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SURVEY FOR POTENTIAL INSECT BIOLOGICAL CONTROL AGENTS OF *LIGUSTRUM SINENSE* (SCROPHULARIALES: OLEACEAE) IN CHINA

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ABSTRACT

A systematic survey of Chinese privet foliage, stems, seeds, and roots for associated phytophagous insects was conducted in China during 2005 and 2006 in order to establish basic information about the insect communities that Chinese privet harbors and to evaluate the abundance and damage caused by these insects. A total of 170 phytophagous insect species in 48 families and 5 orders were collected from Chinese privet in China. The insects belong to 4 feeding guilds: foliage, sap, stem, and root feeders. The impact of foliage feeders varied by site and over time. The mean percent defoliation of Chinese privet over all sites and years was 20.5 ± 8.2%, but ranged as high as 48%.

Key Words: Chinese privet, biological control, invasive species, exotic species

RESUMEN

Se realizo un sondeo sistemático de los insectos fitófagos asociados con el follaje, ramas, semillas y raíces de Cabo chino *Ligustrum sinense* en China durante 2005 y 2006 para establecer información básica sobre las comunidades de insectos que usan *L. sinense* como un refugio y a la vez para evaluar la abundancia y daño causado por estos mismos. Un total de 170 especies de insectos consumidores en 48 familias y 5 órdenes fueron recolectada de *L. sinense* en China, que pertenecen a 4 grupos de consumidores: los que se alimentan sobre el follaje, savia, tallo y raíces. El impacto de los consumidores de follaje varía según el sitio y la época. El promedio del porcentaje de defoliación de *L. sinense* en todos los sitios y años estudiados fue de 20.5 ± 8.2%, pero se observo rangos altos hasta de un 48%.

Chinese privet, *Ligustrum sinense* Lour., is an invasive exotic weed in the United States where it is a perennial, semi-evergreen shrub or small tree that grows to 10 m in height. This species is of great concern in the southeastern United States (Faulkner et al. 1989; Stone 1997), but it ranges from Texas to Florida, and as far north as the New England states (The Nature Conservancy 2004; University of Connecticut 2004). In addition, it has been introduced into Puerto Rico and Oregon (USDA-NRCS 2002).

Chinese privet is native to China, Vietnam, and Laos (The Nature Conservancy 2004; Wu & Raven 2003). In China it is found in the provinces south of the Yangzi River (Qui et al. 1992). It can be found between 200 and 2600 m in elevation where it occurs in mixed forests, valleys, along streams, thickets, woods, and ravines (Wu & Raven 2003; Qui et al. 1992).

Ligustrum sinense has been studied in China for its chemical composition and the medicinal value of its bark and leaves (Ouyang & Zhou 2003; Ouyang 2003). It has never been recorded as a noxious weed in either agricultural or forest settings. Chinese privet is grown nationwide as an ornamental hedge plant, for its berries used in brewing, and for oils extracted from seeds and used in soap making (Qui et al. 1992).

Chinese privet was introduced into the United States in 1852 (Coates 1965; Dirr 1990) as an ornamental shrub, for hedgerows (USDA-NRCS 2002), and sometimes as single specimens for its foliage and profusion of small white flowers (Dirr 1990; Wyman 1973). It is a forage plant for deer in the southeastern U.S. (Stromayer et al. 1998a; Stromayer et al. 1998b; The Nature Conservancy 2004). According to Small (1933), the species was escaping from cultivation in southern Louisiana by the 1930s. A survey of appropriate herbaria reveals collection records from Georgia as early as 1900. Based on herbarium records the species became naturalized and widespread in the southeast and eastern U.S. during the 1950s, 60s, and 70s (USDA-NRCS 2002).

Chinese privet is widely believed to drastically reduce native plant biodiversity because of its ability to shade out native vegetations (USDI Fish and Wildlife Service 1992; Merriam & Feil 2002) and form dense, monospecific stands that dominate the forest understory (Dirr 1990). Recent surveys in the southeastern United States show Chinese privet completely covers 0.9 million acres and colonies of varying densities can be found on another 17.6 million acres (Rudis et al. 2006). In 1998, the U.S. Department of Agriculture listed privet as one of 14 species with the potential to adversely affect management objectives in North Carolina's National Forests. Similarly, the Florida Exotic Pest Plant Council lists Chinese privet as a Category 1 invasive species (FLEPPC 2007). More recently, The Nature Conservancy ranked Chinese privet as having high potential to disrupt the ecological balance (NatureServe 2006).

In addition to privet's impact on natural landscapes, it can be directly harmful to humans. The flower of Chinese privet is toxic to humans causing symptoms such as nausea, headache, abdominal pain, vomiting, diarrhea, weakness, and low blood pressure and body temperature (USDA-NRCS 2002). Where Chinese privet occurs in abundance, floral odors may cause respiratory irritation (Westbrooks & Preacher 1986).

Repeated mowing and cutting will control the spread of *L. sinense*, but may not eradicate it (Tennessee Exotic Pest Plants Council 1996). Although modern herbicides, including glyphosate, effectively kill privet (Tennessee Exotic Pest Plants Council 1996; The Nature Conservancy 2004; Madden & Swarbrick 1990; Harrington & Miller 2005), environmental concerns will limit use of herbicides on public land or in sensitive areas. Faulkner et al. (1989) reported that in experimental trials of prescribed burning, there was no significant difference in the abundance of *Ligustrum sinense* in burned vs. unburned plots.

Plants unimportant in their native habitat may reach damaging levels when released from control by important natural enemies through introduction into new geographic areas (Van Driesche & Bellows 1996). This suggests that exploration for Chinese privet natural enemies in China might detect species suitable for use in a classical biological control program in the U.S. Chinese privet is considered a good candidate for classical biological control because it has no known biological control agents capable of lowering its pest status in North America (The Nature Conservancy 2004), and no native *Ligustrum* spp. occur there. Johnson & Lyon (1991) list at least 27 species of insects or mites that feed on *Ligustrum* spp. in the United States, however, none suppress populations of this plant in forests. In contrast, based on published records, China appears to have a rich complex of natural enemies that attack *Ligustrum* spp. (Zheng et al. 2004) and the potential for finding a biological control agent is high. However, little is known about their relative abundance and impact on their host plant. Therefore, a cooperative program was initiated in 2005 to survey for natural enemies of Chinese privet in China, with the goal of finding potential biocontrol agents. Here we report results of systematic surveys conducted in 2005 and 2006, and provide a list of the phytophagous insects found. We provide basic information about the insect community on Chinese privet in China and identify species that may have potential as biological control agents in the US. Preliminary information on impacts of different feeding guilds on Chinese privet in China is also reported.

Materials and Methods

Survey Sites

Our surveys focused primarily on 6 sites in Huangshan city (118.16, 29.43, elevation approximately 200m) in Anhui Province, China, because the climate-matching program Climex (Hearne Scientific Software, Melbourne, Australia) indicated that this was the province most similar in climate to the southeastern United States (Sun et al. 2006). The seventh site was established in Guiyang (Huaxi, 106.40, 26.25, elevation approximately 1096 m), Guizhou Province, which is another area where Chinese privet is prevalent in China, but it is much further south and warmer than the Anhui sites.

In order to collect the most natural enemies of privet, our survey sites were selected to include habitats varying from natural areas to semi-natural and planted sites. These were as follows:

(1) Pure natural sites included 1 site in Lingnan adjacent to the Jiulong Natural resource conservation area in Xiuning County in the most southern region of Anhui Province; a second site on an unnamed island in the suburb of Huangshan city; and a third site in Guiyang. Chinese privet in these 3 sites grew naturally mixed with many other plant species and most grew relatively tall (over 3 m).

(2) Semi-natural sites included 1 site in Zhanchuan, a small town south of Huangshan city, and a second site at the Institute of Forestry (IOF) located in the north of Huangshan city. Chinese privet plants in these sites grew semi-naturally but were near agricultural lands where they were more likely to be disturbed by local residents.

(3) Planted sites included 1 site in She County east of Huangshan city. The other site was in the center of Huangshan city. Chinese privets in these sites were abundant and planted as ornamental shrubs along roads. All plants were small periodically pruned shrubs less than 1.5 m tall.

Systematic Sampling

At each site, 10 Chinese privet plants were randomly selected for sampling, marked with stakes and surrounded by a circle of colored tape and a sign to prevent human disturbance and for ease of relocation. Privet plants in Zhanchuan, IOF and She county in Anhui Province were surveyed from May to Aug, 2005 and from Apr to Oct, 2006. Privet on the island near Huangshan city was sample from Jun to Aug 2005 when sampling was discontinued because it was cleared for development. Privet in Lingnan, Huangshan city, and Guiyang were surveyed for 1 year from Apr to Sep 2006. At all sites, surveys were conducted at 10-day intervals during the survey periods. Collection of insects feeding on Chinese privet was accomplished by hand-picking, aspirating, and sweep-netting each sample plant 30 times. In some cases, cages were placed over branches to capture insects as they emerged. When immature insects were found, they were collected in a plastic bag together with the plant part on which they were feeding and returned to our lab to be reared to the adult stage to confirm the species.

Most insect species were identified by Professor Yang Chuncai (Anhui Agricultural University). Some Chrysomelidae were identified by Professor Wang Shuyong (Institute of Zoology, Chinese Academy of Sciences [CAS]), some Lepidoptera larvae were identified by Professor Wang Linyao (Institute of Zoology, CAS), and some Homoptera were identified by Professor Liang Aiping (Institute of Zoology, CAS). *Pseudaulacaspis pentagona* (Targioni-Tozzetti) was identified by Professor Xie Yingping (Shanxi University). Others were sent to the Zoological Museum of the Institute of Zoology, CAS, where they were distributed to appropriate taxonomists for identification. All phytophagous insects were evaluated based on their frequency of occurrence on Chinese privet, stage of development, and collecting site. Information on insect host range was obtained from the references "*Economic Insect Fauna of China*", edited by the Editorial Committee of Fauna Sinica, Academia Sinica (Chou et al. 1985; Ge 1966; Tan et al. 1985; Yu et al. 1996; Liu 1963; Liu & Bai 1977; Wang 1980; Zhang 1985; Zhang 1995; Zhao & Chen 1980).

Foliage Damage

Defoliation rate was estimated by averaging defoliation of 120 leaves per plant. Samples consisted of 10 leaves randomly selected from 3 layers (high, middle, and lower layer) and 4 cardinal directions (east, south, west, and north) in each layer, for a total of 12 sampling locations on each plant. Defoliation was estimated by placing leaves on transparent graph paper with a 1-mm^2 grid and measuring total leaf area and leaf area removed.

Stem Damage

Altogether, 900 plants of Chinese privet were investigated for signs of insect feeding within stems, oviposition, and damage at all survey sites. Stem damage was described by attributes, including physical shape, the distance of the damage from the ground, the diameter of stem with boring hole and so on.

Root and Seed Damage

Fifty roots were dug from randomly selected sample sites and examined for root damage. Adult insects found feeding on roots were collected for identification and larvae were returned to the laboratory with pieces of root for rearing to the adult stage. In order to detect insects feeding in seed, 500 immature seeds were collected randomly from survey sites and half were dissected in the laboratory. Also, 200 panicles with 25 to 58 mature seeds per panicle plus the remaining immature seeds were collected and placed in glass containers with fine gauze lids in order to collect adult seed-feeders emerging from them.

Results

The phytophagous insects associated with Chinese privet in China are listed in Table 1. In all, 170 species in 5 orders and 48 families were collected from Chinese privet in Anhui and Guizhou Province from 2005 to 2006. Insects were found in 4 different feeding guilds: foliage, sap, stem, and root feeders. Among them, 95.9% of insects were collected from privet leaves, 1 species was found feeding in stems and 6 species were root feeders. In contrast, only 27 species of insects feed on *Ligustrum* spp. in the U.S. Table 1 also includes an estimate of host range for each insect based on published reports.

Foliage-feeding Insects

Among the foliage-feeding insects in China, *Argopistes tsekooni* (Coleoptera: Chrysomelidae), *Leptoypha hospita* (Hemiptera: Tingidae) and an unidentified sawfly appeared to have the greatest impact on the plant. The extent of defoliation varied among sites, seasons and years (Figs. 1 and 2). In Zhanchuan, defoliation remained relatively constant throughout the sampling period fluctuating only slightly from 20% to 28% (Fig. 1A). Defoliation was highest at the She county site, averaging over 50% in late Jul 2005 (Fig. 1B). At the IOF site, defoliation ranged from about 15% in early May to about 27% in mid-Aug 2005. Defoliation in 2006 was generally higher at the IOF site, averaging about 34% for the year (Fig. 1C). Guiyang, a natural area, had the lowest defoliation of all sites averaging 1.6% in 2006 (Fig. 2). Lingnan had an average defoliation of 16% for 2006. Defoliation at this site ranged from a high of about 16% in late Apr to a low of less than 5% in Sep. Defoliation at the Huangshan city site, a site consisting of planted privet, generally declined over the season from a high of ca. 30% in

TABLE 1. PHYTOPHAGOUS INSECTS COLLECTED FROM CHINESE PRIVET IN CHINA DURING 2005 AND 2006 WITH NOTES ON RELATIVE ABUNDANCE, STAGE OF DEVELOPMENT OBSERVED, METHOD OF CONFIRMATION OF *L. SINENSE* AS A HOST, PLANT PART ATTACKED, AND HOST RANGE.

Order/Family	Species	Relative frequency[a]	Stage found[b]	Host confirmation[c]	Feeding guild	Host range[d]
Lepidoptera						
Hepialidae	*Phassus excrescens* Butler	C	L	√	Stem	Po
Pyralidae	*Diaphania nigropunctalis* (Bremer)	C	L,A	√	Foliage	Ol
	Cnaphalocrocis medinalis(Güenée)	R	L	○	Foliage	Po
	Parapoynx diminutalis Snellen	R	A	○	Foliage	Po
	Parapoynx vittalis (Bremer)	R	A	○	Foliage	Po
	Ostrinia furnacalis (Güenée)	R	A	○	Foliage	Unknown
	Diaphania indica (Saunders)	R	A	○	Foliage	Po
	Pycnarmon cribrata (Fabricius)	R	A	√	Foliage	Po
	Hymenia recurvalis (Fabricius)	R	A	○	Foliage	Po
	Maruca testulais Geyer	R	A	○	Foliage	Po
	Palpita inustata (Butler)	R	A	√	Foliage	Unknown
	Endotricha theonalis (Walker)	R	A	√	Foliage	Unknown
	Diaphania perspectalis (Walker)	R	A	√	Foliage	Po
	Tryporyza incetulas (Walker)	R	A	○	Foliage	Po
Heliodinidae	*Atrijuglans hitauhei* Yang	R	A	○	Foliage	Po
Scythridae	*Scythris sinensis* Felder et Rogenhofer	R	A	○	Foliage	Po
Brahmaeidae	*Brahmaea ledereri* Rogenhofer	O	L,A	√	Foliage	Ol
Sphingidae	*Psilogramma menephron* (Cramer)	O	L	√	Foliage	Po
Gelechiidae	*Telphusa* sp.	R	A	○	Foliage	Unknown
Noctuidae	*Pseudaletia separata* (Walker)	R	L	○	Foliage	Po
	Pangrapta cana Leech	O	L,A	√	Foliage	Unknown
	Helicoverpa assulta (Güenée)	R	A	○	Foliage	Po
	Ericeia fraterna (Moore)	R	L	○	Foliage	Unknown
Arctiidae	*Nyctemera adversata* (Schaller)	R	L	○	Foliage	Po
	Spilarctia subcarnea (Walker)	O	L, A	√	Foliage	Po
	Creatonotus transiens (Walker)	R	A	○	Foliage	Po
	Amsacta lactinea (Cramer)	C	L, A	√	Foliage	Po
	Miltochrista aberrans Butler	R	A	○	Foliage	Unknown
	Cyana sp.	R	A	○	Foliage	Unknown
	Asura sp.	R	A	○	Foliage	Unknown
Psychidae	*Cryptothelea variegata* Snellen	C	L	√	Foliage	Po
Geometridae	*Scopula caricaria* Reutti	R	L	√	Foliage	Unknown
	Percnia luridaria (Leech)	R	A	√	Foliage	Unknown
	Naxa (Psilonaxa) seriaria Motschulsky	O	L,A	√	Foliage	Ol
	Gelasma illiturata Walker	R	A	○	Foliage	Po
	Comostola subtiliaria (Bremer)	R	A	○	Foliage	Unknown
Tortricidae	*Archips seminubilis* (Meyrick)	R	A	○	Foliage	Unknown
	Grapholitha delineana Walker	R	A	○	Foliage	Po
Hemiptera						
Tingidae	*Leptoypha hospita* Drake et Poor	C	N , A	√	Sap	Ol
Pentatomidae	*Nezara viridula* (Linnaeus)	O	A	○	Sap	Po
	Menida sp.	C	A	√	Sap	Unknown
	Eysarcoris sp.	O	A	√	Sap	Unknown
	Pentatoma sp.	R	A	√	Sap	Unknown
	Homoeocerus sp.	O	N,A	√	Sap	Unknown
	Erthesina fullo (Thunberg)	R	A	√	Sap	Po
	Palomena angulosa Motschulsky	R	A	√	Sap	Po
	Carbula obtusangula Reuter	R	A	√	Sap	Po
Coreidae	*Riptortus pedestris* (Fabricius)	O	A	√	Sap	Po
	Cletus punctiger Dallas	R	A	√	Sap	Po
	Riptortus pedestris (Fabricius)	R	A	√	Sap	Po
Urostylidae	*Urochela distincta* Distant	O	A	□	Sap	Po

[a]R, rare, taken at a few sites, usually in small numbers; O, occasionally collected at sites; C, common, taken at most sites.
[b]L, larva; A, adult; N, nymph.
[c]"√"observed feeding on privet, "□"collected from Chinese privet and recorded as privet feeder in literature, "○"collected from Chinese privet, but not directly observed or recorded in literature as feeding on privet.
[d]Po, Polyphagous, feeds on plants from other families; Ol, Oligophagous,feeds mainly on Oleaceae; Mo, Monophagous on Chinese privet.

TABLE 1. (CONTINUED) PHYTOPHAGOUS INSECTS COLLECTED FROM CHINESE PRIVET IN CHINA DURING 2005 AND 2006 WITH NOTES ON RELATIVE ABUNDANCE, STAGE OF DEVELOPMENT OBSERVED, METHOD OF CONFIRMATION OF *L. SINENSE* AS A HOST, PLANT PART ATTACKED, AND HOST RANGE.

Order/Family	Species	Relative frequency[a]	Stage found[b]	Host confirmation[c]	Feeding guild	Host range[d]
Plataspidae	*Megacopta cribraria* (Fabricius)	R	A	○	Sap	Po
Miridae	*Halticus minutus* Reuter	O	A	○	Sap	Po
	Adelphocoris fasiaticollis Reuter	R	A	√	Sap	Po
Scutelleridae	*Hyperoncus lateritius* Westwood	R	A	√	Sap	Po
Lygaeidae	*Nysius ericae* (Schilling)	R	A	○	Sap	Po
Homoptera						
Cicadellidae	*Cicadella viridis* (Linnaeus)	O	N,A	○	Sap	Po
Cercopidae	*Clovia bipunctata* (Kirby)	R	N,A	√	Sap	Po
	Abidama contigua Walker	O	N,A	○	Sap	Unknown
Membracidae	*Tricentrus* sp.	R	A	○	Sap	Unknown
Aphrophoridae	*Aphrophota* sp.	C	N,A	√	Sap	Unknown
Flatidae	*Geisha* sp.	O	A	√	Sap	Unknown
	Salurnis marginella Guérin	C	A	√	Sap	Po
	Lawana sp.	O	A	√	Sap	Unknown
Ricaniidae	*Pochazia* sp.	R	A	√	Sap	Unknown
	Euricania ocellus Walker	C	A	○	Sap	Po
	Pochazia guttifera Walker	C	A	○	Sap	Po
Issidae	*Sivaloka* sp.	O	A	○	Sap	Unknown
Diaspididae	*Pseudaulacaspis pentagona* (Targioni-Tozzetti)	C	N ,A	√	Sap	Po
Coleoptera						
Chrysomelidae	*Argopistes tsekooni* Chen	C	L,A	√	Foliage	Ol
	Longitarsus bimaculatus?Baly?	C	A	√	Foliage	Unknown
	Psylliodes punctifrons Baly	O	A	○	Foliage	Po
	Pseudodera xanthospila Baly	O	A	√	Foliage	Po
	Argopus balyi Harold	O	A	√	Foliage	Ol
	Manobidia nipponica ChujjG	R	A	○	Foliage	Unknown
	Altica viridicyanea Baly	R	A	○	Foliage	Po
	Psylliodes sp.	R	A	○	Foliage	Unknown
	Aphthonomorpha collaris (Baly)	R	A	○	Foliage	Po
	Aphthona varipes Jacoby	R	A	○	Foliage	Po
	Aphthona strigosa Baly	R	A	○	Foliage	Po
	Longitarsus dorsopictus Chen	R	A	○	Foliage	Po
	Longitarsus lohita Maulik	R	A	○	Foliage	Po
	Hemipyxis plagideroides (Motschulsky)	R	A	○	Foliage	Po
	Monolepta hieroglyphica (Motschulsky)	R	A	√	Foliage	Po
	Cryptocephalus sp.	R	A	√	Foliage	Unknown
	Basiprionota bisignata (Boheman)	R	A	√	Foliage	Po
	Ambrostoma quadriimpressum (Motschulsky)	R	A	○	Foliage	Po
	Paleosepharia lequidambra Gressitt & Kimoto	R	A	○	Foliage	Po
	Acrothinium gaschkevitschii (Motschulsky)	R	A	√	Foliage	Po
	Mimastra soreli Baly	R	A	○	Foliage	Po
	Plagiodera versicolora Laicharting	R	A	√	Foliage	Unknown
	Phaedon brassicae Baly	R	A	○	Foliage	Po
	Euliroetis ornata (Baly)	R	A	○	Foliage	Po
	Monolepta selmani Gressitt et Kimoto	R	A	○	Foliage	Unknown
	Coenobius longicornis Chfi ja	R	A	○	Foliage	Po
	Adiscus variabilis (Jacoby)	R	A	○	Foliage	Unknown
	Adiscus exilis (Weise)	R	A	○	Foliage	Unknown
	Colaspoides sp.	R	A	○	Foliage	Unknown
	Oomorphoides yaosanicus (Chen)	R	A	○	Foliage	Po
	Agetocera spp.	R	A	○	Foliage	Unknown
	Gastrolinoides japonica Harold	R	A	○	Foliage	Unknown
	Basilepta ruficolle Jacoby	R	A	○	Foliage	Po

[a]R, rare, taken at a few sites, usually in small numbers; O, occasionally collected at sites; C, common, taken at most sites.
[b]L, larva; A, adult; N, nymph.
[c]"√"observed feeding on privet, "□"collected from Chinese privet and recorded as privet feeder in literature, "○"collected from Chinese privet, but not directly observed or recorded in literature as feeding on privet.
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Order/Family	Species	Relative frequency[a]	Stage found[b]	Host confirmation[c]	Feeding guild	Host range[d]
	Stenoluprus cyaneus Baly	R	A	○	Foliage	Unknown
	Colaphellus bowringii Baly	R	A	○	Foliage	Po
	Phaedon brassicae Baly	R	A	○	Foliage	Po
	Plagiodera versicolora (Laicharting)	O	A	○	Foliage	Po
	Dercefina flavocincta (Hope)	R	A	○	Foliage	Unknown
	Gallerucida ornatipemmis (Duvivier)	R	A	○	Foliage	Unknown
	Cleoporus variabilis (Baly)	R	A	○	Foliage	Unknown
	Eutettix apricus Melichar	R	A	○	Foliage	Po
	Adiscus grandipalpus Tan	R	A	○	Foliage	Unknown
	Melixanthus pieli (Pic)	R	A	○	Foliage	Unknown
	Smaragdina aurita hammarstraemi (Jacobson)	R	A	√	Foliage	Po
	Aulacophora lewisii Baly	R	A	○	Foliage	Po
	Paridea biplagiata (Fairmaire)	R	A	○	Foliage	Po
	Temnaspis nankinea (Pic)	R	A	√	Foliage	Ol
Crioceridae	*Lilioceris maai* Gressitt and Kimoto	R	A	○	Foliage	Po
	Lilioceris impressa (Fabricius)	R	A	√	Foliage	Po
	Lilioceris minima (Pic)	R	A	√	Foliage	Po
	Lema (Lema) scutellaris (Kraatz)	R	A	√	Foliage	Po
	Lema(Lema) concinnipennis Baly	R	A	○	Foliage	Po
	Lilioceris rugata (Baly)	R	A	○	Foliage	Po
	Lilioceris scapularis (Baly)	R	A	○	Foliage	Unknown
Curculionidae	*Sympiezomias velatus* (Chevrolat)	O	A	√	Foliage	Po
	Sympiezomias spp.	O	A	√	Foliage	Unknown
	Euops sp.	R	A	√	Foliage	Unknown
	Apoderus geniculatus Jekel	R	A	√	Foliage	Po
	Alcidodes sauteri (Heller)	O	A	√	Foliage	Unknown
	Myllocerinus aurolineatus Voss	R	A	√	Foliage	Po
	Anthonomus bisignifer Schenkling	R	A	√	Foliage	Unknown
	Callosobruchus chinensis (Linnaeus)	R	A	○	Foliage	Po
	Myllocerinus ochrolineatus Voss	R	A	√	Foliage	Unknown
Meloidae	*Zonitis japonica* Pic	O	A	○	Foliage	Unknown
	Lytta caraganae Pallas	O	A	○	Foliage	Unknown
Hispidae	*Cassida japana* Baly	R	A	√	Foliage	Unknown
	Laccoptera quadrimaculata (Thunberg)	R	A	√	Foliage	Po
	Thlaspida biramosa Boheman	R	A	√	Foliage	Po
	Cassida piperata Hope	R	A	√	Foliage	Po
Eumolpidae	*Smaragdina nigrifrons* (Hope)	R	A	√	Foliage	Po
Coccinellidae	*Henosepilachna vigintioctopunctata* (Fabricius)	O	A	√	Foliage	Po
	Epilachna freyana Beilawski	C	A	√	Foliage	Po
	Epilachna quadricollis (Dieke)	C	A	√	Foliage	Mo
Scarabaeidae	*Holotrichia parallela* Motschulsky	C	A	√	Root	Po
Cetoniidae	*Protaetia (Calo) aerata* (Erichson)	R	A	√	Foliage	Po
	Protaetia brevitarsis Lewis	R	A	√	Foliage	Po
	Oxycetonia bealiae (Gory et Percheron)	R	A	√	Foliage	Unknown
	Pseudodiceros nigrocyaneus (Bourgoin)	R	A	√	Foliage	Unknown
	Rhomborrhina unicolor Motschulsky	R	A	√	Foliage	Unknown
	Oxycetonia jucunda Faldermann	R	A	√	Foliage	Po
Rutelidae	*Anomala corpulenta* Motschulsky	R	A	√	Foliage	Po
	Anomala olivea Lin	R	A	√	Foliage	Unknown
	Adoretus sinicus Burmeister	R	A	√	Foliage	Unknown
	Hoplia communis Waterhouse	O	L,A	√	Root	Po
Oedemeridae	*Xanthochroa hilleri* Harold	R	A	○	Foliage	Unknown
Tenebrionidae	*Gonocephalum pubiferum* Reitter	R	N	○	Root	Po
Nitidulidae	*Librodor japonicus* Motschulsky	R	A	√	Foliage	Unknown

[a]R, rare, taken at a few sites, usually in small numbers; O, occasionally collected at sites; C, common, taken at most sites.
[b]L, larva; A, adult; N, nymph.
[c]"√"observed feeding on privet, "□"collected from Chinese privet and recorded as privet feeder in literature, "○"collected from Chinese privet, but not directly observed or recorded in literature as feeding on privet.
[d]Po, Polyphagous, feeds on plants from other families; Ol, Oligophagous,feeds mainly on Oleaceae; Mo, Monophagous on Chinese privet.

TABLE 1. (CONTINUED) PHYTOPHAGOUS INSECTS COLLECTED FROM CHINESE PRIVET IN CHINA DURING 2005 AND 2006 WITH NOTES ON RELATIVE ABUNDANCE, STAGE OF DEVELOPMENT OBSERVED, METHOD OF CONFIRMATION OF *L. SINENSE* AS A HOST, PLANT PART ATTACKED, AND HOST RANGE.

Order/Family	Species	Relative frequency[a]	Stage found[b]	Host confirmation[c]	Feeding guild	Host range[d]
Elateridae	*Pleonomus canaliculatus* Faldermann	R	A	√	Root	Po
	Agriotes subrittatus Motschulsky	R	A	√	Root	Po
	Sarpedon atratus Fleutiaux	R	A	√	Root	Unknown
Languriidae	*Anadastus analis* Fairmaire	R	A	○	Foliage	Unknown
Lagriidae	*Lagria nigricollis* Hope	R	A	○	Foliage	Unknown
Cantharidae	*Cantharis violaceipemis* Gorh	O	A	○	Foliage	Unknown
	Cantharis sp.	R	A	○	Foliage	Unknown
Buprestidae	*Agrilus* spp.	R	A	√	Foliage	Po
Orthoptera						
Catantopidae	*Oxya intricata* (Stal)	O	N,A	○	Foliage	Po
	Xenocatantops brachycerus (Will)	O	N,A	○	Foliage	Po
Tettigoniidae	*Prohimerta (Anisotima)guizhouensis* Gorochov & Kang	O	N,A	○	Foliage	Po
	Mirollia formosana Shiraki	R	N,A	○	Foliage	Po
	Hexacentrus unicolor Serville	R	N,A	○	Foliage	Po
	Kuzicus (Kuzicus) suzukii Matsumura & Shiraki	R	N,A	○	Foliage	Po

[a]R, rare, taken at a few sites, usually in small numbers; O, occasionally collected at sites; C, common, taken at most sites.
[b]L, larva; A, adult; N, nymph.
[c]"√"observed feeding on privet, "□"collected from Chinese privet and recorded as privet feeder in literature, "○"collected from Chinese privet, but not directly observed or recorded in literature as feeding on privet.
[d]Po, Polyphagous, feeds on plants from other families; Ol, Oligophagous,feeds mainly on Oleaceae; Mo, Monophagous on Chinese privet.

mid-May to a low of ca. 8% in early Oct. A natural site on a nearby island had a defoliation rate of about 30% as well (Fig. 3), suggesting that defoliation was similar in an area regardless of site condition. The mean percent defoliation for Chinese privet per year among all sites and all years of study was 20.5 ± 8.2%.

Stem Damage

Phassus excrescens (Lepidoptera: Hepialoidae) was the only stem borer found feeding on Chinese privet in our survey where 5.3% (48 of 900 privets) of the plants were damaged by it. Larvae of the insect were collected from trunks of Chinese privet where they bored in the xylem causing galls. While feeding, they created an off white mass consisting of silk, excrement, and wood scraps that covered the entrance to the larval gallery. Borer entrance holes were 29.77±1.95cm (n = 48) from the ground and the average diameter of attacked stems was 2.27±0.72cm (n = 48).

Root and Seed Damage

Six species of insects were found feeding on roots of Chinese privet. All 6 fed on fine roots or the root surface. Observations of the above ground plant health gave no indication root-feeders were present. No seed-feeders were found in either immature or mature seeds.

DISCUSSION

In order to collect the most natural enemies of privet, survey sites were selected to include diverse habitats varying from natural areas to semi-natural and planted sites. Anhui province was selected as the primary survey area, because it was the best climatic match to the southeastern United States. Climatic matching is important for conventional biological control to insure the selected agents are adapted to the climate where they will be released (Andres et al. 1976; Harley & Forno 1992). Guizhou province was another important survey area because it is near the center of the range of Chinese privet in China.

Chinese privet is a common ornamental shrub but not a noxious weed in China, suggesting that natural enemies suppress populations. We found 170 phytophagous insect species on Chinese privet in China. Most were foliage-feeding insects despite phenolic compounds in privet leaves that likely provide some protection against damage from generalist herbivores (Swearingen et al. 2002). In the United States, Johnson & Lyon (1991) list at least 27 species of insects or mites that feed on *Ligustrum* spp., however, none suppress populations of this plant in forests. Most are not specialist on Chinese privet so it seems likely that the diverse and abundant insect fauna in China is important in regulating Chinese privet populations in its native habitat. Other factors

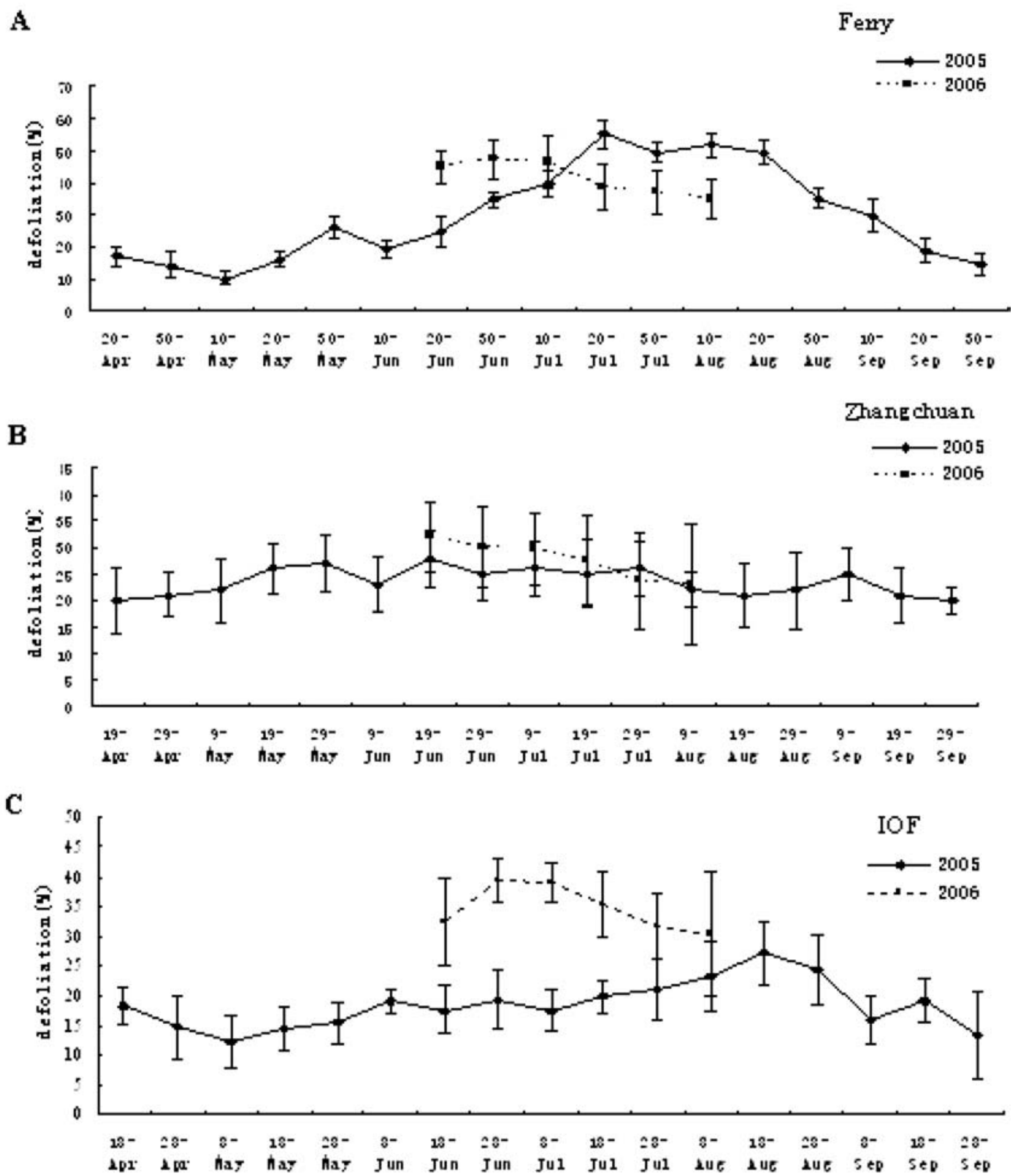

Fig. 1. Seasonal Chinese privet defoliation at: (A) Zhanchuan (a semi-natural site), (B) She County (a planted site), and (C) IOF (a semi-natural site) in Anhui Province. Means ± SME are shown.

also may be involved such as disease organisms not include in this survey. Phytophagous insects were collected by hand picking or net sweeping. Most were determined as feeding on Chinese privet by observations made during surveys in the field and through the literature. However, other insects that were not privet feeders and only occasionally rested on the plants were likely included in sweep net samples. To distinguish among them, we made notes in Table 1 showing which were confirmed as feeding on privet during our surveys (√), were collected during our surveys and recorded as privet feeders in the literatures (□), or collected from Chinese privet, but were not

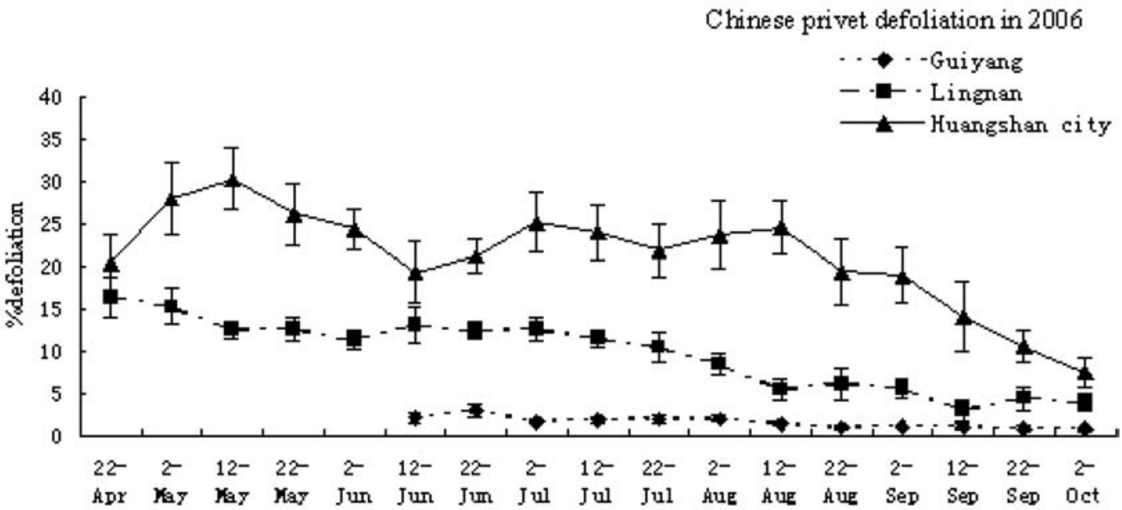

Fig. 2. Seasonal Chinese privet defoliation in 2006 in Guiyang, a natural site in Guizhou Province, Lingnan, a natural site in Anhui Province and Huangshan city, a planted site in Anhui Province. Means±SME are shown.

confirmed as privet feeders by personal observation or in the literature (○). We confirmed 81 feeding on privet by personal observation (Y. Z. Zhang), 88 were collected from privet and were reported in the literature as feeding on privet, and 1 species was collected but could not be confirmed by either method. Table 1 provides the most comprehensive listing of phytophagous insect feeding on Chinese privet to date.

When screening potential biological control agents for invasive weeds, their host range is one of the most important factors because only host specific agents will be considered for release to control invasive weeds. Polyphagous species were included in Table 1 to provide a complete listing with no attempt to differentiate good candidates for testing.

We included all insects found on privet, not just the most common ones, because some insects that are rare in their native country and suppressed by their own natural enemies are effective biological control agents when released from their own population regulating fauna.

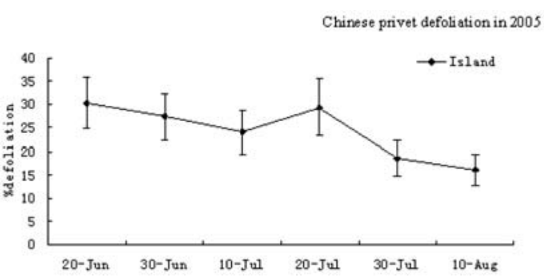

Fig. 3. Seasonal Chinese privet defoliation on an island natural site in Huangshan city in Anhui Province. Means ± SME are shown.

Due to host specificity and the severe damage it caused on Chinese privet (Zhang et al., unpublished data), *A. tsekooni* may be the most promising biological control agent. It was apparent in our field surveys that defoliation rates were high when populations of *A. tsekooni* were large. Also, preliminary host specificity tests suggest its host range is restricted to *Ligustrum* spp. (Zhang et al. unpublished data). Examples of flea beetle as biological control agents of exotic weeds include *Altica carduorum* Guer. (Chrysomelidae: Coleoptera) on *Cirsium arvense* (L.) Scop. (Asteraceae) (Wan et al. 1996) and *Agascicles hygrophila* Selman et Vogt in China for control of *Alternanthera philoxeroides* (Mart.) Griseb., a global virulent weed from South America (Julien et al. 1995). *Argopistes tsekooni* feeds on most members of the genus *Ligustrum*. However, since no indigenous *Ligustrum* spp. occur in the U.S. and all *Ligustrum* spp. in the U.S. are listed as invasive weeds (Miller et al. 2004), *A. tsekooni* is a potential biological control that warrants further testing.

Leptoypha hospita could be another promising biocontrol agent because it has a limited host range in the Oleaceae (Li 2001) and often occurred in high numbers on Chinese privet in our sample areas. Likewise, the unidentified sawfly may also be an important defoliator. Thus far we have been unable to rear adults for identification so we cannot fully evaluate its potential for biological control. However, we have not observed it attacking other plant species during our field surveys.

Feeding by *P. excrescens* weakened the trunk resulting in breakage or, in some cases, the stems died as a result of girdling by the larvae. However, it has a broad host range and is considered an important pest of many plant species. Therefore, it is unlikely that it could be developed as a biological control agent.

Defoliation of privet varied widely among sites. The highest defoliation was recorded at the She County site which was a planted site. The lowest was on privet at the Guiyang site a natural area in Guizhou Province. That site was selected because it was near the center of the range of Chinese privet and, therefore, likely to have high number of phytophagous insects. We are uncertain why privet defoliation was low at this site but it may be the result of high numbers of defoliator natural enemies, or the more widely scattered and shaded privet population we sampled at that location. Defoliation of privet at the Lingnan site in Anhui Province, another natural area, was also relatively low compared with the She County site, or the Zhanchuan and IOF sites which we classified as semi-natural. The average 20% defoliation rate of *L. sinense* in China for all sites combined demonstrates that defoliating insects have a large impact on privet even when their own populations are being regulated by natural enemies. These results suggest that in the absence of natural enemies some of these insects may be effective biocontrol agents.

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