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NATURALIZATION OF THE OIL COLLECTING BEE *CENTRIS NITIDA* (HYMENOPTERA, APIDAE, CENTRINI), A POTENTIAL POLLINATOR OF SELECTED NATIVE, ORNAMENTAL, AND INVASIVE PLANTS IN FLORIDA

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ABSTRACT

The neotropical bee *Centris nitida* Smith has naturalized in southeastern Florida and in Sarasota on the Gulf coast. This furry yellow and black bee has been confused with the closely related *C. lanosa* Cresson, a native bee restricted to northern Florida and the American Southwest and adjacent Mexico. Female *C. nitida* are smaller than those of both *C. lanosa* and *C. errans* Fox, a furry brown-colored native *Centris* which is sympatric with *C. nitida* in southern Florida. The 3 *Centris* bees now occurring in Florida are readily separated by their distinctive facial markings. Female *C. nitida* have a vertical black line in the middle of the clypeus. *Centris nitida* is a polylectic, oil-collecting bee observed to visit flowers of 28 species in 10 plant families, including 8 oil reward flower species in the Malpighiaceae, and 10 species of buzz pollinated flowers in the Fabaceae and Solanaceae in Florida. *Centris nitida* may have environmental impacts through pollination of selected native, ornamental and invasive plants, as well possible competition with the sympatric native *C. errans* through common usage of oil reward flowers.

Key Words: buzz pollination, *Byrsonima lucida*, *Centris errans*, *Centris lanosa*, oil-reward flowers

RESUMEN

La abeja neotropical, *Centris nitida* Smith, se ha naturalizado en el sureste de Florida. Esta abeja peluda de color amarillo y negro ha sido confundida con la cercana especie, *C. lanosa* Cresson, una abeja nativa que es restringida al norte de Florida y al Suroeste Americano y a la región adyacente de México. Las hembras de *C. nitida* son más pequeñas que las de *C. lanosa* y *C. errans* Fox, un centris peludo de color marrón que es nativo y simpátrico con *C. nitida* en el sur de Florida. Las tres abejas Centris que actualmente ocurren en Florida se separan fácilmente por sus marcas faciales distintas. *Centris nitida* es una abeja poliléctica que colecta aceite y que se observaron visitar las flores de 27 especies en nueve familias de plantas, incluyendo 8 especies con flores de de recompensa con aceite en la familia Malpigiáceae, y 10 especies de flores de polinización por zumbido en las familias Fabaceae y Solanaceae en el sur de Florida. El establecimiento de *Centris nitida* puede tener consecuencias ambientales por la polinización de seleccionadas plantas nativas, ornamentales, a invasivas, además posible competencia con la abeja nativa simpátrica *C. errans* por el uso común de de las flores de recompensa de aceite.

Translation provided by the authors.

The genus *Centris* (Apidae: Centridini) contains about 144 species of bees which are Neotropical in distribution, except for few species ranging into the Neartic and Araucarian regions (Michener 2000). Many female *Centris* species are highly specialized collectors of floral oils, which they use to provision their brood and/or in the construction of their nest cells (Simpson et al. 1977; Buchmann 1987). The few *Centris* species that occur in the United States are limited to warm climate areas of the Southwest and Florida (Snelling 1984). Florida has 2 native *Centris* spp.: *C. errans*, formerly *C. versicolor* (F.) and often cited as such (Snelling 1984), and *C. lanosa* (Mitchell 1962; Snelling 1984). In this paper, we report the naturalization of *C. nitida* Smith, a tropical American species, which now appears to be common and widespread in southeastern Florida and in Sarasota on the Gulf coast. We describe the circumstances in which we discovered the occurrence of *C. nitida* in Florida. *Centris nitida* occurs widely in tropical America, with South American collections (Ecuador and Columbia), Central America (Belize, Costa Rica, Honduras, and El Salvador), and numerous collections from many parts of Mexico (Snelling 1984). Droege (2007) adds collec-

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tions from Peru and Bolivia, and single 1985 Ricon Mountains, Pima Co., Arizona collection by Minckley (Droege et al. 2007). There may be some uncertainty about this Arizona occurrence because Snelling (1984) indicated that previous Arizona collections identified as *C. confinis* (Perez), a synonym of *C. nitida*, were misidentified.

Material and Methods

Centris nitida's native range was determined from collection data from specimens in the Snow Entomology Museum Collection, University of Kansas, and the American Museum of Natural History, New York, and posted on the Discover Life Website (Droege et al. 2007) and Snelling (1984). We illustrated the differences in facial color patterns of *C. nitida* and Florida's 2 native *Centris* with a photomontage system at the Florida Department of Agriculture and Consumer Services in Gainesville. To quantify size differences in these bees, we made measurements on specimens of *C. nitida* that we collected in Broward and Miami-Dade Counties, and of *C. lanosa* and *C. errans* from the Florida State Collection of Arthropods (FSCA) (Table 1). We also measured the 2 specimens of male *C. nitida* that were available at the FSCA to increase the sample size. Using a dissecting microscope, we measured the width of the dorsal surface of the thorax inclusive of the wing inserts, the length of the thorax, and the length of the abdomen. We summed the 2 measures of length and then multiplied that by the thorax width to obtain body sizes for the 3 species. We used One-Way ANOVA to determine the differences in body size among the 3 species. Bonferroni tests were used for post hoc pairwise comparisons. Male and female bees were analyzed separately. All statistical analyses were carried out with SPSS 13.0 (SPSS, Inc., Chicago).

Furthermore, we clarified the confusion surrounding the distribution of *C. lanosa* in Florida based on information in Snelling (1984), from J. Neff (University of Texas, Austin), and collection data of all *C. lanosa* specimens from various sources that we examined. In addition, we determined the distribution and the activity period for *C. nitida* from multiple information sources. Firstly, one of us (RWP) made observations on *C. nitida* in a Broward residential yard with a diverse flowering species including oil flowers from Sep 2004 to Jul 2006, during which time the bee was presumed to be *C. lanosa*. Secondly, we made observations and collections frequently in 2 residential gardens, 1 mentioned above, the other in Miami-Dade County, which harbored 15 plants of *Brysonima lucida* Rich. Ex Kunrh. (Malpighiaceae), a native oil reward flower species, during Mar to Sep 2007, after the identity of *C. nitida* became clear to us. Thirdly, we made 5 observation and collection trips to 5 rocky pinelands, the prime habitat for *B. lucida*, during Mar to May 2007, the peak flowering period of *B. lucida* in Miami-Dade and Monroe Counties, and 7 trips to the Fairchild Tropical Botanic Garden in Miami-Dade, where several large plants of *B. lucida* and many introduced species of oil reward flowers were planted. Fourthly, from Mar to Sep 2007 we visited Home Depot home improvement stores in Broward, Miami-Dade, Monroe, Martin, and Palm Beach Counties in southern Florida, and in Orlando, Orange County, in central Florida to observe whether or not *C. nitida* was present on the floral displays of *Angelonia angustifolia* Benth. (Scrophulariaceae), a popular ornamental plant with oil reward flowers. Because *C. nitida* predictably used *A. angustifolia* at the Home Depot stores in Broward and Miami-Dade Counties where the bee was known to be present, we used the Home Depot visits as a supplemental indicator of the bee's presence or absence elsewhere. We also determined the distribution and activity period for *C. errans* based on our observations and collections during the same periods mentioned above. Finally, we summarized host plant information of the sympatric *C. errans* and *C. nitida*. Representative specimens of both bees will be placed in the Florida State Collection of Arthro-

Table 1. *Centris* species body size (thorax length + abdomen length) × thorax width (mm^2) comparison. Six of the 8 males and all females of *C. nitida* were collected from southern Florida, and all other specimens were sampled from the collection of the Florida State Museum of Arthropods. Different letters indicate a statistical difference in body size of different species.

Sex	Bee species	*n*	Mean body size (total length × thorax width mm^2)	Std. Error
Female	*C. errans*	10	64.64 a (11.15 × 5.79)	1.84
	C. lanosa	3	61.99 a (11.81 × 5.24)	4.58
	C. nitida	10	52.14 b (10.64 × 5.01)	1.26
Male	*C. errans*	10	58.80 a (10.16 × 5.79)	1.89
	C. lanosa	10	54.17 a (9.70 × 5.59)	2.44
	C. nitida	8	52.68 a (10.27 × 5.13)	1.60

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pods in Gainesville, the American Museum of Natural History in New York, and the Snow Entomology Museum Collection, University of Kansas in Lawrence.

RESULTS

Discovery of *C. nitida* in Southern Florida

We first encountered *C. nitida* in Ft. Lauderdale, Broward County in southeastern Florida in 2004, while making observations of the recently naturalized orchid bee *Euglossa viridissima* Friese (Pemberton & Wheeler 2006). Both the orchid bee and *C. nitida* were commonly seen collecting (buzzing) pollen from the flowers of cultivated *Senna* and some *Solanum* species. *Centris nitida* also was observed collecting oil from the flowers of the cultivated native *B. lucida* in the same residential garden in Ft. Lauderdale. This bee was presumed to be *C. lanosa*, a similar-sized black and yellow species known to occur in Florida (Mitchell 1962), and reported from Miami-Dade County (Pascarella et al. 1999; Pascarella 2007). However, attempts to confirm the bee's identity with the keys in Mitchell (1962) and the keys in Pascarella (2007)—his Bees of Florida website (based on Mitchell's keys) failed. The bee was subsequently successfully keyed as *C. nitida* with the *Centris* key on Discover Life website (Droege et al. 2007). Correspondence with S. Droege, the lead author of the Discover Life Apoideae section (along with S. Kolski, J. Ascher, and J. Pickering), indicated that the inclusion of *C. nitida* in the key as a species known from Florida, was based on his collection of 2 male *C. nitida* along a Palm Beach County, Florida canal on Jan 26, 2005. Those bees were identified by John Ascher, who compared them to specimens in the American Museum of Natural History collection.

We examined the 2 specimens included in the Pascarella's 1999 paper and website (2007) records for *C. lanosa* in Miami-Dade County, and found them both to be *C. nitida*. These specimens (housed in the K. Waddington laboratory, Department of Biological Sciences, University of Miami) were collected at the Fairchild Tropical Botanic Garden and the University of Miami, Coral Gables in 1997 and identified by J. Pascarella. These specimens constitute the earliest known collections of *C. nitida* in Florida and the eastern United States. We also examined "*C. lanosa*" specimens collected a year later in 1998 by Suzanne Koptur in the Rockdale Pineland, Miami-Dade County. We determined that these specimens (housed in the Koptur Laboratory at Florida International University, Miami) also are *C. nitida.* These early collection sites, the Rockdale Pineland and the University of Miami, are ca. 11 km apart, so it appears that *C. nitida* was already relatively widespread within southeastern Miami-Dade County by 1998, occurring in both urban garden and natural environments. The misidentifications were due to *C. nitida*'s resemblance to *C. lanosa* (both are robust black and yellow medium sized furry bees) and probably to Michell (1962) listing *C. lanosa*'s distribution simply as Florida.

Distinguishing the 3 *Centris* Bees in Florida

While *C. nitida*'s yellow and black furry appearance resembles that of *C. lanosa*, this coloration distinguishes *C. nitida* from *C. errans*, which is furry brown. The color patterns of the faces of the 3 *Centris* bees differ markedly (Fig. 1). The black vertical line on the mostly cream colored clypeus of the face of female *C. nitida* readily separates it from the female of *C. lanosa*, which has a black face with a light colored band in the center just below the antennal insertions, and the female of *C. errans*, which has a black face with a white inverted "T" on the clypeus at the base. The faces of the males of these *Centris* species are yellow marked with black in distinctive patterns that separate them from each other and the females (Fig. 1).

The 3 bees also differed statistically in body size (Between groups MS = 407.57, $F_{2, 20} = 14.17$, $P < 0.001$,). Females of *C. nitida* were smaller than females of both *C. errans* and *C. lanosa* (Bonferroni tests, Table 1). Males of the 3 *Centris* species, however, were not significantly different (Between groups MS = 65.30, $F_{2, 20} = 1.43$, $P = 0.263$, one-way ANOVA, Table 1).

Centris nitida Specimens Collected in Florida

Mar: 1♂ perched next to *Cyrtopodium punctatum* (L.) Lindl. plant, 4 III 2007, Ft. Lauderdale, FL, RW Pemberton; 1♀ on *Cyrtopodium punctatum* flowers, Fairchild Tropical Botanic Garden, Coral Gables, FL, 16 III 2007, H. Liu and R.W. Pemberton; 8♀ on *Byrsonima lucida* flowers, 23 III 2007, Kendall Lakes, Miami-Dade Co. FL, H. Liu; 4♀ on *Brysonima lucida* flowers, 25 III 2007, Ft. Lauderdale, R.W. Pemberton; 1♀ on *Suessenguthia multisetosa* (Rusby) Wassh. & J.R.I.Wood flowers, 25 III 2007, Ft. Lauderdale, FL, R.W. Pemberton; 2♀ on *Cyrtopodium punctatum* flowers, 25 III 2007, Ft. Lauderdale, FL, R.W. Pemberton; 1♀ on *Byrsonima lucida* flowers, 25 III 2007, Kendall Lakes, Miami-Dade FL, H. Liu; 1♀ on *Byrsonima lucida* flowers, 27 III 2007, Kendall Lakes, Miami-Dade FL, H. Liu; 1♀ on *Byrsonima lucida* flowers, 31 III 2007, Kendall Lakes, Miami-Dade Co. FL, H. Liu. 1♀ on *Cyrtopodium punctatum* flowers, 31 III 2007, Fairchild Tropical Botanic Garden, Coral Gables, FL, R.W. Pemberton and H. Liu. Apr: 3♀ on *Angelonia angustifolia* flowers, 1 IV 2007, Ft. Lauderdale, FL, R.W. Pemberton; 1♀ on *Oncidium sphacelatum* Lindl. flowers, 5 IV 2007, Ft. Lauderdale, FL, R.W. Pem-

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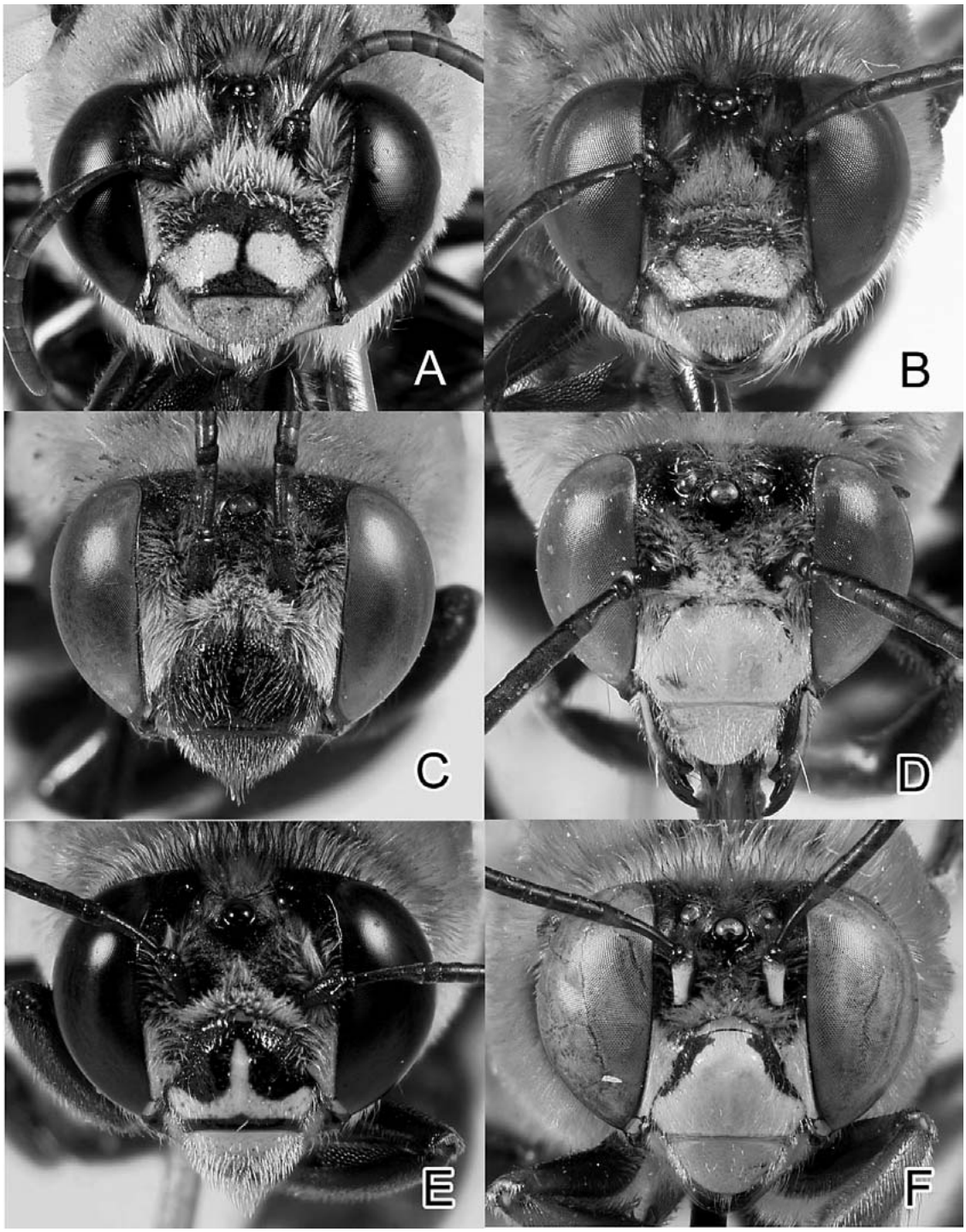


Fig. 1. *Centris* spp. collected in Florida showing the head and distinctive faces of female and male bees of: A. female *C. nitida*, B. male *C. nitida*, C. female *C. lanosa*, D. male *C. lanosa*, E. female *C. errans*, and F. male *C. errans*. The vertical black line in the center of the clypeus of female *C. nitida* readily separates this bee from the others, even in flight.

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berton; 2♀ on *Malpighia emarginata* DC. flowers, 1♂ on *Malpighia emarginata* leaf, 6 IV 2007, Davie, FL, R.W. Pemberton; 1♀ on *Angelonia angustifolia* flowers, 1♂ near *Angelonia angustifolia* flowers, 7 IV 2007, Ft. Lauderdale, FL, R.W. Pemberton; 2♀ on *Malpighia coccigera* flowers, 7 IV 2007, Davie, FL, R.W. Pemberton; 1♀ on *Malpighia "punicea"* flowers, 7 IV 2007, Davie, FL, R.W. Pemberton; 2♂ on *Bunchosia armeniaca* DC. flowers, 18 IV 2007, Davie, FL, R.W. Pemberton; 18 IV 2007, Davie, FL, R.W. Pemberton; 1♂ *Malpighia emarginata* flowers, 1♂ on *Parkinsonia aculeata* L. flowers, 28 IV 2007, West Palm Beach, FL, R.W. Pemberton. May: 1♀ on *Byrsonima lucida* flowers, 11 V 2007, Ft. Lauderdale, FL. R.W. Pemberton; 1♀ on *Brysonima lucida* flowers, 1♂ on *Brysonima lucida* flowers, 10 V 2007, Ft. Lauderdale, FL, R.W. Pemberton; 1♀ on *Malpighia emarginata* flowers, 10 V 2007, Kendall Lakes, Miami-Dade Co. FL, H. Liu; 1♂ perched near *Cyrtopodium polyphyllum* (Vell.) Pabst ex F. Barrios, 19 V 2007, Ft. Lauderdale, FL, R.W. Pemberton, 1♀ on *Cyrtopodium polyphyllum*, 23 V 2007, Boystown Pineland Park, Miami-Dade Co. FL, H. Liu & R.W. Pemberton. June: 1♀ on *Cyrtopodium polyphyllum* flowers, 6 VI 2007, Kendall Lakes, Miami-Dade Co. FL, Q. Liu; 1♀ on *Cyrtopodium polyphyllum* flowers, 7 VI 2007, Kendall Lakes, Miami-Dade Co. FL, Q. Liu. Aug: 1♀ on *Senna alata* (L.) Roxb. flowers, 22 V111 2007, Ft. Lauderdale, FL, R.W. Pemberton. Sep: 1♀ on *Senna alata* flowers, 23 IX 2007, Ft. Lauderdale, FL, R.W. Pemberton. Oct: 5♀ on *Malpighia emarginata* flowers, 1♀ on *Senna ligustrina* (L.) H.S. Irwin & Barneby flowers, 1 X 2007, Marie Selby Botanical Garden, Sarasota, FL, R.W. Pemberton. 1♀ on *Senna mexicana* (Jacq.) H.S. Irwin & Barneby flowers, 8 X 2007, Ft. Lauderdale, FL, R.W. Pemberton. Nov: 1♀ on *Malpighia emarginata* flowers, 1♂ near *Malpighia emarginata*, 3 XI 2007, Mounts Botanical Garden, Palm Beach County, FL, R.W. Pemberton. Dec: 1♀ on *Senna alata* flowers, 4 XII 2007, Fairchild Tropical Botanic Garden, Coral Gables, FL, H. Liu. January: 1♂ on *Cuphea* sp. flowers, 4♀ on *Angelonia angustifolia* flowers, 11 I 2008, Davie, FL, R.W. Pemberton. February: 1♂ on *Cuphea* sp. flowers, 1♀ on *Angelonia angustifolia* flowers, 2 II 2008, Davie, FL, R.W. Pemberton.

Other Collectors—1♀, 3♂, 1997, Fairchild Tropical Botanic Garden, Coral Cables FL, J. Pascarella; 1♀ on *Calyptranthes pallens* Griseb., 1997, Univ. Miami, Coral Cables, FL, J. Pascarella; 2♀ on *Brysonima lucida* flowers, 1 V 1998, Rockdale Pineland, Miami Dade, S. Koptur.

Centris errans Specimens Collected in Southern Florida

Mar: 2♀ on *Cyrtopodium punctatum* flowers, 16 III 2007, Fairchild Tropical Botanic Garden, Coral Gables, FL, R.W. Pemberton and H. Liu; 2♀ on *Brysonima lucida* flowers, 23 III 2007, Kendall Lakes, Miami-Dade Co. FL, H. Liu. Apr: 2♀ on *Brysonima lucida* flowers, 1 IV 2007, R.W. Pemberton and H. Liu, Navy Wells Pineland, Miami-Dade Co., FL, 3♀ on *Brysonima lucida* flowers, 14 IV 2007, Seminole Wayside Park, Homestead, FL, R.W. Pemberton. May: 1♀ on *Brysonima lucida* flowers, 6 V 2007, Ft. Lauderdale, FL, R.W. Pemberton; 1♀ on *Brysonima lucida* flowers, 1♀ on *Stigmaphyllon sagraeanum* A. Juss. flowers, 1♀ on *Galphimia gracilis* Bartl. flowers, 8 May 2007, Fairchild Tropical Botanic Garden, Coral Cables, FL, H. Liu and R.W. Pemberton; 1♀ on *Brysonima lucida* flowers, 28 V 2007, Boystown Pineland County Park, Miami-Dade Co., FL, H. Liu. Jun: 1♀ on potted *Brysonima lucida* flowers, 5 VI 2007, Boystown Pineland County Park, Miami-Dade Co., FL, H. Liu.

Distribution of *Centris* Species in Florida

Centris lanosa is restricted to the northern part of the state. We examined specimens of *C. lanosa* in the Florida Arthropod Collection, Gainesville and found they were from only 3 northern Florida counties (Alachua, Clay, and Gilchrist). These were the only specimens listed by Snelling (1984). *Centris lanosa* has a disjunct distribution occurring in Kansas, Texas, Oklahoma (Snelling 1984), and Arizona (J. Neff, pers. comm.), and then in northern Florida (Snelling 1984) and southern Georgia (J. Neff, pers. comm.), where its plant associate, *Krameria lanceolata* Torr. (Krameriaceae), occurs (J. Neff, pers. comm.). *Krameria lanceolata*, which has oil reward flowers gathered by females of *C. lanosa* to provision their brood, is absent from southern Florida (Wunderlin & Hansen 2003).

Our observations and collections indicate that *C. nitida* occurs in Miami-Dade, Broward, and Palm Beach Counties in southeastern Florida. We also collected this species on the Gulf coast in Sarasota about 60 km south of Tampa. The Sarasota collection site is ca. 260 km from the nearest collection site in southeastern Florida (West Palm Beach in Palm Beach County). Interestingly, the bees were commonly observed to gather oils from the flowers of potted plants of *A. angustifolia* at Home Depot stores in both Broward and Miami-Dade Counties. It was not unusual to see multiple bees foraging on the flowers of the potted plants in these stores at the same time. However, we did not observe *C. nitida* in a Monroe County Home Depot store, or in the Navy Wells Pineland natural area 2 km north of the Everglades National Park, or in the pinelands on Big Pine Key, Monroe County, when *B. lucida* was abundant and in peak bloom. Similarly, we did not detect *C. nitida* on *A. angustifolia* at the visited Home Depot stores in Martin or Orange Counties. This may indicate that *C. nitida* may not have yet reached the ENP, Monroe County, the southern most part of southern Florida, or north of Palm Beach County on the

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southeastern coast. Although one of the early collections of *C. nitida* was from the Rockdale pineland in 1998, our survey in pine rocklands did not locate the bee.

The specimen data for our *C. errans* collections indicate that this species has a larger geographic range, a greater number of floral species associations, and a longer activity period in Florida than previously understood. This bee was thought to be limited to the pine rockland habitats of Miami-Dade and Monroe Counties, where its native oil reward species, *B. lucida*, occurs (Pascarella 2007). We collected a single bee from the flowers of a cultivated *B. lucida* planted in a Ft. Lauderdale garden in Broward County, which is one county north of Miami-Dade County, and well beyond the natural range of the plant.

Centris nitida and *Centris errans* Floral Records in Florida

Centris nitida was observed visiting the flowers of 28 species in 10 different plant families to collect pollen, edible oil, and nectar (Table 2); the bee appears to be polylectic. *Centris errans*, by contrast, was observed to visit the flowers of only 5 species (Table 2). Females of both *C. nitida* and *C. errans* collect the edible oil rewards of flowers to provision their brood or construction of nests. *Centris nitida* was observed to visit 8 oil reward flower species in 5 genera of the Malpighiaceae; all but 1 were introduced ornamental plants, and a single species in the Schrophulariaceae, *A. angustifolia*, an introduced ornamental plant, native to South America (Table 2). *Centris errans* was observed to visit 3 oil reward flower species belonging to the Malpighiaceae, 2 of which were introduced ornamentals, whereas 1 is native to southern Florida (Table 2).

Females of both *Centris* species are able to buzz poricidal (opening by terminal pores) anthers of flowers to remove pollen. *Centris nitida* was observed to buzz flowers of 10 species of plants in the genera *Exacum*, *Lycianthes*, *Senna* and *Solanum* to collect pollen (Table 2), while *C. errans* was observed to buzz flowers of *Chamaecrista keyensis* (Liu & Koptur 2003). Territories of male *C. nitida* territories were observed on and around small *Malpighia emarginata* trees in 4 places in 3 counties. Male territories also were seen near potted plants of *A. angustifolia*, *Galphimia gracilis* (Malpighiaceae), and *Cyrtopodium punctatum*. Both *C. nitida* and *C. errans* visited orchid flowers (Table 2), but the details of these interactions (Pemberton & Liu, unpublished data) will be reported elsewhere.

Phenology of *Centris nitida* and *C. errans* in Florida

From 2004 to 2006, observations of adult *C. nitida* activity, in conjunction with studies of *E. viridissima*, indicate that *C. nitida* to be present during the months Apr, May, Jun, Jul, Sep, Oct, Nov, and Dec. Attempts to collect *C. nitida* in 2007 from Mar through Feb successfully located bees in every month, although they were more abundant in the spring and summer months.

We collected *C. errans* from Mar to Jun. The May and Jun collections were after the recognized adult activity period of Mar to Apr (Michell 1962).

Discussion

Environmental impacts related to the naturalization of *C. nitida* may occur primarily through the bee's pollination of selected native, ornamental, and invasive plants. Twenty two of the 28 species (78.6%) visited by *C. nitida* are introduced plants in Florida, 7 of these plants were naturalized, while 1, *Senna pendula* (L) Roxb., is a Category I invasive plant (http://www.fleppc.org). The value of urban landscapes in providing the specialized flowers needed by native *Centris* has been recently discussed by Koptur (2006). However, introduced oil reward flower species in urban landscapes could promote mutualism with *C. nitida* and lead to increased abundance of these plants and the bee. *Centris nitida* appears to be polylectic because of the large number of plant species it visits. In contrast, the close association of *C. errans* with *B. lucida* coupled with our observations of the bee visiting only 2 other species of Malpighiaceae, suggests that it is oligolectic. Mitchell (1962), however, lists flower records for *C. errans* that include 5 additional genera and families: *Borrichia* (Asteraceae), *Carambola* (Oxalidaceae), *Eugenia* (Myrtaceae), *Ocimum* (Labiaceae), *Securidaca* (Polygalaceae).

It appears that *C. nitida* has a disjunct distribution, in southeastern Florida and in the Sarasota area of the west coast, 2 well separated areas. We do not know if *C. nitida* occurs between these areas. Surveys in Naples on southwest coast failed to detect the bee. The disjunct distribution raises the possibilities of 2 separate introductions of this bee to Florida. Alternatively, *C. nitida* could have been introduced to one area, and then subsequently spread or was moved to the other. Because *C. nitida* is known to nest within wood (Frankie et al. 1993), it may have been introduced as a nest within wood or hollow wooden objects. The recently introduced orchid bee (*E. viridissima*) also nests within enclosed spaces (Scov & Wiley 1995), which suggests that it may have also been imported as a nest(s). All but 1 of the 17 bees accidentally imported and established in North America live in hollow plant stems or other preformed cavities (Ascher 2001), supporting the idea that bees with this type of nests are more able to naturalize than bees that are ground nesters.

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TABLE 2. FLOWER SPECIES VISITED BY *CENTRIS NITIDA* AND *C. ERRANS* IN SOUTHERN FLORIDA. OBSERVATIONS ARE THE AUTHORS EXCEPT WHERE INDICATED BY FOOTNOTES. NATIVE SPECIES ARE IN BOLD, AND NATURALIZED SPECIES ARE UNDERLINED. INTERACTIONS WITH ORCHID SPECIES WILL BE DISCUSSED IN DETAIL ELSEWHERE.

Plant family and species	Resource collected	*Centris nitida*	*Centris errans*
Acanthaceae			
Suessenguthia multisetosa	Nectar	X	
Fabaceae			
Bauhinia blakeana	Nectar	X	
Chamaecrista keyensis[1]	Pollen		X
Parkinsonia aculeata	Pollen	X	
Senna alata	Pollen	X	
Senna ligustrina	Pollen	X	
Senna mexicana	Pollen	X	
Senna pendula	Pollen	X	
Gentianaceae			
Exacum affine	Pollen	X	
Lythraceae			
Cuphea sp.	Nectar	X	
Malpighiaceae			
Brysonima lucida	Oil	X	X
Bunchosia armenica	Oil	X	
Galphimia gracilis	Oil	X	X
Malpighia coccigera	Oil	X	
Malpighia emarginata	Oil	X	
Malpighia linearis	Oil	X	
Malpighia punicea[2]	Oil	X	
Stigmaphyllon sagraenum	Oil	X	X
Myrtaceae			
Calyptranthes pallens[3]	Pollen and nectar?	X	
Orchidaceae			
Cyrtopodium polyphyllum	None	X	
Cyrtopodium punctatum	None	X	X
Oncidium sphacelatum	None	X	
Scrophulariaceae			
Angelonia angustifolia	Oil	X	
Solanaceae			
Lycianthes rantonnetii	Pollen	X	
Solanum seaforthianum	Pollen	X	
Solanum sisymbrifolium	Pollen	X	
Solanum wenlandii	Pollen	X	
Solanum wrightii	Pollen	X	
Verbenaceae			
Stachytarpheta urticifolia	Nectar	X	

[1]Liu & Koptur 2003.
[2]Horticultural name, botanical name uncertain.
[3]J. Pascarella collection, see others' collection records.

The occurrence of *C. nitida* in the Ricon Mountains, Pima County, Arizona appears to be in USDA Hardiness Zone 9 (http://www.cobraplant.com/Zone.GIF). The distribution of *C. nitida* in southeastern Florida is within USDA Hardiness Zone 10b. Zone 9 occupies the northern 2/3 of the Florida peninsula, extending to the Georgia border along the east coast and almost to Cedar Key on the west coast of Florida. If *C. nitida* is dependent on oil reward flowers, it would need to use the flowers of ornamental members of the Malpighiaceae or the common ornamental herb *A. angustifolia*, which it already uses in southern and southwestern Florida, to extend northward.

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The bee already occurs in Broward, Palm Beach, and Sarasota Counties, north of the distribution of *B. lucida*, the only oil reward flower plant native to southern Florida. When it reaches the central and northern Florida peninsula, it could encounter *K. lanceolata*, another native plant with oil reward flowers. As mentioned above, this plant fosters the presence of *C. lanosa* in both northern Florida and in Texas and Arizona. Although not detected in this study, *C. nitida* could spread into the Everglades National Park and in the Florida Keys (Monroe County), where *B. lucida* is abundant in understory of the rocky pinelands. Only a single *C. nitida* was detected in the surveyed rocky pinelands in this study, although it was previously collected in an urban rocky pineland in 1998 (as *C. lanosa*) by S. Koptur. This bee was commonly encountered in urban gardens and parks and this contrast suggest that *C. nitida* may continue to have a greater presence in human habitats than natural areas, which have fewer floral resources for the bee.

The naturalization of *C. nitida* in southern Florida and its potential spread to northern Florida creates the possibility of competition between this exotic bee and Florida's 2 native *Centris*. Both exploitative and interference competition have been suggested in introduced honey bee-native bee interactions (Gross & Mackay 1998; DuPont et al. 2004), and both types of competition could be involved here. There is overlap in floral oil reward plant species used by *C. nitida* and the native *C. errans* in southern Florida, as well as geographic sympatry in Broward and Miami-Dade Counties. We have observed both species to forage at the same time on *B. lucida* flowers in Miami-Dade County but did not observe aggression or apparent physical inference. Larger body size may favor *C. errans* over *C. nitida* in direct contact (interference competition), but the apparent greater abundance of *C. nitida* may favor it over *C. errans* in exploitative competition.

If *C. nitida* spreads into the range of *C. lanosa* in northern Florida, the 2 bees may compete for the resources of *K. lanceolata*. Competition for nest sites between *C. nitida* and the native *Centris* will not occur. *Centris lanosa* and *C. errans* belong to subgeneric taxa (subgenus Centris and subgenus Paracentris) in which all members nest in the ground (J. Neff, pers. comm.), while *C. nitida* is reported to nest in wood (Frankie et al. 1993). Food resource competition with non-*Centris* bees is unlikely to occur for floral oils but might occur for pollen and nectar flowers and for nest sites between *C. nitida* and other wood nesters such as some megachilid bees.

In the limited interaction involving *C. nitida* and the orchid bee (*E. viridissima*) some bumping has been observed among bees at the flowers of *Senna* species with poricidal dehiscent anthers, but the bees appeared to be only momentarily deflected from foraging. Because these tropical bees have naturalized in subtropical southern and southwestern Florida relatively recently, their long-term persistence, environmental interactions, and impacts are unknown. The outcomes of potential competition between *C. nitida*, *E. viridissima* and other bees in Florida also will depend on their foraging patterns in relationship to resource availability (Schaffer et al. 1979). More studies are needed to understand the impacts of these newly naturalized solitary bees on Florida's environments.

Although naturalized bees are relatively rare compared to naturalized plants, increasing numbers of exotic bees are being detected in temperate North America (Ascher 2001). Until recently only 3 exotic bees, *Apis mellifera* L., *Megachile lanata* (Fabricius) and *M. concinna* Smith, were known from Florida (Deyrup et al. 2002). With the recent naturalizations of *E. viridissima* (Pemberton & Wheeler 2006) and *C. nitida* the number of exotic bees in Florida has almost doubled.

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