and West, is extremely polyphagous and frequently a hyperparasitoid, and it, in turn has a parasitoid: *Baryscapus coerulescens* (Ashmead) (= *Tetrastichus coerulescens* Ashmead) (Eulophidae). **Bethylidae:** *Parasierola emigrata* (Rohwer) — TX; *Parasierola* sp. nr. *nigrifemur* (Ashmead) — PR; *P. punctaticeps* Kieffer — X and West. Three native species — *Bracon hebetor* Say (Braconidae), *Spilochalcis torvina* (Cresson) (Chalcididae) and *Parasierola nigrifemur* (Ashmead) (Bethylidae) — have adapted to this host in unspecified West Indian islands (Cock 1985).

Biological control attempts: *Apanteles angaleti* Muesebeck, *Bracon brevicornis* Wesmael, *B. greeni* Ashmead, *B. kirkpatricki* (Walker), *B. nigrorufum* (Cushman), *Chelonus blackburni* Cameron, *C. heliopae* Gupta, *C. narayani* Rao, *C. pectinophorae* Cushman (Braconidae), and *Exeristes roborator* F. (Ichneumonidae) are reported from Africa or Asia as parasitoids of this host. All of these parasitoid wasps were released in large numbers in TX, and six (*Apanteles angaleti*, *Bracon kirkpatricki*, *Chelonus blackburni*, *C. heliopae*, *C. narayani*, and *Exeristes roborator*) in FL, four (*Apanteles angaleti*, *Bracon brevicornis*, *Chelonus heliopae*, and *C. narayani*) in NC and SC, three (*Bracon kirkpatricki*, *Chelonus blackburni*, and *Exeristes roborator*) in PR, and at least two (*Apanteles angaleti*, *Chelonus heliopae*) in LA, between the late 1920s and mid 1950s because the host is a pest of cotton as well as of some other Malvaceae. None became established. Several of them as well as other species were released in islands of the Commonwealth Caribbean, also without success (Cock 1985).

Biological control possibilities: Importation of parasitoids for control of *P. gossypiella* has been unsuccessful, but one of the parasitoids occurring naturally in the United States and which has adapted to *P. gossypiella* is *Bracon gelechiae* Ashmead (Braconidae). It was exported to India in 1944-1945 against *Phthorimaea operculella* (Zeller) (Gelechiidae) and became established. As a forestry pest, *P. gossypiella* is more important in PR than the South, and parasitoids known from FL and TX (lists above) and other West Indian islands should be imported to PR for a renewed attempt at classical biological control.

Phyllophaga luctuosa (Horn)

a white grub

Scarabaeidae

Native: AL, FL, GA, LA, MS, NC, OK, SC, TN, VA.

Resident natural enemies: **Tachinidae:** *Sitophaga georgiae* (Brauer and Bergenstamm) (= *Biomyia lachnosternae* Townsend) — GA, FL, MS, SC, VA (Davis 1919). Many other natural enemies are known from other *Phyllophaga* species in the United States, and lack of records for *P. luctuosa* may only be due to lack of sufficient sampling.

Biological control attempts: None known.

Biological control possibilities: Poor, especially because of the existence of rare and endangered species of *Phyllophaga* in the South, which might be attacked by biological control agents. Bioinsecticides are being developed to provide temporary control of *Phyllophaga* species attacking high-value crops. When these pesticides are available commercially, they may be used against species attacking trees if their price is low enough.

Phyllophaga portoricensis Smyth

a white grub

Scarabaeidae

Native: PR; intercepted in plant shipments to FL but not established.

Resident natural enemies: **Elateridae:** *Ignelater luminosus* (Illiger). **Tachinidae:** *Cryptomeigenia aurifacies* Walton — PR; *Eutrixoides jonesii* Walton — PR. **Scoliidae:** *Campsomeris tricineta* F. (= *Dielis pyrura* Rohwer) — PR; *C. trifasciata* F. — PR; *Elis ephippium* F. (= *E. xanthonotus* Rohwer). *Campsomeris trifasciata*, *C. tricineta*, and *Elis ephippium* are parasitoids of larvae of this scarab and of *Cnemarachis vandinei* in PR, but exert little control, which may or may not be due to hyperparasitism by Bombyliidae (Diptera) (Box 1925, Jepson 1934, Wolcott 1950). *Cryptomeigenia aurifacies* and *Eutrixoides jonesii* attack adult scarabs in moister parts of PR, but parasitize only a trivial percentage of them even in favorable environments (Wolcott 1951). Larvae of *Ignelater luminosus* are generalist predators credited with killing many scarab larvae (Wolcott 1950).

Biological control attempts: *Pyrgota undata* (Wiedemann) (Pyrgotidae) a parasitoid of adult *Phyllophaga* in the United States (FL, TX and North), was released in PR before 1920 but did not become established. *Bufo marinus* (L.) (Bufonidae), native to South America, was introduced into PR in the 1920s as a biological control agent for this species and for *Cnemarachis vandinei*. This predatory toad is credited with causing a great reduction in populations of these and other scarabs, and thus in being of great benefit to agriculture, though to its debit it possibly caused extinction of some scarab species (Wolcott 1950). Introduction of this toad into PR, Australia, Hawaii, and elsewhere is now considered a serious error in which the interests of agriculture were placed ahead of the interests of the environment, because the toad's diet is too broad. Although the toad may have greatly reduced populations of pest scarabs in PR, they remain important enough pests to be of concern to forestry.

Biological control possibilities: Highly specific natural enemies are needed for the control of this pest to avoid risk to nontarget scarabs. *P. portoricensis* is native to Puerto Rico, and chances of discovering a natural enemy elsewhere that would attack it and no nontarget species are low. See also comments under *Phyllophaga luctuosa*.

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Phyllophaga prununculina (Burmeister)

a white grub

Scarabaeidae

Native: AL, FL, GA, LA, MS, NC, SC.

Resident natural enemies: Tachinidae: *Sitophaga georgiae* (Brauer and Bergenstamm) (= *Biomyia lachnosternae* Townsend) — GA, FL, MS, SC, VA (Davis 1919).

Biological control attempts: None known.

Biological control possibilities: Poor, especially because of the existence of rare and endangered species of *Phyllophaga* in the South, which might be attacked by biological control agents. See also comments under *Phyllophaga luctuosa*.

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Pissodes nemorensis Germar

eastern pine weevil

Curculionidae

Native: AL, FL, GA, KY, NC, OK, SC, VA, TX, WV and North.

Resident natural enemies: Trogossitidae: *Temnochila virescens* (F.) — FL; **Braconidae:** *Coeloides pissodes* (Ashmead) — FL, GA, TX and North is a major mortality agent in Florida (Atkinson et al. 1988); *Spathius pallidus* Ashmead — GA, TX and North.

Biological control attempts: None known.

Biological control possibilities: Any biological control attempt against *Pissodes strobi* (below) may result in some control of *P. nemorensis* because of their phylogenetic and ecological similarities. Such biological control attempt should target both pests simultaneously, noting that *P. nemorensis* is much more widespread in the South.

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Pissodes strobi (Peck)

white pine weevil

Curculionidae

Native: NC, WV and North and West.

Resident natural enemies: Cleridae: *Phyllobaena verticalis* (Say) (= *Hydnocera verticalis*) — FL, MS, NC, OK, TN, VA and North; *Placopterus thoracicus* Olivier — FL, GA, NC, OK, TX and North. **Lonchaeidae:** *Lonchaea corticis* Taylor — VA and North. **Tachinidae:** *Compsilura concinnata* (Meigen) — not in South, introduced from Europe in 1906 as a biological control

agent for *Lymantria dispar*. **Braconidae**: *Allodorus crassigaster* (Provancher) — not in South; *Bracon pini* (Muesebeck) — VA and North and West; *Coeloides pissodes* (Ashmead) — GA, TX, VA and North; *Spathius brachyurus* Ashmead — NC, TN; **Ichneumonidae**: *Dolichomitus terebrans* (Ratzeburg) — not in South; *Labena grallator* (Say) — FL and North and West; **Pteromalidae**: *Dinotiscus pulchripennis* (Crawford) (= *Rhopalicus pulchripennis*) — GA, MS and North and West; *D. tutela* Walker — not in South, introduced from Europe in mid 1930s; *Rhaphitellus maculatus* Walker — NC and North and West. **Eurytomidae**: *Eurytoma cleri* (Ashmead) — GA, NC, VA, WV and West; *E. conica* Provancher — NC and North and West; *E. pissodis* Girault — VA and North. **Chalcididae**: *Trigonura tarsata* (Dalla Torre) — NC, VA, WV and North. **Eupelmidae**: *Eupelmus pini* Taylor — not in South. Existing natural enemies in the South are helpful in preventing excessively high weevil populations but are incapable of preventing intolerable loss (Drooz 1985).

Biological control attempts: None known.

Biological control possibilities: In eastern North America, the egg-larval guild (represented in the West by *Allodorus crassigaster* and in Europe in other *Pissodes* spp. by *Eubazus semirugosus* (Nees) and *E. robustus* (Ratzeburg) (Braconidae)) is empty (Kenis and Mills 1994); those authors suggest importation of the two *Eubazus* spp. from Europe as potential biological control agents of *P. strobi*.

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Plectrodera scalator (F.)

cottonwood borer

Cerambycidae

Native: AL, AR, FL, GA, KY, LA, MS, SC, TN, TX, MS.

Resident natural enemies: **Sarcophagidae**: *Sarcophaga vericauda* Coquillett, *S. kelleyi* Aldrich.

Biological control attempts: None known.

Biological control possibilities: The genus *Plectrodera* has no other species, but the closely related genus *Monochamus* occurs worldwide in the Northern Hemisphere. Natural enemies of *Monochamus* from Europe or Asia could be investigated as potential biological control agents for *Plectrodera scalator*.

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Prionoxystus robiniae (Peck)

carpenterworm

Cossidae

Native: FL, MS, NC, TX and eastern United States.

Resident natural enemies: **Ichneumonidae**: *Ichneumon devinctus* Say (= *Pterocormus devinctus*) — GA and North. Mortality due to insect parasitoids is inconsequential.

Biological control attempts: None known.

Biological control possibilities: European and Asian parasitoids of the related genus *Cossus*, which has ecological similarity, might prove useful as biological control agents of *Cossula* and *Prionoxystus*.

Prodiplosis morrisi Gagné

a midge

Cecidomyiidae

Native: MS, TX and North.

Resident natural enemies: None known. A related species, *P. longifila* Gagné, which also occurs in Colombia and Peru, caused damage to citrus blossoms in Florida over a period of a few years; its populations were attacked by a parasitoid wasp, *Synopeas* sp. (Platygastridae) (Peña et al. 1990), and declined to the point where use of chemical treatments is no longer recommended (J.E. Peña pers. comm.).

Biological control attempts: None known.

Biological control possibilities: Not much is known about *Prodiplosis* species in other continents, but they are known to exist in Europe, South America, and perhaps elsewhere (Gagné 1986).

Pseudaonidia duplex (Cockerell)

camphor scale

Diaspididae

Adventive (Asia) ca. 1911: AL, FL, GA, LA, MS, TX.

Resident natural enemies: **Coccinellidae:** *Chilocorus stigma* (Say) (= *C. bivulnerus* Mulsant) — all southern states; *Microweisia misella* LeConte — the entire South except peninsular FL and western TX. **Aphelinidae:** *Aphytis cylindratius* Compere — FL (presumably an immigrant species, probably native to eastern Asia); *Aphytis proclia* (Walker) (= *A. fuscipennis* Howard) — cosmopolitan; *Coccophagoides fasciata* (Malenotti) — FL, TX and North; *Encarsia aurantii* (Howard) — cosmopolitan; *E. citrina* (Craw) — cosmopolitan. **Signiphoridae:** *Signiphora flavopalliatia* Ashmead — FL, GA, LA and West, acts as a hyperparasitoid.

Biological control attempts: None known.

Biological control possibilities: *Aphytis cylindratius* Compere and *Encarsia pseudoaonidiae* (Ishii) (Aphelinidae), and *Comperiella unifasciata* Ishii (Encyrtidae) have been reported from *P. duplex* from Japan. *Aphytis longicaudus* Rosen and DeBach was described from Hong Kong, and *P. duplex* was one of its hosts. Shiao (1977) detected four parasitoids from *P. duplex* in Taiwan: *Anabrolepis bifasciata* Ishii and *Thomsonisca* sp. (Encyrtidae), *Aphytis* sp. (Aphelinidae), and *Neochrysocharis* sp. (Eulophidae) as well as a predator, *Pharoscyrmus taoi* Sasaji (Coccinellidae). Specialist parasitoids or predators that do not occur in the South should be considered for importation against *P. duplex*.

Pseudaulacaspis cockerelli (Cooley)

Diaspididae

magnolia white scale
(formerly false oleander scale)**Adventive** (Asia): AL, FL, GA, LA, SC.**Resident natural enemies:** Apparently none reported.**Biological control attempts:** None known.**Biological control possibilities:** The species is common and probably native throughout southern Asia, where natural enemies should be sought for potential biological control.*Pseudaulacaspis pentagona* (Targioni-Tozzetti)

Diaspididae

white peach scale**Native:** AL, FL, GA, LA, MS, NC, SC, TN, TX, VA, WV, PR.**Resident natural enemies:** **Cosmopterigidae:** *Pyroderces rileyi* (Walsingham) — NC.

Chrysopidae: *Chrysopa* sp. **Coccinellidae:** *Chilocorus stigma* (Say) — all southern states; *Rhyzobius lophanthae* (Blaisdell) — all southern states except OK and the northern parts of TX, AR, KY and WV, after introduction from Australia into California in 1892. **Aphelinidae:** *Ablerus clisiocampae* (Ashmead) (= *Centrodorus clisiocampae*) — AL, FL, LA, WV and North; *A. perspicuosus* Girault — not in South; *Aphytis proclia* (Walker) — cosmopolitan; *Coccophagoides kuwanae* (Silvestri) — not in South; *C. murtfeldtia* (Howard) — AR and North; *Encarsia berlesei* (Howard) — FL, LA and North; *E. citrina* (Craw) — cosmopolitan; *E. diaspidicola* (Silvestri) — PR; *Marietta pulchella* (Howard) — cosmopolitan; *Pteroptrix bicolor* (Howard) (= *Archenomus bicolor*) — GA, VA and North. **Signiphoridae:** *Chartocerus pulcher* (Girault) — AR, NC and North; *Signiphora townsendi* Ashmead — TX and North.

Biological control attempts: *Chilocorus kuwanae* Silvestri, from Japan, was introduced into NC in 1983-1984 mainly against *Unaspis euonymi* (Comstock) (Diaspididae). *C. kuwanae* became established but appears less effective against *P. pentagona* than is the native *Chilocorus stigma*, and it has a parasitoid, *Aprostocetus neglectus* (Domenechini) (Nalepa et al. 1993). *Chilocorus cacti* (L.), which is native to FL, TX and Cuba, was imported into PR from Cuba in 1938, and became established, but later its population became undetectable (Wolcott 1960). *Encarsia berlesei* was imported from LA into PR in 1936-1937, but evidence that it became established is lacking (Clausen 1978). *E. berlesei* has been claimed to give good control of the scale in southern Europe but in the United States often is inadequate. Nevertheless, its importation into PR should again be attempted. *Aphytis diaspidis* (Howard) is native to the United States (LA, VA and North) and has been exported to several countries; stock was shipped from Italy to Bermuda in 1921-1924, became established, and was claimed to give good control of *P. pentagona* (Clausen 1978), but the species nevertheless seems unreported from this host in the United State, perhaps due to errors of identification.

Biological control possibilities: Importation of *Encarsia berlesei* into PR should again be attempted. The identity, origin, and distribution of *Aphytis diaspidis* need reexamination before stocks are moved into or from the South or into PR.

Rhyacionia frustrana (Comstock)

Nantucket pine tip moth

Tortricidae

Native: AL, AR, FL, GA, KY, LA, MS, NC, SC, OK, TN, TX, VA, WV, and North, and Cuba and West Indies.

Resident natural enemies: **Tachinidae:** *Lixophaga mediocris* Aldrich — AL, FL, GA, KY, NC, SC, TN, VA and North; *L. plumbea* Aldrich — VA and North. **Braconidae:** *Agathis acrobasis* (Cushman) — AR, FL, GA, LA, MS, SC, TX and North; *A. binominata* Muesebeck — VA; *A. pini* (Muesebeck) — VA and North; *Apanteles bushnelli* Muesebeck — FL, NC and North; *A. petrovae* Walley — SC and North; *Bracon gelechia* Ashmead — AR, GA, SC and West Indies (which, in turn, is attacked by *Baryscapus coerulescens* (Ashmead) (= *Tetrastichus coerulescens* Ashmead (Eulophidae))); *B. gemmaecola* (Cushman) — AR, FL, GA, MS, NC, SC, TX, VA and North and West; *B. mellitor* Say — AR, GA, SC, VA; *B. rhyacioniae* (Muesebeck) — not in South, a dubious record; *Chelonus petrovae* McComb — not in South; *Macrocentrus ancylivorus* Rohwer — AR, FL, GA, SC; *Microgaster epagoges* Gahan — SC and North; *Pauesia gillettei* (Gahan) — SC; *Phanerotoma rhyacioniae* Cushman — AR, GA, LA, MS, SC, VA and North. **Ichneumonidae:** *Campoplex frustranae* Cushman — AL, AR, GA, MS, NC, SC, and North; *Enytus obliteratus* (Cresson) — FL and North, a dubious record; *Exeristes comstocki* (Cresson) — FL, GA, SC, VA and North and West; *Glypta rufiscutellaris* Cresson — GA, VA and North and West; *G. varipes* Cresson — not in South; *Itopectis conquisitor* (Say) — AR, FL, GA, LA, SC, VA and North and West can act as a hyperparasitoid of *Hyposoter fugitivus*, *Phobocampe clisiocampe*, *P. pallipes*, and *Rogas stigmator*; *I. evetriae* Viereck — GA and West; *Parania geniculata* (Holmgren) — GA, VA and North and West; *Phaeogenes walshiae* Ashmead — FL, MS and North; *Pimpla hesperus* (Townes) (= *Coccygomimus hesperus*) — not in South; *Pristomerus austrinus* Townes and Townes — GA, TX and North; *Scambus aplopappi* (Ashmead) — not in South; *Scambus hispae* (Harris) — AL, GA, VA and North and West, acts also as a hyperparasitoid attacking *Hyposoter fugitivus*; *Temelucha epagoges* (Cushman) — MS, SC, VA and North; *T. evetriae* (Cushman) — not in South; *T. minor* (Cushman) — LA, TX, VA and North; *T. rhyacioniae* (Cushman) — not in South. **Pteromalidae:** *Habrocytus phycidis* Ashmead — GA, SC and North and West; *H. thyridopterigis* Howard — AR, NC, SC, VA and North (a primary or secondary parasitoid); *Perilampus fulvicornis* (a hyperparasitoid) — AR, GA, SC, TX and North. **Eurytomidae:** *Eurytoma extremitatis* Bugbee — VA; *E. pini* Bugbee — AR, GA, OK, SC, VA and North (a primary or secondary parasitoid). **Chalcididae:** *Brachymeria molestae* Burks — FL, MS, SC, TN and North; *Haltichella rhyacioniae* Gahan — AR, FL, GA, SC, TX, VA and North; *Spilochalcis flavopicta* (Cresson) — AR, FL, GA, SC, VA and North and West, acts also as a hyperparasitoid by attacking *Lixophaga mediocris*; *S. leptis* Burks — AR, SC, VA and North and West, acts also as a hyperparasitoid; **Eupelmidae:** *Eupelmus amicus* Girault — AR, GA, NC, TX, VA and North and West, also acts as a hyperparasitoid by attacking *Hyposoter fugitivus*. *E. cyaniceps* Ashmead — FL, GA, SC, VA and North and West, also acts as a hyperparasitoid by attacking *Hyposoter fugitivus*. **Encyrtidae:** *Copidosoma geniculatum* (Dalman) — VA and North. **Eulophidae:** *Aprostocetus longicarpus* (Girault) (= *Tetrastichus longicarpus*) — not in South; *A. marylandensis* (Girault) (= *Epitetrastichus cuneiformis* = *Epitetrastichus marylandensis*) — FL, GA, LA, MS, VA and North; *A. varicornis* (Girault) (= *Tetrastichus varicornis*) — GA, LA, NC and North; *Elachertus pini* Gahan — VA and North; *Elasmus setosiscutellaris* Crawford — FL, SC, VA and North and West, perhaps a secondary parasitoid; *Euderus argyresthetiae* (Crawford) — FL, SC and North and West; *E. frustrana* (Comstock) — FL and North and West; *E. subopacus* (Gahan) — AR,

LA, VA, WV and North, acts also as a hyperparasitoid by attacking *Bracon variabilis*; *Hyssopus rhyacioniae* Gahan — AR, FL, GA, LA, SC, TX and North; *H. thymus* Girault — FL, SC, VA and North and West; *Paraolinx taedae* Miller — AR, NC; *Sympiesis stigmatipennis* Girault — SC and North and West. **Trichogrammatidae:** *Trichogramma minutum* Riley — AR, GA, VA and North and West. **Bethylidae:** *Goniozus columbianus* Ashmead — VA and North and West; *G. electus* Fouts — LA, SC; *G. longiceps* Kieffer — LA, TX; *G. longinervis* Fouts — not in South. At least 60 species of parasitoids have been recorded, but they are rarely abundant enough to provide satisfactory control in the South (Yates and Beal 1962). A high level of parasitism (64%) of *Rhyacionia* eggs by *Trichogramma minutum* was recorded from GA, but with uncertainty whether the eggs were of *R. frustrana* or *R. rigidana* (Yates 1966).

Biological control attempts: In the 1920s, parasitoids (*Campoplex frustranae*, *Eurytoma pini* and *Haltichella rhyacioniae*) were collected in the East and shipped to Nebraska for control of *Rhyacionia frustrana bushnelli* (Busck). *Campoplex frustranae*, when released in Nebraska in 1925, achieved 80% parasitism of *Rhyacionia frustrana bushnelli* by 1930, but apparently was unable to develop in *R. neomexicana* (Dyar) which populated the same area. This latter species increased its population rapidly about this time, attracting oviposition by the parasitoid although development did not take place in it, thus having a severe deleterious effect on the population of the parasitoid. In 1974, parasitoids were shipped from the South to San Diego, where an outbreak of *R. frustrana*, new to California, was damaging *Pinus radiata* (Monterey pine); releases of *Campoplex frustranae* led to a parasitoid population that increased during 1976-1977 and reduced the pest population and prevented damage (Scriven and Luck 1978).

Parasitoids introduced into Canada in 1928-1958 and into the United States in the 1930s against *Rhyacionia buoliana* (Schiffmüller), an adventive species from Europe, are reviewed by Clausen (1978). Those that became established were *Orgilus obscurator* (Nees) (Braconidae), *Temelucha interruptor* (Gravenhorst) (Ichneumonidae) and *Tetrastichus turionum* (Hartig) (Eulophidae). None of the three produced outstanding control, though *Orgilus obscurator* achieved over 60% parasitism against *R. buoliana* in Quebec. None seems to have adapted to *R. frustrana* or to other native *Rhyacionia* species. *Orgilus obscurator* was also introduced into Argentina, where *R. buoliana* was likewise adventive and troublesome, but this introduction was unsuccessful (Brewer and Naumann 1968).

Biological control possibilities: Eurasian parasitoids of other *Rhyacionia* species are the best potential source of biological control agents. Most European effort has been spent in obtaining knowledge of parasitoids of *R. buoliana* (Schröder 1966), and little into parasitoids of other species. The effort in Japan has for the most part not yet extended beyond generic determinations. The parasitoids introduced into North America and South America against *Rhyacionia* have so far been from Europe and targeted toward *R. buoliana*. There remains much potential to find natural enemies suitable for use against *R. frustrana*, *R. rigidana*, and *R. subtropica*. The world survey of natural enemies of *Rhyacionia* edited by Harman and Kulman (1972) could serve as a basis for future knowledge.

Rhyacionia rigidana (Fernald)

Tortricidae

pitch pine tip moth

Native: AL, AR, FL, GA, KY, LA, MS, NC, SC, TN, TX, VA, WV and North.

Resident natural enemies: **Tachinidae:** *Lixophaga mediocris* Aldrich — AL, FL, GA, KY, NC, SC,

TN, VA and North; *L. variabilis* (Coquillett) — GA, MS, SC, TX, VA and North. **Braconidae:** *Macrocentrus dioryctriae* Muesebeck — AR, FL, MS and North; *M. instabilis* Muesebeck — FL, SC, TX and North. **Ichneumonidae:** *Campoplex frustranae* Cushman — AL, AR, GA, MS, NC, SC and North; *Exeristes comstocki* (Cresson) — FL, GA, SC, VA and North and West; *Trathala retiniae* (Cresson) — VA and North. **Pteromalidae:** *Habrocytus thyridopterigis* Howard — AR, NC, SC, VA and North. **Eurytomidae:** *Eurytoma pini* Bugbee — AR, GA, OK, SC, VA and North; **Chalcididae:** *Haltichella rhyacioniae* Gahan — AR, FL, GA, SC, TX, VA and North. **Eulophidae:** *Hyssopus thymus* Girault — FL, SC, VA and North and West. **Trichogrammatidae:** *Trichogramma minutum* Riley — a high level of parasitism (64%) of *Rhyacionia* eggs by *Trichogramma minutum* was recorded from GA, but with uncertainty whether the eggs were of *R. frustrana* or *R. rigidana* (Yates 1966). The following parasitoids seem to be shared neither with *R. frustrana* nor with *R. subtropica*: *Lixophaga variabilis*, *Microcentrus dioryctriae*, *M. instabilis*, and *Trathala retiniae*.

Biological control attempts: None known.

Biological control possibilities: See comments under *Rhyacionia frustrana*.

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Rhyacionia subtropica Miller

subtropical pine tip moth

Tortricidae

Native: AL, FL, GA, MS, SC, PR and Cuba.

Resident natural enemies: **Braconidae:** *Bracon gemmaecola* (Cushman) — AR, FL, GA, MS, NC, SC, TX, VA and North and West. **Ichneumonidae:** *Temelucha* sp. — FL. **Eulophidae:** *Hyssopus rhyacioniae* Gahan — AR, FL, GA, LA, SC, TX and North. **Eupelmidae:** *Arachnophaga ferruginea* Gahan — FL; **Chalcididae:** *Haltichella rhyacioniae* Gahan — AR, FL, GA, SC, TX, VA and North; *Spilochalcis flavopicta* (Cresson) — AR, FL, GA, SC, VA and North and West, acts also as a hyperparasitoid by attacking *Lixophaga mediacris*. Only *Arachnophaga ferruginea* seems not to be shared with *R. frustrana*.

Biological control attempts: None known.

Biological control possibilities: See comments under *Rhyacionia frustrana*.

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Rhynchophorus cruentatus (F.)

giant palm weevil

Curculionidae

Native: FL, GA, LA, SC, TX, West Indies and South America.

Resident natural enemies: None reported.

Biological control attempts: None known.

Biological control possibilities: *Parabillaea rhynchophori* Blanchard (Tachinidae) is known as a parasitoid of *Rhynchophorus palmarum* (L.) in Bolivia (Candia and Simmonds 1965), and *Paratheresia menezesii* Townsend (Tachinidae) is known from the same species in Bahia, Brazil (Moura et al. 1993). Both should be investigated as potential biological control agents for *R. cruentatus*. In India, a cytoplasmic polyhedrosis virus has been reported from *Rhynchophorus*

ferrugineus F. (Gopinadhan et al. 1990), and it, too, could be a potential classical biological control agent.

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Sannina uroceriformis Walker

persimmon borer

Sesiidae

Native: FL, NC, TX and eastern two-thirds of the United States as far North as New Jersey.

Resident natural enemies: Not reported.

Biological control attempts: None known.

Biological control possibilities: The genus *Sannina* has no other species, and is perhaps most closely related to the genus *Podosesia*. The African species *Podosesia sarodes* Hampson may perhaps have natural enemies that would attack *Sannina uroceriformis* and might have potential as biological control agents.

1

Selenothrips rubrocinctus (Giard)

redbanded thrips

Thripidae

Adventive (Asia): FL, PR.

Resident natural enemies: Eulophidae: *Goetheana shakespearei* Girault — FL, PR

Biological control attempts: *Goetheana shakespearei* Girault was introduced from West Africa to Trinidad in 1935, and subsequently to PR and continental United States. It is established in FL and PR but seems to parasitize only a small percentage of *S. rubrocinctus* (Bennett et al. 1993).

Biological control possibilities: Dennill (1992) found *Orius thripobius* (Hesse) (Anthocoridae) to be a useful predator of *S. rubrocinctus* in South Africa, where it is native, and suggested that it may be useful against the same pest in other parts of the world.

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Sericoceros krugii Cresson syn. *Schizocerina krugii*

a sawfly

Argidae

Native: PR, VI, and Dominican Republic.

Resident natural enemies: Apparently none reported.

Biological control attempts: None known.

Biological control possibilities: Obscure, due to lack of information about natural enemies of this species or of close relatives in the neotropics. The possibility of classical biological control is higher if the species has a wider distribution than reported, or if related species attack the same host plant.

Terastia meticulosalis Guenée

bucare twig borer, Erythrina twig borer

Pyralidae

Native: FL and southeastern United States, PR and West Indies.**Resident natural enemies:** None reported.**Biological control attempts:** None known.**Biological control possibilities:** A search for natural enemies in West Indian islands other than PR might lead to the discovery of natural enemies that could be used as biological control agents in PR and the southern United States. The genus *Terastia* has no other species, so there are no known closely related species with similar habits.*Tetralopha robustella* Zeller

pine webworm

Pyralidae

Native: FL, NC, TX, VA and eastern United States.**Resident natural enemies:** **Tachinidae:** *Eufrontina spectabilis* (Aldrich) — not in South?; *Eusisyropa blanda* (Osten Sacken) — FL, NC, the North, and Cuba. **Braconidae:** *Apanteles epinotiae* Viereck — FL, TX and North; *Hormius vulgaris* Ashmead — AR, FL and North; *Macrocentrus robustus* Muesebeck — FL and North; *Meteorus tetralophae* Muesebeck — FL and North. **Ichneumonidae:** *Campoplex conocola* (Rohwer) — AR, FL, and North and West; *Cryptus albitarsis* (Cresson) — AL, SC, TX and North and West; *Syzeuctus elegans* (Cresson) — FL and North; *Triclistus emarginalus* (Say) — FL and North and West. **Eulophidae:** *Achrysocharella silvia* Girault — not in South; *Horismenus microgaster* (Ashmead) — NC, TX and North, also functions as a hyperparasitoid; *Sympiesis fragariae* Miller — GA, VA, WV and North.**Biological control attempts:** None known.**Biological control possibilities:** *Nemorilla maculosa* Macquart (Tachinidae) is reported from *Tetralopha scabridella* Ragonot in PR (Wolcott 1951); it should be investigated as a possible biological control agent for *T. robustella* in the South.*Tetyra bipunctata* (H.-S.)

shield-backed pine seedbug

Pentatomidae

Native: AL, FL, GA, LA, MS, NC, TN, TX, VA and North, also Mexico (Ebel et al. 1980, Hedlin et al. 1980).**Resident natural enemies:** **Eupelmidae:** *Anastatus reduvii* (Howard) — FL, TX, West Indies and North is a parasitoid of eggs. **Nyssonidae:** *Bicyrtes quadrifasciata* (Say) — uses *T. bipunctata* to provision its nest.

Biological control attempts: None known.

Biological control possibilities: A search for natural enemies of *T. bipunctata* or of *T. antillarum* Kirkaldy or *T. robusta* Uhler in Mexico, where all three species occur, may yield a potential biological control agent.

Thyridopteryx ephemeraeformis (Haworth)

bagworm, evergreen bagworm

Psychidae

Native: AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, TX, VA, WV and North.

Resident natural enemies: **Pyrilidae:** *Dicymolomia julianalis* Walker — AR, FL, TX and North.

Tachinidae: *Archytas aterrimus* (Robineau-Desvoidy) — AL, FL, NC and North, but the host record is questionable; *Drino rhoeo* (Walker) — FL, GA, MS, NC, TX, and North, PR, and Jamaica; *Erynnia tortricis* (Coquillett) — VA, WV and North and West; *Eusisyropa blanda* (Osten Sacken) — FL, NC, and North, and Cuba; *E. virilis* (Aldrich and Webber) — VA, WV and North and West; *Patelloa leucaniae* (Coquillett) — AR, MS, NC, TN and North.

Braconidae: *Iphiaulax manteri* Nettleton — AL, FL, GA, MS. **Ichneumonidae:** *Calliephialtes grapholithae* (Cresson) — FL, TX and North; *Chirotica thyridopteryx* (Riley) — FL and North and West; *Coccygomimus disparis* (Viereck) — introduced to NC, VA and WV and North in 1974-1979 from Asia against *Lymantria dispar* and is established in some states, has been shown also to attack *Thyridopteryx ephemeraeformis* (Schaefer et al. 1989); *Gambrus ultimus* (Cresson) — FL, TX and North and West; *Iseropus stercorator* (F.) ssp. *orgyiae* (Ashmead) — not in South; *Itopectis conquisitor* (Say) — AR, FL, GA, LA, SC, VA and North and West can act as a hyperparasitoid of *Hyposoter fugitivus*, *Phobocampe clisiocampe*, *P. pallipes*, and *Rogas stigmator*, and is most efficient at low host density (Cronin 1989); *Pimpla aequalis* Provancher (= *Coccygomimus aequalis*) — FL, TX and North; *Scambus hispae* (Harris) — AL, GA, VA and North and West, acts also as a hyperparasitoid attacking *Hyposoter fugitivus*. **Torymidae:** *Monodontomerus minor* (Ratzeburg) — VA and North and West, acts also as a hyperparasitoid by attacking *Gambrus extrematis*. **Pteromalidae:** *Dibrachys cavus* (Walker) — FL and North and West, is extremely polyphagous and frequently is a hyperparasitoid, and it, in turn has a parasitoid: *Baryscapus coerulescens* (Ashmead) (= *Tetrastichus coerulescens* Ashmead) (Eulophidae); *Habroclytus thyridopterigis* Howard — AR, NC, SC and North; *Pteromalus puparum* (L.) — FL and North and West, an immigrant from Europe in the 19th century.

Chalcididae: *Brachymeria ovata* (Say) (= *Blepharipa ovata*); *Spilochalcis mariae* (Riley) — FL and North and West; **Encyrtidae:** *Anagyrus thyridopterigis* (Ashmead) — FL and North; this record may be in error, and the host may be a coccid.

Biological control attempts: None known.

Biological control possibilities: Another species of this genus, *T. meadi* H. Edwards, occurs in California and northern Mexico. A search for natural enemies of *T. meadi* may lead to the discovery of natural enemies that could be used as biological control agents of *T. ephemeraeformis*.

Toumeyella liriodendri (Gmelin)

tuliptree scale

Coccidae

Native: AL, FL, GA, KY, MS, NC, SC, TN, VA, WV.**Resident natural enemies:** **Pyralidae:** *Laetilia coccidivora* (Comstock) — FL and North.**Coccinellidae:** *Adalia bipunctata* (L.) — northern AL, AR, northern GA and North and West; *Chilocorus stigma* (Say) — all southern states; *Hyperaspis proba* (Say) — AR, KY, NC, OK, SC, TN, TX, VA, WV and North; *H. signata* Olivier — northwestern FL, all other southern states, and North to the Great Lakes. **Syrphidae:** *Baccha costata* Say — FL, GA, LA and North;**Encyrtidae:** *Anicetus toumeyella* Milliron — VA and North; *Metaphycus flavus* (Howard) — FL, TX and North; **Aphelinidae:** *Coccophagus flavifrons* Howard — FL, TX and North; *C. lycimnia* (Walker) — which in turn has a parasitoid, *Aprostocetus minutus* (Howard) (= *Tetrastichus minutus* (Eulophidae)).**Biological control attempts:** none known.**Biological control possibilities:** Ants tending the scales drive off natural enemies and sometimes cause outbreaks of this scale (Burns 1964, Burns and Donley 1970, Simpson and Lambdin 1983). These outbreaks could largely be prevented at low cost by using poisoned baits to kill ants near the affected trees, or by banding the trees to prevent ants from climbing them. There are 12 described species of *Toumeyella*, of which 9 occur in America north of Mexico and 3 are neotropical. One of these three, *T. cubensis* Heidel and Kohler, is a pest in Cuban citrus groves (Heidel and Kohler 1979). The other two, *T. nectandrae* Hempel and *T. paulista* Hempel (Hempel 1929), are Brazilian. The two Brazilian species may have parasitoids that could be useful as classical biological control agents of *T. liriodendri*. However, the finding by Simpson and Lambdin (1983) that up to 98% of female scales in Tennessee were killed by parasitoids argues against importation of additional parasitoids.*Umbonia crassicornis* (Amyot and Serville)

thorn bug

Membracidae

Native: FL to SC.**Resident natural enemies:** Not reported.**Biological control attempts:** None known.**Biological control possibilities:** *U. crassicornis* is a widely distributed neotropical species that occurs in Mexico, Central America, and South America. Search in one or several of those regions may lead to the discovery of natural enemies that could be imported into the South for use as biological control agents.

Xanthogaleruca luteola (Müller) syn. *Pyrrhalta luteola*

elm leaf beetle

Chrysomelidae

Adventive (Europe) early 1800s: AR, VA and North and transcontinental

Resident natural enemies: **Coccinellidae:** *Coleomegilla maculata* (DeGeer) — eastern OK and TX, GA and northward. **Tachinidae:** *Aplomyiopsis gallerucae* Villeneuve — not in South; *Erynniopsis antennata* Rondani — not in South, introduced from Europe. **Eulophidae:** *Oomyzus brevistigma* (Gahan) (= *Tetrastichus brevistigma*) — KY and North, has been established in California; *Oomyzus gallerucae* (Fonscolombe) — not in South, introduced from Europe.

Biological control attempts: *Lebia scapularis* Dejean (Carabidae) was imported from Europe in 1934 and released in Massachusetts, but did not establish (Clausen 1978). *Erynniopsis antennata* Rondani (= *E. rondanii* Townsend) was imported from Europe into California in 1939 and established; prior and subsequent liberations in the East were unsuccessful; it has a parasitoid, *Baryscapus erynniae* (Domenechini) (= *Tetrastichus erynniae*), which probably arrived from Europe as a contaminant of *Erynniopsis antennata* when the latter was introduced for biological control purposes.

Oomyzus brevistigma (Gahan) is native to the northeastern United States, but was exported to California in 1934, and became established there (Clausen 1978). *Oomyzus gallerucae* (Fonscolombe) (= *Tetrastichus gallerucae*, sometimes misspelled *galerucae*) was imported from Europe into the United States and released in VA and states to the north in 1908, 1911, 1925, and 1932-1935, but was not found to be established until 1982, in Ohio. Material from Ohio and from Europe was shipped to California, and the species is now established in a small area of northern California.

Tetrastichus sp., a parasitoid of *Xanthogaleruca maculicollis* (Motschulsky) in Japan, was imported into California in 1934 and 1936, but did not establish (Clausen 1978).

Biological control possibilities: Apparently no effort has been made to release *Oomyzus gallerucae* in the South (except for VA), and release of this parasitoid may be the most worthwhile first strategy for two reasons. First, this parasitoid has become established in California, though it seems to overwinter poorly there, unlike in France (Dreistadt and Dahlsten 1991). Second, methods for rearing large numbers of *O. gallerucae* have been developed (Clair et al. 1987). A more expensive strategy is to import additional natural enemies from Europe, such as other eulophid wasps listed by Graham (1985). There have been subsequent changes in generic assignment of some of the wasps listed by Graham (1985).

Xylastodoris luteolus Barber

royal palm bug

Thaumastocoridae

Native: FL, Cuba.**Resident natural enemies:** None known.

Biological control attempts: None known.

Biological control possibilities: Natural enemies could be sought in Cuba, which is the major part of the range of this species.

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Xyleborus spp. including (1) *X. affinis* (Eichhoff) **ambrosia beetles**
Scolytidae (2) *X. xylographus* (Say)

Native: (1) AL, FL, GA, LA, MS, NC, SC, TX, VA, WV, PR; (2) AR, FL, GA, NC, SC, VA, WV.

Resident natural enemies: Apparently none reported.

Biological control attempts: None known. Individuals of *Thanasimus formicarius* (Cleridae) were exported from England to Sri Lanka (Ceylon) in 1908 for control of *Xyleborus formicatus* Eichhoff, whose host plant (tea) and climate differ substantially, but did not become established (Clausen 1978).

Biological control possibilities: See comments under *Dendroctonus frontalis* and *Ips calligraphus*.

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Xylosandrus compactus (Eichhoff) **black twig borer**
Scolytidae

Adventive (Asia) ca. 1941: AL, FL, GA, LA, MS, TX, PR, Cuba.

Resident natural enemies: Apparently not reported.

Biological control attempts: None known.

Biological control possibilities: The best approach is a search for specific natural enemies in the native (Asian) range of this species. See also comments under *Dendroctonus frontalis* and *Ips calligraphus*.

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Xylosandrus crassiusculus (Motschulsky) syn. *Xyleborus crassiusculus* **a twig borer**
Scolytidae

Adventive (Asia) ca. 1983: FL, NC, SC, TX.

Resident natural enemies: Apparently none reported.

Biological control attempts: None known.

Biological control possibilities: The best approach is to search for specific natural enemies in the native (Asian) range of this species. See also comments under *Dendroctonus frontalis* and *Ips calligraphus*.

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Index of vernacular names of pest insects

The Latin name at right is the name under which information is arranged in the main body of this paper, where arrangement of names of genera is alphabetical.

A

ambrosia beetles = *Xyleborus* spp.
Apopka weevil = *Diaprepes abbreviatus*
appletree borer, flatheaded = *Chrysobothris femorata*
Australian pine borer = *Chrysobothris tranquebarica*



B

bagworm = *Thyridopteryx ephemeraeformis*
bagworm, evergreen = *Thyridopteryx ephemeraeformis*
baldcypress coneworm = *Dioryctria pygmaeella*
balsam woolly adelgid = *Adelges piceae*
banded hickory borer = *Knulliana cincta*
black turpentine beetle = *Dendroctonus terebrans*
black twig borer = *Xylosandrus compactus*
blackheaded pine sawfly = *Neodiprion excitans*
blister coneworm = *Dioryctria clarioralis*
borer, Australian pine = *Chrysobothris tranquebarica*
borer, banded hickory = *Knulliana cincta*
borer, bucare twig = *Terastia meticulosalis*
borer, cottonwood = *Plectrodera scalator*
borer, flatheaded appletree = *Chrysobothris femorata*
borer, golden oak = *Paranthrene simulans*
borer, hickory spiral = *Agrilus arcuatus torquatus*
borer, mahogany shoot = *Hypsipyla grandella*
borer, persimmon = *Sannina uroceriformis*
borer, poplar clearwing = *Paranthrene dollii*
borer, seagrape = *Hexeris enhydris*
borer weevil, West Indian sugarcane rootstock = *Diaprepes abbreviatus*
bucare twig borer = *Terastia meticulosalis*
buck moth = *Hemileuca maia*



C

caculo taladrador, el = *Apate monacha*
camphor scale = *Pseudaonidia duplex*
cane weevil = *Metamasius hemipterus*
cankerworm, fall = *Alsophila pometaria*
cankerworm, spring = *Paleacrita vernata*
carpenterworm = *Prionoxystus robiniae*
carpenterworm, pecan = *Cossula magnifica*
casebearer, pecan cigar = *Coleophora laticornella*



cicada, periodical = *Magicicada septendecim*
citrus whitefly = *Dialeurodes citri*
coconut scale = *Aspidiotus destructor*
Columbian timber beetle = *Corthylus columbianus*
coneworm, baldcypress = *Dioryctria pygmaeella*
coneworm, blister = *Dioryctria clarioralis*
coneworm, loblolly pine = *Dioryctria merkei*
coneworm, mountain pine = *Dioryctria yatesi*
coneworm, southern coastal = *Dioryctria ebeli*
coneworm, southern pine = *Dioryctria amatella*
cottonwood borer = *Plectrodera scalator*

E

eastern fivespined ips = *Ips grandicollis*
eastern pine weevil = *Pissodes nemorensis*
eastern tent caterpillar = *Malacosoma americanum*
el caculo taladrador = *Apate monacha*
elm leaf beetle = *Xanthogaleruca luteola* (= *Pyrrhalta luteola*)
elm leaf beetle, larger = *Monocesta coryli*
elm spanworm = *Ennomos subsignarius*
eriococcin, Gillette = *Eriokermes gillettei*
Erythrina twig borer = *Terastia meticulosalis*
evergreen bagworm = *Thyridopteryx ephemeraeformis*

F

fall cankerworm = *Alsophila pometaria*
fall webworm = *Hyphantria cunea*
flatheaded appletree borer = *Chrysobothris femorata*
Florida red scale = *Chrysomphalus aonidum*
forest tent caterpillar = *Malacosoma disstria*
fruittree leafroller = *Archips argyrospila*

G

giant palm weevil = *Rhynchophorus cruentatus*
Gillette eriococcin = *Eriokermes gillettei* (= *Eriococcus gillettei*)
golden oak borer = *Paranthrene simulans*
gypsy moth = *Lymantria dispar*

H

hemlock woolly adelgid = *Adelges tsugae*
hickory borer, banded = *Knolliana cincta*
hickory spiral borer = *Agrilus arcuatus torquatus*
hormiguilla = *Myrmelachista ambigua ramulorum*

I

introduced pine sawfly = *Diprion similis*
ips, eastern fivespined = *Ips grandicollis*
ips, sixspined = *Ips calligraphus*

L

la plumilla = *Megalopyge krugii*
 la vaquita = *Diaprepes abbreviatus*
 lace bug, oak = *Corythucha arcuata*
 lace bug, sycamore = *Corythucha ciliata*
 larger elm leaf beetle = *Monocesta coryli*
 leaf beetle, elm = *Xanthogaleruca luteola*
 leaf beetle, larger elm = *Monocesta coryli*
 leafcutting ant, Texas = *Atta texana*
 leaffooted pine seedbug = *Leptoglossus corculus*
 leafroller, fruittree = *Archips argyrospila*
 loblolly mealybug = *Oracella acuta*
 loblolly pine coneworm = *Dioryctria merkei*
 loblolly pine sawfly = *Neodiprion taedae linearis*
 longleaf pine seedworm = *Cydia ingens* (= *Laspeyresia ingens*)

M

magnolia white scale = *Pseudaulacaspis cockerelli*
 mahogany notcher = *Copturus floridanus*
 mahogany shoot borer = *Hypsipyla grandella*
 mealybug = *Dysmicoccus morrisoni*
 mealybug, loblolly = *Oracella acuta*
 midge = *Prodiptosis morrisoni*
 mimosa webworm = *Homadaula anisocentra*
 mountain pine coneworm = *Dioryctria yatesi*

N

Nantucket pine tip moth = *Rhyacionia frustrana*
 notcher, mahogany = *Copturus floridanus*

O

oak borer, golden = *Paranthrene simulans*
 oak lace bug = *Corythucha arcuata*
 oak skeletonizer = *Bucculatrix ainsliella*
 oakleaf caterpillar, variable = *Lochmaeus manteo*
 oakworm, pinkstriped = *Anisota virginensis*

P

pales weevil = *Hylobius pales*
 palm leaf skeletonizer = *Homaledra sabalella*
 palm weevil, giant = *Rhynchophorus cruentatus*
 pecan carpenterworm = *Cossula magnifica*
 pecan cigar casebearer = *Coleophora laticornella*
 pecan weevil = *Curculio caryae*
 periodical cicada = *Magicicada septendecim*
 persimmon borer = *Sannina uroceriformis*

pin oak sawfly = *Caliroa liturata* (= *Caliroa lineata*)
 pine aphid, white = *Cinara strobi*
 pine beetle, southern = *Dendroctonus frontalis*
 pine borer, Australian = *Chrysobothris tranquebarica*
 pine cone beetle, white = *Conophthorus coniperda*
 pine engraver, small southern = *Ips avulsus*
 pine engraver, southern = *Ips grandicollis*
 pine root weevil, southern = *Hylobius aliradicis*
 pine sawfly, blackheaded = *Neodiprion excitans*
 pine sawfly, introduced = *Diprion similis*
 pine sawfly, loblolly = *Neodiprion taedae linearis*
 pine sawfly, redheaded = *Neodiprion lecontei*
 pine sawfly, sand = *Neodiprion pratti pratti*
 pine sawfly, slash = *Neodiprion merkei*
 pine sawfly, Virginia = *Neodiprion pratti pratti*
 pine seedbug, leaffooted = *Leptoglossus corculus*
 pine seedbug, shield-backed = *Tetyra bipunctata*
 pine seedworm, longleaf = *Cydia ingens*
 pine spittlebug = *Aphrophora parallela*
 pine tip moth, Nantucket = *Rhyacionia frustrana*
 pine tip moth, pitch = *Rhyacionia rigidana*
 pine tip moth, subtropical = *Rhyacionia subtropica*
 pine webworm = *Tetralopha robustella*
 pine weevil, eastern = *Pissodes nemorensis*
 pine weevil, white = *Pissodes strobi*
 pink bollworm = *Pectinophora gossypiella*
 pinkstriped oakworm = *Anisota virginiensis*
 pitch-eating weevil = *Pachylobius piciporus*
 pitch pine tip moth = *Rhyacionia rigidana*
 plumilla, la = *Megalopyge krugii*
 poplar clearwing borer = *Paranthrene dollii*
 poplar tentmaker = *Closteria inclusa*
 poplar weevil, yellow = *Odontopus calceatus*
 puss caterpillar = *Megalopyge opercularis*

R

redbanded thrips = *Selenothrips rubrocinctus*
 redheaded pine sawfly = *Neodiprion lecontei*
 royalpalm bug = *Xylastodoris luteolus*

S

sand pine sawfly = *Neodiprion pratti pratti*
 sawfly = *Neodiprion warreni*
 sawfly = *Sericoceros krugii* (= *Schizocerina krugii*)
 sawfly, blackheaded pine = *Neodiprion excitans*
 sawfly, introduced pine = *Diprion similis*
 sawfly, loblolly pine = *Neodiprion taedae linearis*
 sawfly, pin oak = *Caliroa liturata*

sawfly, redheaded pine = *Neodiprion lecontei*
 sawfly, sand pine = *Neodiprion pratti pratti*
 sawfly, slash pine = *Neodiprion merkei*
 sawfly, Virginia pine = *Neodiprion pratti pratti*
 scale = *Aulacaspis yasumatsui*
 scale = *Oceanaspidiotus araucariae* (= *Octaspidiotus araucariae*)
 scale, camphor = *Pseudaonidia duplex*
 scale, coconut = *Aspidiotus destructor*
 scale, Florida red = *Chrysomphalus aonidum*
 scale, magnolia white = *Pseudaulacaspis cockerelli*
 scale, tessellated = *Eucalymnatus tessellatus*
 scale, tuliptree = *Toumeyella liriodendri*
 scale, white peach = *Pseudaulacaspis pentagona*
 seagrape borer = *Hexeris enhydris*
 shield-backed pine seedbug = *Tetyra bipunctata*
 shoot borer, mahogany = *Hypsipyla grandella*
 six-spined engraver = *Ips calligraphus*
 sixspined ips = *Ips calligraphus*
 skeletonizer, oak = *Bucculatrix ainsliella*
 skeletonizer, palm leaf = *Homaledra sabalella*
 slash pine flower thrips = *Gnophothrips fuscus*
 slash pine sawfly = *Neodiprion merkei*
 small southern pine engraver = *Ips avulsus*
 southern coastal coneworm = *Dioryctria ebeli*
 southern pine beetle = *Dendroctonus frontalis*
 southern pine coneworm = *Dioryctria amatella*
 southern pine engraver = *Ips grandicollis*
 southern pine engraver, small = *Ips avulsus*
 southern pine root weevil = *Hylobius aliradicis*
 spanworm, elm = *Ennomos subsignarius*
 spiral borer, hickory = *Agrilus arcuatus torquatus*
 spittlebug, pine = *Aphrophora parallela*
 spring cankerworm = *Paleacrita vernata*
 sugarcane rootstock borer weevil, West Indian = *Diaprepes abbreviatus*
 subtropical pine tip moth = *Rhyacionia subtropica*
 sycamore lace bug = *Corythucha ciliata*

T



tent caterpillar, eastern = *Malacosoma americanum*
 tent caterpillar, forest = *Malacosoma disstria*
 tentmaker, poplar = *Clostera inclusa*
 tessellated scale = *Eucalymnatus tessellatus*
 Texas leafcutting ant = *Atta texana*
 thorn bug = *Umbonia crassicornis*
 thrips, redbanded = *Selenothrips rubrocinctus*
 thrips, slash pine flower = *Gnophothrips fuscus*
 timber beetle, Columbian = *Corthylus columbianus*
 tuliptree scale = *Toumeyella liriodendri*

turpentine beetle, black = *Dendroctonus terebrans*
tussock moth, white-marked = *Orgyia leucostigma*
twig borer = *Xylosandrus crassiusculus* (= *Xyleborus crassiusculus*)
twig borer, black = *Xylosandrus compactus*
twig borer, bucare = *Terastia meticulosalis*
twig borer, Erythrina = *Terastia meticulosalis*

V

vaquita, la = *Diaprepes abbreviatus*
variable oakleaf caterpillar = *Lochmaeus manteo* (= *Heterocampa manteo*)
Virginia pine sawfly = *Neodiprion pratti pratti*

W

walkingstick = *Diapheromera femorata*
walnut caterpillar = *Datana integerrima*
webworm, fall = *Hyphantria cunea*
webworm, mimosa = *Homadaula anisocentra*
webworm, pine = *Tetralopha robustella*
weevil = *Compsus maricao*
weevil, Apopka = *Diaprepes abbreviatus*
weevil, cane = *Metamasius hemipterus*
weevil, eastern pine = *Pissodes nemorensis*
weevil, giant palm = *Rhynchophorus cruentatus*
weevil, pales = *Hylobius pales*
weevil, pecan = *Curculio caryae*
weevil, pitch-eating = *Pachylobius picivorus*
weevil, southern pine root = *Hylobius aliradicis*
weevil, West Indian sugarcane rootstock borer = *Diaprepes abbreviatus*
weevil, white pine = *Pissodes strobi*
weevil, yellow poplar = *Odontopus calceatus*
West Indian sugarcane rootstock borer weevil = *Diaprepes abbreviatus*
white grub = *Cnemarachis vandinei*
white grub = *Phyllophaga luctuosa*
white grub = *Phyllophaga portoricensis*
white grub = *Phyllophaga prununculina*
white-marked tussock moth = *Orgyia leucostigma*
white peach scale = *Pseudauleacaspis pentagona*
white pine aphid = *Cinara strobi*
white pine cone beetle = *Conophthorus coniperda*
white pine weevil = *Pissodes strobi*
whitefly, citrus = *Dialeurodes citri*
whitefringed beetles = *Graphognathus* spp.
woolly adelgid, balsam = *Adelges piceae*
woolly adelgid, hemlock = *Adelges tsugae*

Y

yellow poplar weevil = *Odontopus calceatus*