Occurrence of Boisduval Scale, Diaspis boisduvalii (Hemiptera: Diaspididae), on Native Epiphytic Orchids in Collier Co., Florida, Including Fakahatchee Strand State Preserve

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OCCURRENCE OF BOISDUVAL SCALE, *DIASPIS BOISDUVALII* (HEMIPTERA: DIASPIDIDAE), ON NATIVE EPIPHYTIC ORCHIDS IN COLLIER CO., FLORIDA, INCLUDING FAKAHATCHEE STRAND STATE PRESERVE

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Abstract

We present the results of a field study conducted in 2011 to assess native epiphytic orchids in South Florida for infestations of armored scales (Hemiptera: Coccoidea: Diaspididae). A total of 1,726 orchids spanning 10 taxa were surveyed at 7 locations at 3 sites. Boisduval scale, *Diaspis boisduvalii* Signoret, was detected on 2.3% of the orchids from 6 of the 10 orchid species, and was present at all 3 primary sites surveyed. *Prosthechea cochleata* and *Epidendrum amphistomum* (Asparagales: Orchidaceae) appeared to be most vulnerable to this scale, with infection totals of 5.8% and 2.1%, respectively. Of 44 scales from the 39 orchids, 27% hosted hymenopteran parasitoids in various stages of development. The presence of *D. boisduvalii* adds an additional burden to state-endangered orchid populations and indicates that resource managers may need to expand management approaches to include plant-parasitic insect control.

Key Words: Orchidaceae, conservation, exotics, *in situ*, parasitoids

Resumen

Nosotros presentamos las resultas de un estudio de campo que fue realizado en 2011 para aquilatar y calcular la presencia de infestaciones de escamas acorazadas (Hemiptera: Coccoidea: Diaspididae) en las orquídeas epifíticas nativas en el sur de Florida. En total, 1.726 orquídeas de diez especies fueron observadas en siete lugares dentro de tres colocaciones. Boisduval scale, *Diaspis boisduvalii* Signoret, fue detectado en 2,3 por ciento de las orquídeas observadas dentro de seis de las diez especies de orquídeas y estaba presente en las tres colocaciones observada primarias. *Prosthechea cochleata* y *Epidendrum amphistomum* (Asparagales: Orchidaceae) aparecieron muy vulnerables a esa escama. Tienen totales de infección de 5,8 por ciento y 2,1 por ciento respectivamente. Dentro de las 44 escamas de las 39 orquídeas, 27 por ciento fueron huéspedes parasitoides himenópteros durante varios puntos del desarrollo. La presencia de *D. boisduvalii* agrega un estrés o tensión adicional a las orquídeas en peligro de extinción en el estado de Florida. Lo indica que los directores de recursos necesitarían aumentar sus esfuerzos para incluir el control la población de los parásitos de plantas.

Armored scale insects (Hemiptera: Diaspididae) are major pests of orchids in cultivation because of the damage they inflict via piercing-sucking mouthparts, which results in tissue damage such as chlorosis (Johnson 2010). Long-term feeding may weaken or eventually kill the host plant (Johnson 2010). The 2 scale species known to inflict heaviest damage to cultivated orchids are the brown soft scale (*Coccus hesperidium* L.) and the Boisduval scale (*Diaspis boisduvalii* Signoret), both of which are common and widespread (Johnson 2010). The former is a cosmopolitan polyphagous pest indigenous to the Old World (Miller et al. 2005), whereas *D. boisduvalii* originated from tropical America and primarily targets monocots, especially Orchidaceae (Balachowsky 1954; Espinosa et al. 2009) and Arecaceae (Howard et al. 2001; Miller & Davidson 2005). Although much has been published on armored scales in general, especially regarding their pestiferous nature and control, little is known about their life history *in situ*.

About half (106) of North America's orchid species are found in Florida, and half of these species are restricted to the southernmost part of the state, primarily in the Big Cypress Basin

eco-region (Brown 2005). In this area, large tracts of land have been set aside to protect South Florida's unique flora and fauna, but invasive species, environmental degradation, and poaching still constitute omnipresent threats. In 2009, Sadler et al. (2011) initially documented the presence of scales (Coccidae, Pseudococcidae; later identified as *Pulvinaria* sp. and *Ferrisia* sp., respectively, by Zettler et al. (2012) *in situ* on inflorescences of the rare ghost orchid, *Dendrophylax lindenii* (Lindl.) Bentham ex Rolfe (Asparagales: Orchidaceae), in a secluded area surrounded by urban development in Naples, Florida. The following year, Zettler et al. (2012) conducted a preliminary survey of other native orchids infested with plant parasitic Hemiptera in the Florida Panther National Wildlife Refuge (Collier County), and documented 3 species of scales on 27 of 81 plants, including, *Asterolecanium epidendri, C. hesperidium,* and *D. boisduvalii*. Given their documented status as pests of cultivated ornamentals, the discovery of these scales *in situ* in the orchid species-rich Big Cypress Basin eco-region is of considerable concern.

In this paper, we provide a summary of an expanded follow-up study conducted in 2011 to assess native epiphytic orchids for scales in remote areas of Collier County, including Fakahatchee Strand State Preserve—which is widely regarded as one of the most important orchid habitats in North America (Luer 1972).

Materials and Methods

Native epiphytic orchids inhabiting 7 disjunct sites in Collier County, Florida, were sampled for Diaspididae, Flatidae and Acanaloniidae during 16 Jun-12 Jul 2011. Four of the sites (McBride's Pond, Cochran Lake, Fritz's Boulevard, Haleigh's Pond) were located within the 10,684 ha Florida Panther National Wildlife Refuge (FPNWR) which served as the primary study area. The other sites consisted of an isolated swamp surrounded by an urban area in Naples, Florida (the exact location has been withheld to deter poaching), and 2 within the Fakahatchee Strand State Preserve, bordering the FPNWR to the south (Fig. 1). The Fakahatchee Strand sites – separated by approximately 0.5 km - were chosen because of their high abundance and diversity of epiphytic orchids. In total, 10 species were sampled: *Epidendrum nocturnum* Jacquin (Night Scented Orchid), *Epidendrum amphistomum* A. Richard (Dingy-Flowered Star Orchid), *Epidendrum rigidum* Jacquin (Rigid Epidendrum), *Encyclia tampensis* (Lindley) Small (Florida Butterfly Orchid), *Prosthechea cochleata* (L.) W. E. Higgins var. *'triandra'* (Ames) W. E. Higgins (Florida Clamshell Orchid), *Polystachia concreta* (Jacquin) Garay & Sweet (Yellow Helmet Orchid; Fig. 2), *Dendrophylax lindenii* (Lindley) Bentham *ex* Rolfe (Ghost Orchid), *Cyrtopodium punctatum* (Linnaeus) Lindley (Cigar Orchid), *Campylocentrum pachyrrhizum* (Reichenbach *f.*) Rolfe (Ribbon Orchid), and *Ionopsis utricularioides* (Swartz) Lindley (Delicate Ionopsis), (Brown 2005). With the exception of *E. tampensis*, all of these are listed as endangered on Florida's Regulated Plant Index (Coile & Garland 2003). At each of the 7 sites, we attempted to survey all orchids accessible by foot, affixed to host trees from ground level up to a height of 2 m. At each site, all orchids were sampled within an area of 200 m × 200 m. For each orchid specimen encountered, species identification, GPS locality data and host tree species were recorded. Each orchid specimen was observed by up to 3 different people, and those infested were given an ID number for the purposes of long-term monitoring. Leaves, roots, and/or inflorescences from each infested plant were then assessed for severity of scale infestation, with a severe infestation defined as a scale colony measuring > 2 cm in diameter on the leaf surface, and a low/moderate infestation recorded as < 2 cm. Scale populations on severely infested leaves were vouchered by removing by scalpel a 1 cm^2 leaf sample (Fig. 3), which was returned to the laboratory for processing and identification by compound light microscope. Slides of the scales were prepared following the protocol outlined by Miller & Davidson (2005). Vouchers of slide mounted scales are deposited in the Florida State Collection of Arthropods, DPI-FDACS, Gainesville, Florida. Occasionally, flatid planthoppers (Hemiptera: Flatidae) were observed and recorded; however, given that this study focused primarily on scales, flatids were not identified further.

Results and Discussion

Of 1,726 orchids sampled throughout the region, 36.4% were *E. amphistomum*, followed by *P. concreta* (19.0%), *P. cochleata* (16.8%), *E. nocturnum* (16.2%), *E. rigidum* (8.0%), *E. tampensis* (2.0%), *D. lindenii* (1.0%), *C. pachyrrhizum* (0.2%), *C. punctatum* (0.1%) and *I. utricularioides* (0.1%). Boisduval scale was detected on 2.3% (39 of 1,726) of the orchids and 6 of the 10 taxa (Table 1; Fig. 3), and was present at all 3 primary survey sites in Collier County, including Fakahatchee Strand. *P. cochleata* and *E. amphistomum* (Fig. 3) appeared to be most vulnerable to this scale insect, with infection totals of 5.8% and 2.1%, respectively (Table 1) and found in both Fakahatchee Strand and Florida Panther NWR. Although fewer scales were detected on *E. nocturnum* (0.7% of plants sampled), this species also harbored *D. boisduvalii* at the both sites, and had the highest incidence of flatid planthoppers (Hemiptera: Flatidae) among the orchid taxa sampled (3.2%; Table 1). Scales were absent on both leafless taxa (*C. pachyrrhizum*, *D. lindenii*), as well as *C. punctatum* and *I. utricularioides,* each of which con-

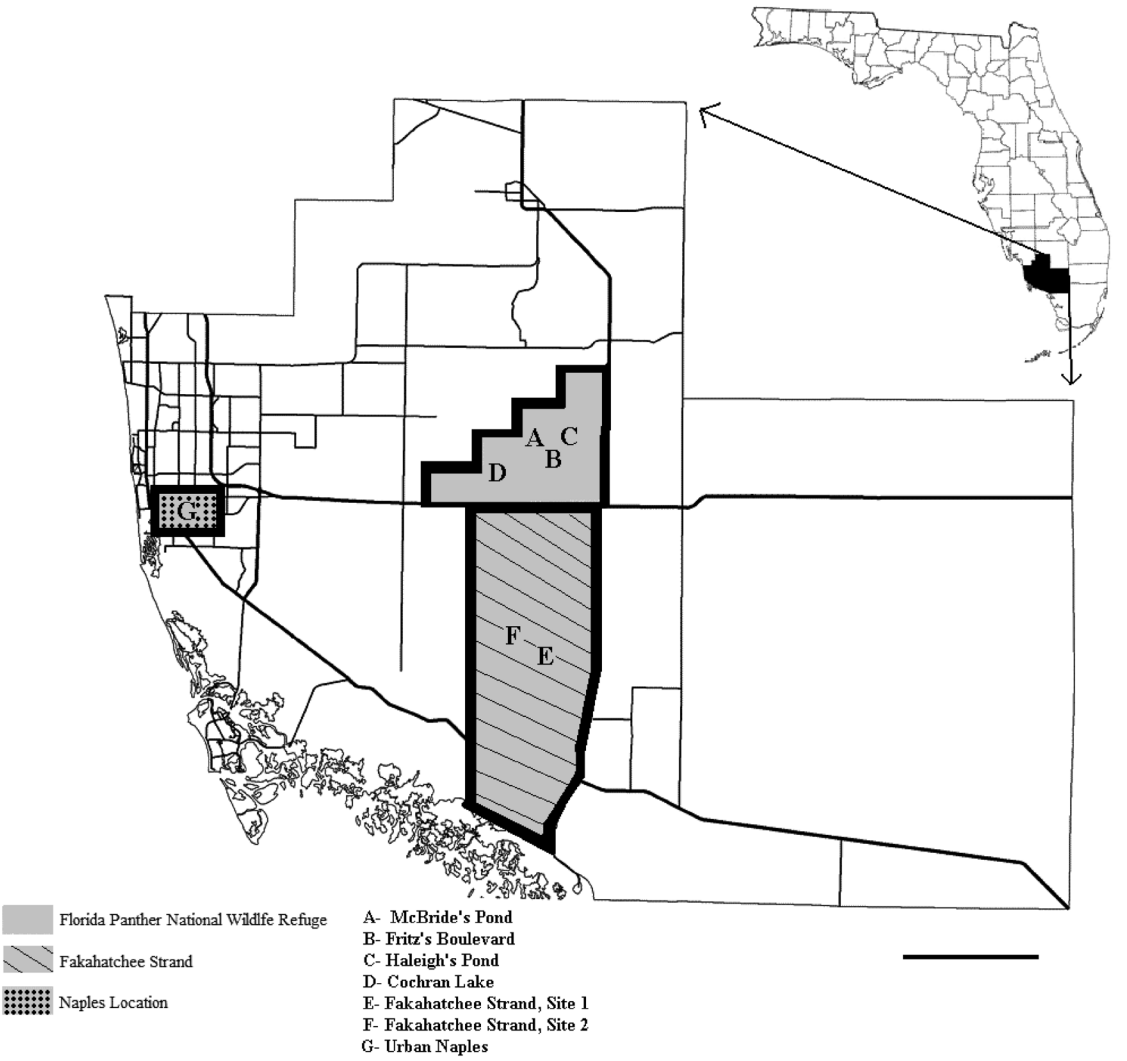
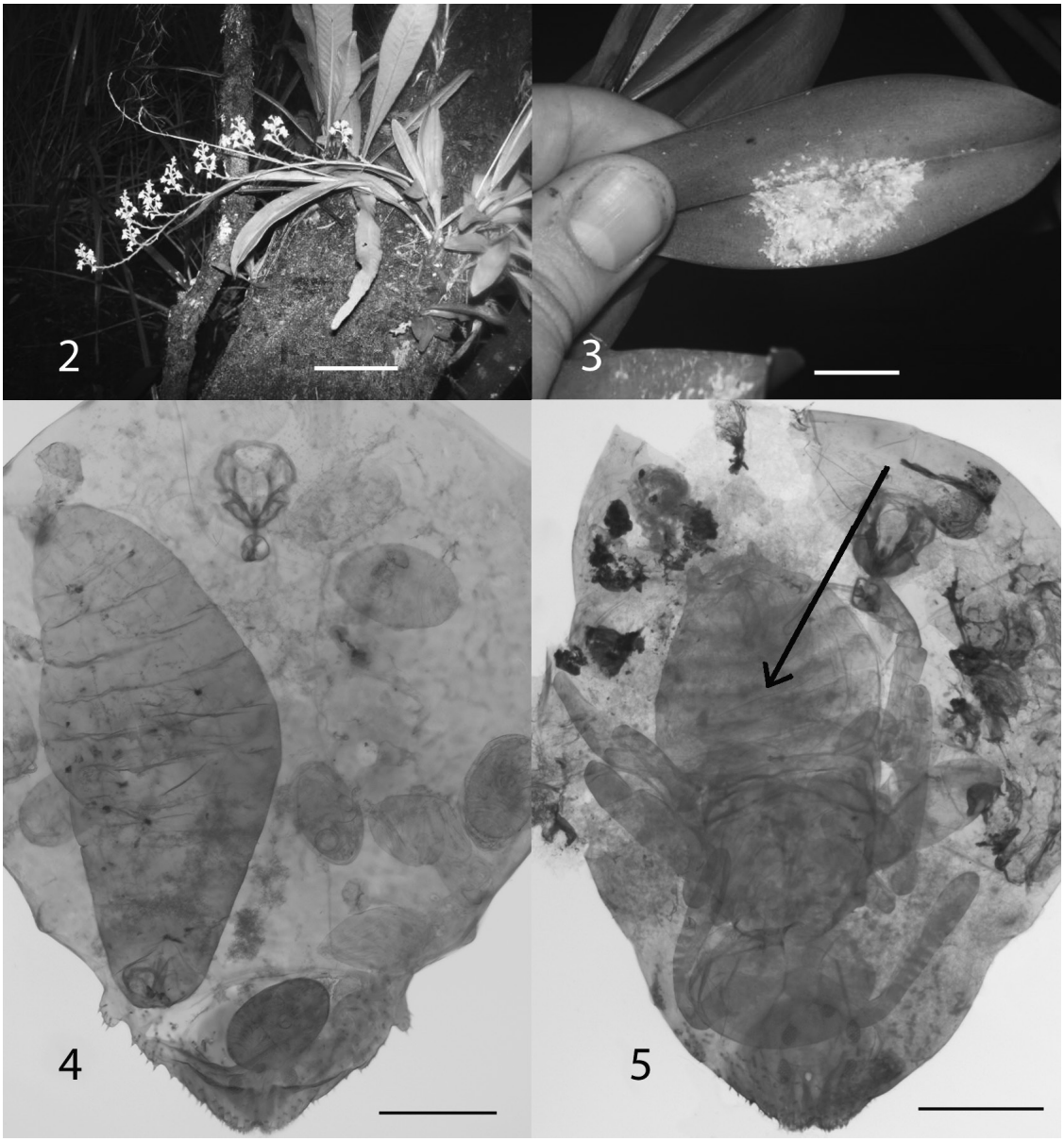


Fig. 1. Locations of the seven orchid sites sampled for pestiferous insects in Collier Co., Florida during 16 Jun-12 Jul 2011. Scale bar = 13 km.

sisted of a solitary specimen. Within the Fakahatchee Strand and Florida Panther NWR, scales were widespread, as evidence by their presence in 5 of the 6 disjunct areas sampled (Table 1). Although Fakahatchee Strand and Florida Panther NWR border one another, scales were present on orchids in these 2 areas separated by a distance of approximately 15 km, and up to 30 km from the urban Naples site (Fig. 1). Thus, *D. boisduvalii* appears to be widespread throughout Collier County.

Zettler et al. (2012) reported *D. boisduvalii* and 2 other exotic scale species (brown soft scale and orchid pit scale, *Asterolecanium epidendri* (Bouché) from epiphytic orchids in the Florida Panther NWR in 2010, and also noted higher incidences of scales (e.g., *P. cochleata* = 41%, *P. concreta* = 69% infested, respectively). Moreover, 2 ant species (*Pseudomyrex simplex* F. Smith, *Pheidole moerens* Wheeler, Hymenoptera: Formicidae) were observed tending brown soft scales on *P. concreta* and *P. cochleata*, respectively. In the present study, neither of these scale species was documented from orchids at the 3 major sites, nor were ants observed at the time of sampling. As to why only *D. boisduvalii* was present is not known, but its persistence in the Florida Panther NWR during the past 2 yr, coupled with its new discovery in the Fakahatchee Strand, suggests that this important pest has established itself in remote, orchid-rich natural areas of Collier Co. The presence of *D. boisduvalii* on state-endangered native orchids is of special concern because this scale is considered the most important pest of cultivated



Figs. 2-5. 2. Yellow helmet orchid, *Polystachya concreta*, in flower photographed at McBride's Pond in the Florida Panther National Wildlife Refuge at the time of scale sampling (Jun 2011). Scale bar = 6 cm. 3. Colony of armored scales on leaf surface of *Epidendrum amphistomum* in Collier Co., Florida. Scale bar = 1 cm. 4. Mature *Diaspis boisduvalii* acquired from *Epidendrum amphistomum* in McBride's Pond, Florida Panther National Wildlife Refuge, with presence of parasitoid larva. Scale bar = 0.03 mm, and 5. Boisduval scale on *Epidendrum nocturnum* at McBride's Pond, and harboring a hymenopteran parasitoid in the pupal stage, denoted by the arrow. Scale bar = 0.03 mm.

orchids in Florida (Dekle 1965) due to its ability to weaken or kill the host plant (Johnson 2010).

Of 44 scales acquired from the 39 infected orchids, 12 (27%) were parasitized by Hymenoptera in various stages of development (Fig. 5). Scales with parasitoids were collected in both Fakahatchee Strand and the Florida Panther NWR, suggesting that both parasitoid and scale were widespread. All but one of the parasitoids were collected from either McBride's Pond (6 of 17 scales or 35%) or Cochran Lake (5 of 21 scales or 24%), both within the Florida Panther NWR. Attempts to identify these parasitoids were inconclusive. At least 2 major families are known to

TABLE 1. A COMPILATION OF ALL OF THE PHYTOPHAGOUS INSECTS, BOTH SCALES AND PLANTHOPPERS (HEMIPTERA: DIASPIDIDAE, FLATIDAE, RESPECTIVELY) ON 10 ORCHID TAXA AT THE 7 SITES SURVEYED IN COLLIER CO, FLORIDA, COLLECTED DURING 16-VI- 12-VII-2011. NUMBERS IN PARENTHESIS REFLECT INFESTATION PERCENTAGES (DATA FROM *CYRTOPODIUM PUNCTATUM* (SOLITARY SPECIMEN LOCATED AT MCBRIDE'S POND), *IONOPSIS UTRICULARIOIDES* (SOLITARY SPECIMEN LOCATED AT COCHRAN LAKE), AND *CAMPYLOCENTRUM PACHYRRHIZUM* (SOLITARY SPECIMEN LOCATED AT FAKAHATCHEE STRAND SITE 2 AND 2 SPECIMENS AT COCHRAN LAKE) HAVE BEEN OMITTED BELOW DUE TO MINOR SAMPLE SIZES AND NO INFESTATION).

Site	Sample[1]	*Epidendrum nocturnum*	*Epidendrum rigidum*	*Encyclia tampensis*	*Epidendrum amphistomum*	*Dendrophylax lindenii*	*Prosthechea cochleata*	*Polystachya concreta*	Total
Fakahatchee Strand Site 1									
	Orchids	33	6	2	9	—	10	80	140
	Scale	1	0	0	1	—	2	0	4 (2.9)
	Hopper	2	0	0	2	—	2	1	7 (5.0)
Fakahatchee Strand Site 2									
	Orchids	78	23	1	119	—	4	19	244
	Scale	0	0	0	3	—	0	1	4 (1.6)
	Hopper	1	0	0	4	—	0	0	5 (2.0)
McBride's Pond									
	Orchids	50	4	3	95	—	134	71	357
	Scale	1	0	0	7	—	11	1	20 (5.6)
	Hopper	1	0	0	0	—	0	1	2 (0.56)
Cochran Lake									
	Orchids	105	44	4	214	4	97	128	596
	Scale	0	2	0	1	0	4	0	7 (1.2)
	Hopper	5	0	0	2	0	1	0	8 (1.3)
Fritz's Blvd									
	Orchids	7	43	1	166	—	46	30	293
	Scale	0	0	0	0	—	0	0	0 (0.0)
	Hopper	0	0	0	0	—	0	0	0 (0.0)
Haleigh's Pond									
	Orchids	—	—	24	4	—	—	—	28
	Scale	—	—	3	0	—	—	—	3 (10.7)
	Hopper	—	—	0	0	—	—	—	0 (0.0)
Naples									
	Orchids	8	19	—	22	14	—	—	63
	Scale	0	0	—	1	0	—	—	1 (1.6)
	Hopper	0	0	—	1	0	—	—	1 (1.6)
Total									
	Orchids	281	139	35	629	18	291	328	1726
	Scale	2 (0.72)	2 (1.4)	3 (8.6)	13 (2.1)	0 (0.0)	17 (5.8)	2 (0.61)	39 (2.3)
	Hopper	9 (3.2)	0 (0.0)	0 (0.0)	9 (1.4)	0 (0.0)	3 (1.0)	2 (0.61)	23 (1.3)

parasitize armored scales, i.e., Aphelinidae, and Encyrtidae, but it is suspected that these wasps were encyrtids, based on longer antennae visible in at least 1 specimen (G. Evans, pers. com.). Subfamilies of Chalcidoidea, however, are extremely difficult to separate, especially their larvae and pupae, and positive identification will require further work. While it is not known if parasitoid wasps had a significant role on suppressing scale populations throughout our survey area, a long-held assumption is that local populations of phytophagous insects are held in check by natural enemies (e.g., Huffaker 1971; Southwood & Comins 1976; Hassel 1985). However, natural enemies have seldom been shown to influence the distribution of phytophagous insects over a widespread area spanning various habitats (Hanks & Denno 1993). Thus, high parasitoid load in one local habitat (e.g., McBride's Pond) may not be true for all habitats in the region (e.g., Collier Co.), as our survey seems to suggest. Hanks and Denno (1993) linked patchy distributions of an armored scale, *Pseudaulacaspis pentagona* (Targioni), to both natural enemies and plant-water relations such as host plant water stress. Indeed, numerous publications suggest that water-stressed host plants have a negative impact on sap-feeding insects (e.g., Conner 1988; Sumner et al. 1986; Wearing & van Emden 1967), including armored scales (Cockfield & Potter 1986). The presence of parasitoids in *D. boisduvalii* in Collier Co., coupled with the prevailing drought conditions in that region during 2009-2011 (www.nws.noaa.gov) may have contributed to low scale numbers evidenced by our survey, and could explain the absence of the other orchid infesting scale species, such as *C. hesperidum* and *A. epidendri*.

Implications for Orchid Conservation

In light of South Florida's urban expansion, the region's widespread agricultural land use, and the impact of periodic hurricanes, it is not surprising that Boisduval scale was documented in remote natural areas of Collier Co. For example, first instars of *D. boisduvalii* are known to utilize wind currents as a dispersal agent (Washburn & Washburn 1984), and it is conceivable that the orchids in Fakahatchee Strand and Florida Panther NWR became infected in this manner from nearby areas impacted by human activity. As to why the orchids at the Naples site had lower (4.5%) incidence of infection when the opposite would be expected is not known. However, this particular site is occasionally subjected to pesticides aimed at mosquito control in the nearby urban community, and this might account, in part, for lower scale numbers observed.

As an invasive species, *D. boisduvalii* is not unique, as it represents one of a growing number of exotic species that have infiltrated natural habitats in South Florida. While some exotics out-compete native plants and animals, others like Boisduval scale inflict physical harm, posing a direct threat (reviewed by Pimentel et al. 2005). Given the notorious history of this scale as a pest of cultivated orchids, the presence of *D. boisduvalii* adds an additional burden to state-endangered orchid populations already vulnerable to habitat loss, environmental degradation and poaching.

Although armored scale outbreaks are most often associated with urban landscapes where natural enemies are less abundant (Edmunds 1973; Pinto 1980; Davidson and Miller 1990; McClure 1990), the potential still exists for *D. boisduvalii* to hamper conservation efforts aimed at critically rare orchids within the Big Cypress Basin eco-region. Should future scale outbreaks threaten such orchid populations, control measures, including the use of pesticides at specific sites and/or on individual plants, may prove necessary. Several studies have been published that document the control of scales on cultivated orchids (e.g., Cating et al. 2010) and non-orchids (e.g., Rebek and Sadof 2003), and some protocols may have practical merit when applied *in situ*. For example, Cating et al. (2010) reported that the wetting agent, Silwet® L-77, plus petroleum oil was effective at removing *D. boisduvalii* and mites from infested orchids in cultivation with little or no phytotoxicity. Moreover, they suggest that this treatment may be cost-effective relative to standard pesticides, and could potentially conserve natural enemies. We advocate that land managers carefully monitor orchid populations in the region for signs of armored scales, and be prepared to take appropriate action involving integrated pest management. More surveys in Collier Co. are planned for 2012 as well as long-term monitoring, but additional surveys in neighboring counties are urgently needed.

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