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THE DIVERSITY OF INSECTS VISITING FLOWERS OF SAW PALMETTO (ARECACEAE)

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Abstract

A survey of insect visitors on flowers of *Serenoa repens* (saw palmetto) at a Florida site, the Archbold Biological Station, showed how nectar and pollen resources of a plant species can contribute to taxonomic diversity and ecological complexity. A list of 311 species of flower visitors was dominated by Hymenoptera (121 spp.), Diptera (117 spp.), and Coleoptera (52 spp.). Of 228 species whose diets are known, 158 are predators, 47 are phytophagous, and 44 are decomposers. Many species that visited *S. repens* flowers also visited flowers of other species at the Archbold Biological Station. The total number of known insect-flower relationships that include *S. repens* is 2,029. There is no evidence of oligolectic species that are dependent on saw palmetto flowers. This study further emphasizes the ecological importance and conservation value of *S. repens*.

Key Words: pollination, flower visitor webs, pollinator diversity, floral resources, saw palmetto, *Serenoa repens*

Resumen

Un estudio sobre los insectos que visitan las flores de Serenoa repens (palma enana americana o palmito de sierra) en un sitio de la Florida, la Estación Biológica Archbold, mostró cómo los recursos de néctar y polen de una especie vegetal puede contribuir a la diversidad taxonómica y complejidad ecológica. Una lista de 311 especies de visitantes de flores fue dominada por los Hymenóptera (121 spp.), Diptera (117 spp.) y Coleoptera (52 spp.). De las 228 especies cuyas dietas son conocidas, 158 son depredadores, 47 son fitófagos, y 44 son descomponedores. Muchas de las especies que visitaron las flores de S. repens también visitaron las flores de otras especies en la Estación Biológica Archbold. El número total conocidos de relaciones entre insectos y flores que incluye S. repens es 2029. No hay evidencia de especies oligolecticas que dependen de las flores de la palma enana americana. Este estudio destaca además la importancia ecológica y el valor para la conservación de S. repens.

Palabras Clave: polinización, redes de visitantes de flores, diversidad de polinizadores, recursos florales, palma enana americana, palmito de sierra, Serenoa repens

Generalized flower visitor systems are complex community affairs, diverse and dynamic, with species of plants forming nexuses in an ecological web (Olesen & Jordano 2002, Memmott 1999). Saw palmetto, *Serenoa repens* (Bartram) Small (Arecaceae) is an example of a common species whose copious production of nectar and pollen should make it an important node in a local ecological network. A survey of the assortment of insects whose activities are fueled by nectar and pollen of saw palmetto flowers might illuminate part of a larger ecological network.

This survey had the following goals: 1. To document the taxonomic diversity of insects supported by nectar and pollen of saw palmetto at a single site. 2. Examine qualitative ways in which saw palmetto flowers support invertebrate food webs, including additional trophic roles (e.g. predator, parasite) by providing energy and nutrients to insects. 3. Characterize saw palmetto as a node in a flower-visitor network by quantifying additional floral hosts of saw palmetto flowers. 4. Investigate whether there is a group of specialized insects dependent on saw palmetto flowers, and whether pollen-feeders, especially bees, are more likely to belong to this hypothetical specialized group.

Saw palmetto is recognized as a foundation species (Takahashi et al. 2011) in landscapes of the Atlantic Coastal Plain of southeastern North America. It dominates extensive habitats (Hilmon 1969; Abrahamson & Hartnett 1990), provides edible fruits for numerous vertebrates and shelter for many more (Maehr & Layne 1996), and determines landscape processes by facilitating

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fires that rapidly propagate among highly inflammable palmetto clumps (Abrahamson & Hartnett 1990). Individual plants are clonal and capable of extreme longevity, in the range of thousands of years (Takahashi et al. 2011). The abundance and long-term stability of individual saw palmettos suggests that this species should be a foundation species in flower visitor networks as well.

Serenoa repens is a southeastern endemic that is the only member of its genus (Henderson et al. 1995). Its range extends relatively far north into zones that have regular sub-freezing winter temperatures, including northern Florida, coastal Alabama and Mississippi, the coastal plain of Georgia, and a strip along southern coastal South Carolina (Hilmon 1969). It is adapted to frequent fires (Tomlinson 1990), showing rapid vegetative recovery following fire (Hilmon 1969; Abrahamson & Abrahamson 2006), and increased, often accelerated flowering following fire (Hilmon 1969; Abrahamson 1999). Saw palmetto forms shrub-like ground vegetation that covers large portions of the southeastern Coastal Plain, especially in flatwoods and prairie communities that have sandy soil and a seasonally high water table (Hilmon 1969). Saw palmetto provides insects with seasonal nectar and pollen resources over a wide geographic area, including about 50% of Florida's land area (Abrahamson & Hartnett 1990). In many parts of this area, however, flower visitor diversity is likely to be limited by periodic flooding or high water tables that affect species with subterranean larvae, including most bees and sphecid wasps. Frequent fires in saw palmetto habitats may affect populations of flower-visiting insects that nest in dead wood or hollow twigs, such as some Vespidae and Megachilidae.



Fig. 1. Flowers of *Serenoa repens*.

Individual flowers (Fig. 1) are bisexual, with three carpels and six exerted stamens bearing anthers that produce yellowish pollen. The stigma is also exerted, slightly shorter than the stamens. The flower is shallow enough that nectar can be obtained by insects with relatively short mouthparts, such as those of most sphecid wasps. Flowers are spirally arranged on tomentose branchlets on a large inflorescence with three to four order branching (Henderson et al. 1995). The inflorescence (Fig. 2) is usually sheltered and partially hidden by leaves, but is conspicuous because of its large size and strong fragrance. Each flower is open 3-4 days, with the most pollen available the first day and the stigma usually receptive after the first day (Carrington et al. 2003). Saw palmetto appears to require insect pollination, and there is some indication that cross-pollination increases fruit set (Carrington et al. 2003). The heavy blooming with multiple inflorescences that can occur on a single saw palmetto plant may reduce the incentive for insect pollinators to visit a series of plants.

Field Site and Methods

The study site is the Archbold Biological Station (ABS) (N 27° 11' W 81° 21'), a 2001.6 ha private research station 12 km south of the town of Lake Placid in Highlands County, Florida. The ABS is located on the Lake Wales Ridge, a sand ridge about 160 km long with an unusual concentration of endemic plants and animals (Neil 1957; Turner et al. 2006), including insects (Deyrup 1990). Saw palmetto occurs in 8 of the native plant associations, representing more than 10% cover in 5 of these (Abrahamson et al. 1984). It achieves 36%-77% cover in 3 different flatwoods associations, and 16%-22% cover in 2 Florida scrub associations (Abrahamson et al. 1984). These palmetto-rich habitats together cover about 1110 ha on the ABS (Abrahamson et al. 1984). The climate of the ABS is generally subtropical, with wet rainy summers and dry winters, but short cold periods well below 0 °C during the winter may inhibit some plants and insects (Abrahamson et al. 1984). Soils are primarily silica sand, low in plant nutrients and usually acidic, ranging from excessively well-drained to poorly drained (Abrahamson et al. 1984). Natural habitats with saw palmetto at the ABS are managed with fire to maintain low vegetation characteristic of saw palmetto habitats.

Insect flower visitors were collected from saw palmetto as part of a long-term survey of all flower visitors on flowers of all species in all habitats at the ABS. This project was begun in 1984 and has continued, sometimes at a low level, up to the present. This has been a simple diversity survey: no attempt was made to assess the abundance of

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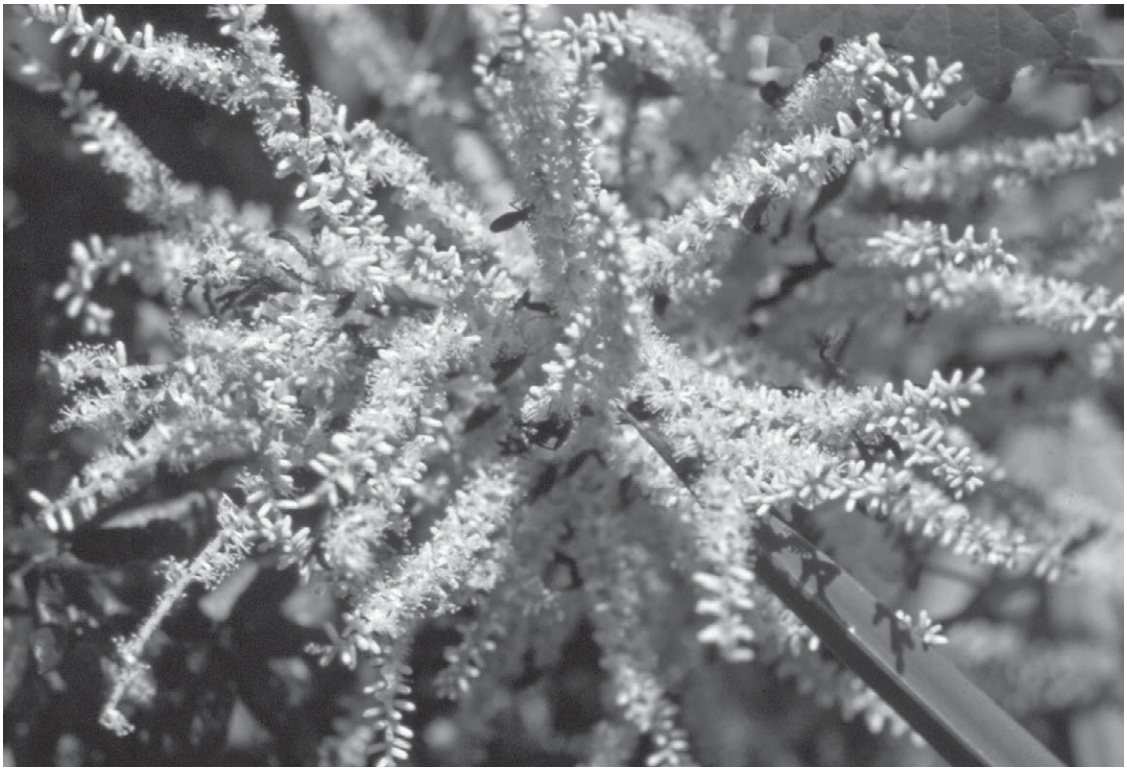


Fig. 2. Inflorescence of *Serenoa repens*.

insect species or pollination effectiveness on species of floral hosts, nor was there any attempt to devote equal effort to each plant species.

Insects were observed on saw palmetto inflorescences to assess whether they were collecting floral resources, rather than utilizing the inflorescence in some other way, such as an observational perch. Vouchers were collected and made into standard museum specimens, their labels including the floral host. Every flower visitation record cited in this survey has at least one associated pinned, labeled voucher specimen in the ABS arthropod collection. Identifications are by the authors and by a number of specialists listed in the acknowledgement section below. Collections were made by the authors and by a succession of entomology interns listed in the acknowledgement section below.

Results

Results are summarized in Table 1, which lists 311 species encountered, the number of additional flower records from the ABS, the diet of each species in addition to nectar or pollen of saw palmetto, and the source of the latter information. It is assumed that species whose diets have been studied elsewhere have similar trophic roles at the ABS.

Taxonomic Diversity of Insects Supported by Saw Palmetto Flowers

Hymenoptera. This order includes the largest number of species visiting saw palmetto flowers at the ABS. These species represent 15 out of 49 Hymenoptera families recorded at the ABS (30.6%). Of the 121 species, 116 belong to 6 superfamilies that comprise the aculeate wasps and bees. Bees (Apoidea) seem to be much commoner on saw palmetto flowers than sphecid wasps, according to casual observations at the ABS, and more methodical observations by Carrington et al. (2003). Nevertheless, the number of species of saw palmetto flower-visiting Sphecidae (37) is greater than that of bees (29). The known sphecid fauna at the ABS (129 species) is larger than that of bees (113 species), but the percentage of sphecid species visiting saw palmetto flowers is slightly higher (28.7%) than that of bees (25.7%). Pollen-collecting by bees at the ABS on saw palmetto is largely restricted to extreme generalists such as *Bombus impatiens*, *Apis mellifera*, and Halictidae in the genus *Lasioglossum* and in the tribe Augochlorini. Saw palmetto pollen might be deficient in nutrients or repellent for most bees; this possibility is mentioned by Deyrup et al. (2002). Among other aculeate families with 10 or more species visiting saw palmetto flowers at

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TABLE 1. *SERENOA REPENS* FLOWER VISITORS AT THE ARCHBOLD BIOLOGICAL STATION.

Order/Family	Species	AFR[1]	Role	Source
Blattaria				
Blattidae	*Eurycotis floridana* (F. Walker)			
	Periplaneta australasiae (Fabricius)			
Blattellidae	*Cariblatta lutea* Saussure & Zehntner			
Neuroptera				
Chrysopidae	*Nodita floridana* (Banks)		Predator of small insects on vegetation	(ABS)
Coleoptera				
Carabidae	*Calleida fulgida* Dejean		Predator of Chrysomelidae	(ABS)
	Cymindis limbalis Dejean		Predator prey unknown (genus)*	(Ball & Bousquet 2001)
	Galerita bicolor (Drury)			
	Lebia viridis Say		Predator of beetle pupae (genus)*	(Ball & Bousquet 2001)
Scarabaeidae	*Diplotaxis bidentata* LeConte		Phytophagous on roots (genus)*	(Ratcliff et al. 2002)
	Euphoria limbalis Fall		Decomposer of rotten wood	(Blatchley 1910)
	Euphoria sepulchralis (Fabricius)	2	Decomposer of decaying plants	(Ritcher 1966)
	Trichiotinus lunulatus (Fabricius)	6	Decomposer of rotten wood	(Ritcher 1966)
	Trichiotinus rufobrunneus (Casey)	6	Decomposer of rotten wood	(Ritcher 1966)
	Trigonopeltastes delta (Forster)	18	Decomposer of palm bracts	(Ritcher 1966)
	Trigonopeltastes floridana (Casey)	3	Decomposer (genus)*	(Ritcher 1966)
Scirtidae	*Cyphon* sp. A			
	Cyphon sp. B			
Elateridae	*Anchastus asper* LeConte			
	Neotrichophorus carolinensis Schaeffer			
Lycidae	*Calochromus perfacetus* (Say)		Decomposer & mycetophagous (family)+	(Lawrence 1991a)
	Lycus lateralis Melsheimer	3	Decomposer & mycetophagous (family)+	(Lawrence 1991a)
	Plateros flavoscutellatus Blatchley	2	Decomposer & mycetophagous (family)+	(Lawrence 1991a)
Lampyridae	*Pyractonema angulata* (Say)		Decomposer & mycetophagous (family)+	(Lawrence 1991a)
Cantharidae	*Chauliognathus marginatus* (Fabricius)	17	Predator of small insects (genus)*	(Blatchley 1910)
	Polemius laticornis Say			
	Tytthonyx flavicollis Blatchley			
Dermestidae	*Attagenus fasciatus* (Thunberg)	1	Decomposer of dry organic matter	(Ali 1993)
	Cryptorhopalum focale Beal	5	Decomposer of dead insects (genus)*	(Kiselyova 2002)
	Cryptorhopalum ruficorne LeConte		Predator of Lepidoptera eggs	(Mason and Ticehurst 1984)

[1]Additional floral hosts at the Archbold Biological Station.
*Dietary role known for species in this genus, presumed for this species.
+Dietary role known for species in this family or subfamily, presumed for this species.

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TABLE 1. (CONTINUED) *SERENOA REPENS* FLOWER VISITORS AT THE ARCHBOLD BIOLOGICAL STATION.

Order/Family	Species	AFR[1]	Role	Source
Cleridae	*Enoclerus lunatus* (Klug)	2	Predator of insects on trees (genus)*	(Foster & Lawrence 1991a)
Melyridae	*Attalus circumscriptus* Say	3		
	Attalus sp.			
	Collops subtropicus Fall	3	Predator of small insects (genus)*	(Foster & Lawrence 1991b)
Nitidulidae	*Carpophilus* sp.		Decomposer of plant matter (genus)*	(ABS)
	Epurea luteola (Erichson)		Decomposer of dead cactus	(ABS)
	Stelidota coenosa Erichson		Mycetophagous	(ABS)
Languriidae	*Pharaxonotha floridana* (Casey)		Phytophagous on *Zamia* flowers	(ABS)
Coccinellidae	*Cycloneda sanguinea* (Linnaeus)	3	Predator of Aphididae	(ABS)
Corylophidae	*Orthoperus* sp.		Mycetophagous (genus)*	(Lawrence 1991b)
Mordellidae	*Mordella atrata* Melsheimer	19	Decomposer of wood & mycetophagous (genus)*	(Lawrence 1991c)
	Mordella knulli Liljeblad	5	Decomposer of wood & mycetophagous (genus)*	(Lawrence 1991c)
	Mordella marginata Melsheimer	4	Decomposer of wood & mycetophagous (genus)*	(Lawrence 1991c)
	Mordellistena masoni Liljeblad		Phytophagous (genus)*	(Lawrence 1991c)
Tenebrionidae	*Epitragodes tomentosa* (LeConte)			
	Hymenorus sp.			
Oedemeridae	*Oxycopis thoracica* (Fabricius)	1		
Meloidae	*Pseudozonitis longicornis* Horn	1		
Scraptiidae	*Allopoda lutea* (Haldeman)	1		
Cerambycidae	*Anelaphus pumilus* (Newman)		Decomposer of hardwoods	(Lingafelter 2007)
	Elaphidion mucronatum (Say)	1	Decomposer of dead *Smilax* tubers & hardwoods	(ABS), (Lingafelter 2007) (ABS)
	Lycochoriolaus lateralis (Olivier)	3	Decomposer of dead wood	(Lingafelter 2007)
	Strangalia strigosa Newman	4	Decomposer of dead wood	(Lingafelter 2007)
	Typocerus fulvocinctus Knull	2	Decomposer of dead wood	(Lingafelter 2007)
	Typocerus zebra (Olivier)	5	Decomposer of dead wood	(Lingafelter 2007)
Chrysomelidae	*Caryobruchus gleditsiae* (Linnaeus)		Phytophagous in seeds of Arecaceae	(Kingsolver 2004)
Curculionidae	*Notolomus basalis* LeConte	2	Phytophagous in buds of *Serenoa repens*	(ABS)
Lepidoptera				
Sesiidae	*Carmenta texana* (Edwards)		Phytophagous in stems of Asteraceae	(Heppner et al. 2003)
Hesperiidae	*Wallengrenia otho* Abbot & Smith	3	Phytophagous on Gramineae	(Heppner et al. 2003)
Lycaenidae	*Calycopis cecrops* (Fabricius)	6	Decomposer of dead leaves	(Heppner et al. 2003)
	Fixsenia favonius (Smith)	2	Phytophagous on *Quercus*	(Heppner et al. 2003)
	Parrhasius m-album (Boisduval & LeConte)	3	Phytophagous on *Quercus*	(Heppner et al. 2003)

[1]Additional floral hosts at the Archbold Biological Station.
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+Dietary role known for species in this family or subfamily, presumed for this species.

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TABLE 1. (CONTINUED) *SERENOA REPENS* FLOWER VISITORS AT THE ARCHBOLD BIOLOGICAL STATION.

Order/Family	Species	AFR[1]	Role	Source
Nymphalidae	*Vanessa virginiensis* (Drury)	2	Phytophagous on Asteraceae	(Heppner et al. 2003)
Pyralidae	*Samia ecclesialis* (Guenee)		Phytophagous (genus)*	(Heppner et al. 2003)
Arctiidae	*Dahana atripennis* Grote		Phytophagous on *Tillandsia*	(Heppner et al. 2003)
	Utetheisa bella (Linnaeus)	1	Phytophagous on seeds of *Crotalaria*	(ABS)
Noctuidae	*Anicla infecta* Ochsenheimer		Phytophagous on herbaceous plants	(Heppner et al. 2003)
	Catocala consors (Abbot & Smith)		Phytophagous on *Carya*	(Heppner et al. 2003)
	Metallata absumens (Walker)		Phytophagous (genus)*	(Heppner et al. 2003)
	Mocis latipes (Guenee)		Phytophagous on Gramineae	(Heppner et al. 2003)
	Pseudaletia unipuncta (Haworth)		Phytophagous on herbaceous plants	(Heppner et al. 2003)
	Spodoptera frugiperda (Smith)		Phytophagous on herbaceous plants	(Heppner et al. 2003)
	Spodoptera ornithogalli Guenee		Phytophagous on herbaceous plants	(Heppner et al. 2003)
	Spragueia onagrus (Guenee)	3	Phytophagous (genus)*	(Heppner et al. 2003)
Diptera				
Bibionidae	*Dilophus orbatus* (Say)	2		
	Dilophus spinipes Say			
	Plecia nearctica Hardy	34	Decomposer of plant matter	(ABS)
Culicidae	*Culex* sp.		Consumes aquatic microorganisms; adult hematophagous	
Ceratopogonidae	*Allohelea johannseni* (Wirth)		Predator of small insects (genus)*	(Wirth & Grogan 1988)
	Clinohelea bimaculata (Loew)			
Tabanidae	*Chlorotabanus crepuscularis* (Bequaert)	1		
	Tabanus americanus Forster		Predator of aquatic invertebrates (genus)*; adult hematophagous	(Oldroyd 1964)
	Tabanus lineola Fabricius	4	Predator of aquatic invertebrates (genus)*; adult hematophagous	(Oldroyd 1964)
	Tabanus trijunctus Walker		Predator of aquatic invertebrates (genus)*; adult hematophagous	(Oldroyd 1964)
Mydidae	*Mydas carbonifer* Osten Sacken		Predator of subterranean Coleoptera larvae (genus)*	(Genung 1959)
	Mydas clavatus (Drury)		Predator of subterranean Coleoptera larvae (genus)*	(Genung 1959)
	Mydas maculiventris (Westwood)	3	Predator of subterranean Coleoptera larvae	(Genung 1959)
	Phyllomydas parvulus (Westwood)	1		
Stratiomyidae	*Hedriodiscus trivittatus* (Say)	2	Aquatic microorganisms (subfamily)+	(Foote 1991a)
	Odontomyia sp.		Aquatic microorganisms (subfamily)+	(Foote 1991a)
	Stratiomys floridensis Steyskal		Aquatic microorganisms (subfamily)+	(Foote 1991a)

[1]Additional floral hosts at the Archbold Biological Station.
*Dietary role known for species in this genus, presumed for this species.
+Dietary role known for species in this family or subfamily, presumed for this species.

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TABLE 1. (CONTINUED) *SERENOA REPENS* FLOWER VISITORS AT THE ARCHBOLD BIOLOGICAL STATION.

Order/Family	Species	AFR[1]	Role	Source
Bombyliidae	*Bombylius fraudulentis* Johnson	4	Predator of subterranean Hymenoptera larvae (genus)*	(Hull 1973)
	Chrysanthrax cypris (Meigen)	16	Predator of subterranean Hymenoptera larvae (genus)*	(Hull 1973)
	Chrysanthrax dispar (Coquillett)	21	Predator of subterranean Hymenoptera larvae (genus)*	(Hull 1973)
	Chrysanthrax mira (Coquillett)	17	Predator of subterranean Hymenoptera larvae (genus)+	(Hull 1973)
	Exprosopa fasciata Macquart	22	Predator of subterranean Hymenoptera larvae	(Krombein 1979a)
	Exprosopa fascipennis (Say)	22	Predator of subterranean Hymenoptera larvae	(Krombein 1979a)
	Geron senilis (Fabricius)	1	Predator of Lepidoptera larvae (genus)*	(Hull 1973)
	Geron vitripennis (Loew)	22	Predator of Lepidoptera larvae (genus)*	(Hull 1973)
	Hemipenthes sp. nr. *bigradata* (Loew)	4	Predator of Hymenoptera larvae (genus)*	(Hull 1973)
	Poecilognathus punctipennis Walker	3		
	Poecilognathus sulphurea Loew	10		
	Poecilognathus sp.	8		
	Toxophora amphitea Walker	3	Predator of Vespidae larvae	(Krombein 1967) (ABS)
	Villa sp.	19	Predator of Hymenoptera larvae (genus)*	(Krombein 1979a)
Mythicomyiidae	*Glabellula* sp.	9	Predator of Apoidea larvae (genus)*	(Hull 1973)
Syrphidae	*Allograpta exotica* (Wiedemann)		Predator of Homoptera (genus)*	(Weems 1971)
	Allograpta obliqua (Say)	13	Predator of Homoptera	(Weems 1971)
	Copestylum mexicanum (Macquart)	26	Decomposer of cactus	(ABS)
	Copestylum sexmaculatum (Palisot de Beauvois)	1		
	Meromacrus acutus (Fabricius)	3	Decomposer of rotten wood	(Perez-Banon et al. 2003)
	Ocyptamus costatus (Say)	4	Predator of Homoptera	(Wirth et al. 1965)
	Palpada agrorum (Fabricius)	36	Decomposer of plant matter (genus)*	(Perez-Banon et al. 2003)
	Pseudodoros clavatus (Fabricius)	21	Predator of Homoptera (genus)*	(Wirth et al. 1965)
	Toxomerus verticalis (Curran)	5	Consumer of pollen (genus)*	(Reemer et al. 2009)
	Trichopsomyia banksi (Curran)	2	Predator of Homoptera (genus)*	(Wirth et al. 1965)
Conopidae	*Physocephala sagittaria* (Say)	18	Predator of adult Apoidea	(Freeman 1966)
	Physocephala tibialis (Say)	2	Predator of adult Apoidea (genus)*	(Freeman 1966)
	Physoconops brachyrhynchus (Macquart)	13	Predator of adult Apoidea (genus)*	(Freeman 1966)
	Physoconops bulbirostris (Loew)	6	Predator of adult Apoidea (genus)*	(Freeman 1966)
	Physoconops floridanus Camras	1	Predator of adult Apoidea (genus)*	(Freeman 1966)
	Physoconops obscuripennis (Williston)	3	Predator of adult Apoidea (genus)*	(Freeman 1966)

[1]Additional floral hosts at the Archbold Biological Station.
*Dietary role known for species in this genus, presumed for this species.
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TABLE 1. (CONTINUED) *SERENOA REPENS* FLOWER VISITORS AT THE ARCHBOLD BIOLOGICAL STATION.

Order/Family	Species	AFR[1]	Role	Source
	Physoconops sylvosus (Williston)	5	Predator of adult Apoidea (genus)*	(Freeman 1966)
	Zodion abitus Adams	1	Predator of adult Apoidea (genus)*	(Freeman 1966)
	Zodion americanum Wiedemann	5	Predator of adult Apoidea (genus)*	(Freeman 1966)
Micropezidae	*Grallipeza nebulosa* (Loew)			
Lonchaeidae	*Lonchaea* sp.	1		
Ulidiidae	*Delphinia picta* (Fabricius)			
	Euxesta sp.	3		
	Notogramma stigma (Fabricius)		Decomposer on cactus	(ABS)
Platystomidae	*Rivellia vaga* Namba	1	Phytophagous on Legume nodules (genus)*	(Bibro & Foote 1986)
	Senopterina varia Coquillett			
Milichiidae	*Desmometopa* sp.	8		
	Milichia sp.			
	Milichiella sp.	7		
	Paramyia nitens (Loew)	12		
	Pholeomyia dispar (Becker)	2		
	Pholeomyia pseudodecora (Becker)	1		
Sepsidae	*Paleosepsis pusio* (Schiner)	9	Decomposer, organic matter (family)+	(Foote 1991b)
	Sepsidimorpha brunnipes Melander & Spuler	2	Decomposer, organic matter (family)+	(Foote 1991b)
Lauxaniidae	*Homoneura* sp.		Decomposer of leaves (genus)*	(Miller & Foote 1976)
	Poecilominettia puncticeps (Coquillett)		Decomposer of leaves (genus)*	(Miller & Foote 1976)
	Poecilominettia valida Walker	1	Decomposer of leaves (genus)*	(Miller & Foote 1976)
Trixoscelididae	*Spilochroa ornata* (Johnson)	2		
Ephydridae	*Allotrichoma abdominalis* (Williston)	16	Decomposer of aquatic organisms (genus)*	(Thier & Foote 1980)
	Ceropsilopa adjunctus Cresson	6		
	Discocerina obscurella (Fallen)	11	Aquatic microorganisms	(Foote 1995)
	Mimapsilopa cressoni L. de Grosso	5		
	Ochthera exsculpta Loew	1	Predator of aquatic invertebrates (genus)*	(Foote 1995)
	Ochthera tuberculata Loew		Predator of aquatic invertebrates (genus)*	(Foote 1995)
	Psilopa dupla Cresson	10	Phytophagous, leaf miner (genus)*	(Foote 1995)
	Ptilomyia mabelae (Cresson)	5		
	Typopsilopa sp.	1	Decomposer of plant matter (genus)*	(Foote 1995)

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TABLE 1. (CONTINUED) *SERENOA REPENS* FLOWER VISITORS AT THE ARCHBOLD BIOLOGICAL STATION.

Order/Family	Species	AFR[1]	Role	Source
Chloropidae	*Apallates dissidens* (Tucker)	12	Decomposer of plant matter (genus)*	(Mulla 1962)
	Hippelates plebjus Loew		Decomposer of plant matter (genus)*	(Mulla 1962)
	Liohippelates pusio (Loew)	15	Decomposer of plant matter	(Mulla 1962)
	Monochaetoscinella sp.	1		
	Olcella quadrivittata (Sabrosky)			
	Tricimba sp.		Mycetophagous	(ABS)
Muscidae	*Atherigona orientalis* Schiner	5	Phytophagous & decomposer of plant matter	(Butcher 1954)
	Coenosopsia prima Malloch	6		
	Coenosia sp.	2		
	Lispe sp.			
	Musca domestica Linnaeus	9	Decomposer of plant & animal matter	(ABS)
	Philornis porteri Dodge		Parasite of nestling birds	(ABS)
Calliphoridae	*Chrysomya rufifacies* (Macquart)	10	Decomposer of carrion	(Wells & Greenberg 1992)
	Cochliomyia macellaria (Fabricius)	12	Decomposer of carrion	(Wells & Greenberg 1992)
	Lucilia caeruliviridis Macquart	4	Decomposer of carrion	(ABS)
Sarcophagidae	*Amobia floridensis* (Townsend)	7	Predator of larval Hymenoptera	(Krombein 1967)
	Eusenotainia rufoventris (Coquillett)	1	Predator of larval Hymenoptera	(Krombein 1979a)
	Helicobia sp.		Decomposer of dead arthropods	(ABS)
	Oxysarcodexia ventricosa (Van der Wulp)	4	Decomposer of dung	(Downes 1965)
	Senotainia literalis (Allen)		Predator of larval Hymenoptera	(Krombein 1979a)
	Senotainia trilineata (Van der Wulp)	12	Predator of larval Vespidae	(Krombein 1967)
Tachinidae	*Archytas aterrimus* (Robineau-Desvoidy)	5	Predator of larval Lepidoptera	(Arnaud 1978)
	Chaetogaedia analis (Van der Wulp)		Predator of larval Lepidoptera	(Arnaud 1978)
	Chaetostigmoptera crassinervus (Walton)		Predator (family)+	(Arnaud 1978)
	Chetogena floridensis (Townsend)	5	Predator of larval Lepidoptera	(Arnaud 1978)
	Chetogena scutellaris (Van der Wulp)	3	Predator of larval Lepidoptera (genus)*	(Arnaud 1978)
	Crocinosoma cornuale Reinhard	7	Predator of larval Lepidoptera (genus)*	(Sabrosky &Arnaud 1965)
	Drino sp.		Predator of larval Lepidoptera (genus)*	(Arnaud 1978)
	Masiphya confusa Aldrich		Predator of Mantodea (genus)*	(Wood 1987)
	Masiphya floridana Townsend		Predator of Mantodea (genus) *	(Wood 1987)
	Paradidyma sp.	9	Predator of larval Lepidoptera (genus)*	(Arnaud 1978)
	Prosenoides flavipes Coquillett	6	Predator of larval Coleoptera.	(Sabrosky & Arnaud 1965)
	Pseudochaeta sp.		Predator of larval Lepidoptera (genus)*	(Arnaud 1978)

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TABLE 1. (CONTINUED) *SERENOA REPENS* FLOWER VISITORS AT THE ARCHBOLD BIOLOGICAL STATION.

Order/Family	Species	AFR[1]	Role	Source
	Ptilodexia sp.	2	Predator of larval Coleoptera (genus)*	(Arnaud 1978)
	Trichopoda pennipes (Fabricius)	18	Predator of adult Heteroptera	(Arnaud 1978)
	Trichopoda plumipes (Fabricius)	3	Predator of adult Heteroptera	(Arnaud 1978)
	Vanderwulpia sequens Townsend	5	Predator of larval Lepidoptera (genus)*	(Sabrosky & Arnaud 1965)
	Xanthomelanotes atripennis (Say)	2	Predator of adult Heteroptera (genus)*	(Sabrosky & Arnaud 1965)
	Zaira sp.			
Hymenoptera				
Braconidae	*Dolichogenidea* sp.		Predator of larval Lepidoptera (genus)*	(Whitfield 1997)
Leucospidae	*Leucospis affinis* Say	12	Predator of larval Apoidea	(Krombein 1967)
	Leucospis birkmani Brues		Predator of larval Hymenoptera (genus)*	(Burks 1979)
	Leucospis robertsoni Crawford	14	Predator of larval Hymenoptera (genus)*	(Burks 1979)
	Leucospis slossonae Weld	23	Predator of larval Apoidea	(Burks 1979)
Bethylidae	*Goniozus nigrifemur* Ashmead		Predator of larval Lepidoptera	(Evans 1978)
Chrysididae	*Chrysis archboldi* Kimsey		Predator of larval Hymenoptera (genus)*	(Krombein 1967)
	Chrysis inaequidens Dahlbom	1	Predator of larval Vespidae	(Krombein 1967) (ABS)
Tiphiidae	*Myzinum carolinianum* (Panzer)	18	Predator of larval Scarabaeidae (genus)*	(Krombein 1979c)
	Myzinum dubiosum Cresson	26	Predator of larval Scarabaeidae (genus)*	(Krombein 1979c)
	Myzinum maculatum (Fabricius)	2	Predator of larval Scarabaeidae (genus)*	(Krombein 1979c)
	Paratiphia texana Cameron	7	Predator of larval Scarabaeidae (genus)*	(Krombein 1979c)
	Tiphia floridana Robertson	7	Predator of larval Scarabaeidae (genus)*	(Krombein 1979c)
Mutillidae	*Dasymutilla pyrrhus* (Fox)	2	Predator of larval Sphecidae	(ABS)
	Pseudomethoca sanbornii (Fox)		Predator of larval Apoidea	(Krombein 1979c)
	Timulla ferrugata (Fabricius)		Predator of larval Vespidae	(Krombein 1979c)
Scoliidae	*Campsomeris plumipes* (Drury)	30	Predator of larval Scarabaeidae	(Krombein 1979c)
Formicidae	*Brachymyrmex obscurior* Forel		Honeydew, nectar	(ABS)
	Camponotus castaneus (Latreille)	1	Predator of insects & guards honeydew-producing Homoptera	(ABS)
	Camponotus impressus (Roger)	2	Predator of insects & guards honeydew-producing insects	(ABS)
	Camponotus inaequalis Roger		Predator of insects & guards honeydew-producing insects	(ABS)
	Camponotus nearcticus Emery		Predator of insects & guards honeydew-producing insects	(ABS)

[1]Additional floral hosts at the Archbold Biological Station.
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TABLE 1. (CONTINUED) *SERENOA REPENS* FLOWER VISITORS AT THE ARCHBOLD BIOLOGICAL STATION.

Order/Family	Species	AFR[1]	Role	Source
	Formica archboldi M.R. Smith	1	Predator and decomposer of insects	(ABS)
	Formica pallidefulva Latreille	5	Predator and decomposer of insects	(ABS)
	Monomorium viride Brown	2	Predator and decomposer of insects	(ABS)
	Paratrechina longicornis (Latreille)		Decomposer of arthropods & guards honey-dew-producing insects	(ABS)
	Pseudomyrmex ejectus (F. Smith)		Predator of arthropods	(ABS)
	Pseudomyrmex gracilis (Fabricius)	6	Predator of arthropods	(ABS)
	Solenopsis invicta Buren		Predator of arthropods & guards honeydew-producing insects	(ABS)
Vespidae	*Eumenes smithii* Saussure	9	Predator of larval Lepidoptera	(Krombein 1979b)
	Euodynerus auranus (Cameron)	1	Predator of larval Lepidoptera (genus)*	(Krombein 1979b)
	Mischocyttarus cubensis (Saussure)	9	Predator of larval Lepidoptera	(ABS)
	Monobia quadridens (Linnaeus)	8	Predator of larval Lepidoptera	(Krombein 1967) (ABS)
	Pachodynerus erynnis (Lepeletier)	34	Predator of larval Lepidoptera	(Krombein 1979b)
	Parancistrocerus histrio (Lepeletier)	1	Predator of larval Lepidoptera	(Krombein 1979b)
	Parancistrocerus saecularis rufulus Bohart	21	Predator of larval Lepidoptera	(Krombein 1967) (ABS)
	Polistes bahamensis Bequaert & Salt	1	Predator of larval Lepidoptera	(ABS)
	Polistes bellicosus Cresson	5	Predator of larval Lepidoptera	(ABS)
	Polistes fuscatus (Fabricius)	1	Predator of larval Lepidoptera	(ABS)
	Polistes metricus Say	3	Predator of larval Lepidoptera	(ABS)
	Stenodynerus australis (Robertson)	2	Predator of larval Lepidoptera (genus)*	(Krombein 1979b)
	Stenodynerus lineatifrons Bohart	10	Predator of larval Lepidoptera	(Krombein 1967) (ABS)
	Vespula squamosa (Drury)	10	Predator of arthropods	(ABS)
	Zethus slossonae Fox	18	Predator of larval Lepidoptera (genus)*	(Krombein 1979b)
	Zethus spinipes Say	16	Predator of larval Lepidoptera	(Krombein 1979b)
Pompilidae	*Ageniella obscura* Banks		Predator of Araneida (genus)*	(Townes 1957)
	Anoplius marginalis (Banks)	1	Predator of Lycosidae	(Evans 1951a)
	Aporinellus fasciatus (Smith)		Predator of Salticidae	(Evans 1951b
	Ceropales elegans quaintanzei Viereck		Predator of Pompilidae	(Townes 1957)
	Episyron conterminus posterus (Fox)	16	Prededator of Araneidae	(Evans 1950)
	Pepsis saphirus Palisot		Predator of Araneida	(Townes 1957)
	Poecilopompilus interruptus (Say)	4	Predator of Araneidae	(Evans 1950)

[1]Additional floral hosts at the Archbold Biological Station.
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TABLE 1. (CONTINUED) *SERENOA REPENS* FLOWER VISITORS AT THE ARCHBOLD BIOLOGICAL STATION.

Order/Family	Species	AFR[1]	Role	Source
	Psorthaspis legata (Cresson)		Predator of Ctenizidae	(Krombein 1979d)
	Sericopompilus apicalis (Say)	2	Predator of Araneida	(Evans 1950)
	Tachypompilus ferrugineus (Say)	2	Predator of Lycosidae	(Evans 1950)
Sphecidae	*Ammophila procera* Dahlbom	7	Predator of larval Lepidoptera	(Krombein 1979a)
	Ammophila urnaria Dahlbom	4	Predator of larval Lepidoptera	(Krombein 1979a)
	Bembecinus floridanus Krombein & Willink	5	Predator of Homoptera (genus)*	(Krombein 1979a)
	Bembix sayi Cresson	8	Predator of adult Diptera	(Krombein 1979a)
	Bicyrtes quadrifasciata (Say)	12	Predator of Heteroptera	(Krombein 1979a)
	Cerceris blakei Cresson	24	Predator of adult Coleoptera	(Krombein 1979a)
	Cerceris flavofasciata floridensis Banks	5	Predator of adult Coleoptera	(Krombein 1979a)
	Cerceris fumipennis Say	8	Predator of adult Coleoptera	(ABS)
	Cerceris rufopicta F. Smith	1	Predator of adult Coleoptera (genus)*	(Krombein 1979a)
	Chalybion californicum (Saussure)	1	Predator of Araneida	(Krombein 1979a)
	Crabro hilaris rufibasis (Banks)	3	Predator of adult Diptera	(Krombein 1979a)
	Ectemnius decimmaculatus tequesta Pate	12	Predator of adult Diptera (genus)*	(Krombein 1979a)
	Ectemnius maculosus (Gmelin)	1	Predator of adult Diptera (genus)*	(Krombein 1979a)
	Ectemnius rufipes ais Pate	25	Predator of adult Diptera	(Krombein 1979a)
	Isodontia auripes (Fernald)	4	Predator of Orthoptera	(Krombein 1967)
	Isodontia exornata Fernald	19	Predator of Orthoptera	(Krombein 1979a)
	Isodontia mexicana (Saussure)	2	Predator of Orthoptera	(Krombein 1967) (ABS)
	Larropsis greeni Rohwer	1	Predator of Orthoptera	(Krombein 1979a)
	Liris beata (Cameron)		Predator of Orthoptera	(Krombein 1979a)
	Liris fulginosa muspa (Pate)		Predator of Orthoptera (genus)*	(Krombein 1979a)
	Liris panamensis muesebecki (Krombein)	3	Predator of Orthoptera (genus)*	(Krombein 1979a)
	Oxybelus decorosus (Mickel)	9	Predator of adult Diptera (genus)*	(Bohart & Menke 1976)
	Oxybelus emarginatus Say	4	Predator of adult Diptera	(Krombein 1979a)
	Oxybelus laetus fulvipes Robertson	12	Predator of adult Diptera	ABS
	Philanthus sanbornii Cresson		Predator of adult Apoidea	(Krombein 1979a)
	Philanthus ventilabris Fabricius	18	Predator of adult Apoidea	(Krombein 1979a)
	Podium rufipes Fabricius		Predator of Blattaria	(Krombein 1967) (ABS)
	Sphecius speciosus (Drury)		Predator of adult Cicadidae	(Krombein 1979a)
	Sphex ichneumoneus (Linnaeus)	6	Predator of Orthoptera	(Krombein 1979a)

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TABLE 1. (CONTINUED) *SERENOA REPENS* FLOWER VISITORS AT THE ARCHBOLD BIOLOGICAL STATION.

Order/Family	Species	AFR[1]	Role	Source
	Sphex pensylvanicus Linnaeus		Predator of Orthoptera.	(Krombein 1979a)
	Stictia carolina (Fabricius)	1	Predator of adult Diptera	(Krombein 1979a)
	Stictiella serrata (Handlirsch)	6	Predator of adult Lepidoptera	(Krombein 1979a)
	Tachytes grisselli Bohart (5)	5	Predator of Orthoptera (genus)*	(Krombein 1979a)
	Tachytes guatemalensis Cameron	2	Predator of Orthoptera (genus)*	(Krombein 1979a)
	Tachytes mergus Fox	1	Predator of Orthoptera	(ABS)
	Tanyoprymnus moneduloides (Packard)	4	Predator of Homoptera	(Krombein 1979a)
	Trypargilum clavatum johannis (Richards)	3	Predator of Araneida	(Krombein 1967) (ABS)
Colletidae	*Colletes banksi* Swenk	3	Nectar & pollen	(ABS)
	Colletes brimleyi Mitchell	8	Nectar & pollen	(ABS)
	Colletes mandibularis Smith	22	Nectar & pollen	(ABS)
	Colletes nudus Robertson	5	Nectar & pollen	(ABS)
	Colletes sp.	6	Nectar & pollen	(ABS)
	Hylaeus graenicheri Mitchell	1	Nectar & pollen	(ABS)
Halictidae	*Agapostemon splendens* (Lepeletier)	38	Nectar & pollen	(ABS)
	Augoclora pura Say	21	Nectar & pollen	(ABS)
	Augoclorella aurata (Smith)	46	Nectar & pollen	(ABS)
	Augochloropsis metallica (Fabricius)	37	Nectar & pollen	(ABS)
	Augochloropsis sumptuosa (Smith)	41	Nectar & pollen	(ABS)
	Halictus poeyi Say	39	Nectar & pollen	(ABS)
	Lasioglossum coreopsis (Robertson)	19	Nectar & pollen	(ABS)
	Lasioglossum miniatulus (Mitchell)	22	Nectar & pollen	(ABS)
	Lasioglossum nymphalis (Smith)	55	Nectar & pollen	(ABS)
	Lasioglossum pectoralis (Smith)	17	Nectar & pollen	(ABS)
	Lasioglossum placidensis (Mitchell)	47	Nectar & pollen	(ABS)
	Lasioglossum tegulare (Robertson) sp. group	18	Necta & pollen	(ABS)
	Sphecodes heraclei Robertson	14	Predator of Apoidea (cleptoparasite)	(ABS)
Megachilidae	*Coelioxys sayi* Robertson	24	Predator of Megachilidae (cleptoparasite)	(ABS)
	Dianthidium floridiense Schwarz	21	Nectar & pollen	(ABS)
	Megachile policarius Say	5	Nectar & pollen	(ABS)
	Megachile xylocopoides Smith	14	Nectar & pollen	(ABS)

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TABLE 1. (CONTINUTED) *SERENOA REPENS* FLOWER VISITORS AT THE ARCHBOLD BIOLOGICAL STATION.

Order/Family	Species	AFR[1]	Role	Source
Apidae	*Apis mellifera* Linnaeus	73	Nectar & pollen	(ABS)
	Bombus impatiens Cresson	50	Nectar & pollen	(ABS)
	Bombus pennsylvanicus (DeGeer)	16	Nectar & pollen	(ABS)
	Epeolus erigeronis Mitchell	3	Predator of Apoidea (cleptoparasite)	(ABS)
	Epeolus glabratus Cresson	2	Predator of Apoidea (cleptoparasite)	(ABS)
	Epeolus zonatus Smith	9	Predator of Apoidea (cleptoparasite)	(ABS)

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the ABS, Formicidae are represented by 10.3% of ABS species, Pompilidae by 19.2% of ABS species, and Vespidae by 37.2% of ABS species.

Nectar and pollen of saw palmetto support activities of about 20% of approximately 575 known species of aculeate Hymenoptera at the ABS, a significant portion of the local arthropod fauna. There are undoubtedly additional species that have not been seen and recorded, especially among Sphecidae and Pompilidae. Most of these 116 aculeate Hymenoptera have alternate floral hosts at the ABS.

A scarcity of flower visitors among the great variety of parasitoid wasps in the Ichneumonoidea and Chalcidoidea is not confined to saw palmetto, but is a general unexplained pattern at the ABS and probably elsewhere. Ichneumonoids are well represented at the ABS, but the only regular flower visitors appear to be certain Braconidae in the subfamilies Agathidinae, Cardiochilinae and Microgastrinae. An unidentified species of *Dolichogenidea* (Microgastrinae) is the only braconid species known to take nectar from saw palmetto flowers at the ABS. There are few nectar feeders among the Chalcidoidea, but Leucospidae commonly feed on nectar from a wide variety of flowers, including saw palmetto, at the ABS. Leucospidae are also reported to consume pollen (Burks 1979), but this needs further investigation.

Diptera. With 117 species, the Diptera is the second best represented order among visitors to saw palmetto flowers at the ABS. These species represent 24 families, 33.3% of the 72 families of flies known from the ABS. The large suborder Nematocera contributes only 6 of these species, the remaining 111 distributed irregularly among the Brachycera. Saw palmetto nectar and pollen support activities of 19.7% of 563 Brachycera known from the ABS. Most of the 111 species of Brachycera listed in Table 2 have alternative floral hosts at the ABS. The real number of brachyceran Diptera occurring at the ABS is probably considerably greater than 563, as there are several families, such as the Chloropidae, that are poorly known. Small, uncommon brachycerans that visit saw palmetto flowers are probably greatly underrepresented in our samples. It is virtually certain that the real number of species of brachyceran Diptera that visit saw palmetto flowers at the ABS is much larger than that of aculeate Hymenoptera.

With 66 species, the Tachinidae is the largest family of Brachycera at the ABS; 17 species (25.6%) visit saw palmetto flowers. Somewhat surprisingly, only 10 (18%) of the 57 species of ABS Syrphidae have been found on saw palmetto flowers. Some common, spring-flying, generalist species in the genera *Copestylum*, *Palpada* and *Toxomerus* were not recorded from saw palmetto flowers, although these are found on other flowers blooming at the same time as saw palmetto.

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Many ABS Syrphidae regularly ingest pollen, and it is possible that pollen-feeding Syrphidae find saw palmetto pollen deficient or repellent. Pollen-feeding Bombyliidae, however, are common on these flowers: 14 out of 37 ABS species (37.8%) visit saw palmetto flowers. Conopidae and Ephydridae are each represented by 9 species on saw palmetto flowers, a number that accounts for 56.2% of the 16 ABS Conopidae, and 21.4% of the 42 ABS Ephydridae. Flower-visiting by ABS Ephydridae was discussed by Deyrup & Deyrup (2008), including a list of floral hosts.

Coleoptera. Fifty-two species of ABS Coleoptera visit saw palmetto flowers. Records are scattered through 22 families, 25.9% of the 85 families found on the ABS. The best represented family is the Scarabaeidae, with 7 species, but this is only 8.0% of the 87 ABS species. The 52 species of Coleoptera found on saw palmetto flowers represent only 3.2% of 1592 species in the unpublished list of beetles known from the ABS. Individual species of palmetto-visiting beetles, however, are no less interesting than those of other orders. *Typocerus fulvocinctus*, for example, is a rare and distinctive cerambycid endemic to peninsular Florida, known from a small number of sites in three central Florida counties (Peck & Thomas 1998).

The Ecological Network of Insects Supported by Saw Palmetto Flowers

A complex series of ecological roles is carried out by insects whose activities are fueled by saw palmetto flowers at the ABS. The insects involved include species that visit additional floral hosts, predators (including parasitoids), phytophagous species, scavenger/decomposers, and fungus feeders (Table 1). Many species have multiple roles; for example, the sphecid wasp *Oxybelus laetus fulvipes* captures calypterate flies for its larvae, but also visits 13 species of flowers at the ABS. Species that have been extensively studied at the ABS provide a glimpse of the true complexity of the ecological network of which blooming saw palmetto is a node. The vespid wasp *Parancistrocerus saecularis rufulus* visits flowers of 24 additional species at the ABS (Table 1). Larval hosts are caterpillars of at least 12 species belonging to 6 families of Lepidoptera (Krombein 1967). Larvae of this wasp, or their larval provisions, are consumed at the ABS by at least three species of Bombyliidae, one species of Phoridae, at least one species of Sarcophagidae, two species of Chrysididae, and one species of Eulophidae (Krombein 1967). All of these enemies of *P. saecularis rufulus* have known or probable alternate insect hosts at the ABS, and five are also known to visit various flowers at the ABS.

Saw palmetto flowers support a wide range of insect ecological roles chiefly by fueling adult activities of insects whose larvae have other dietary habits. Feeding and growth of holometabolous insects occurs primarily in larval stages; subsidizing activities associated with reproduction should have significant cumulative impacts on ecological webs. Of the 311 species of saw palmetto flower visitors the larval diets of 228 are known with some certainty, based on ABS records and literature records (Table 1). In some cases the larval diet of a particular species is not known but it is probable that this species shares the larval diet recorded for its congeners. For example, prey records are not known for one species of *Oxybelus* listed in Table 1, but all members of this genus prey on adult Diptera (Bohart & Menke 1976).

Predatory Species. Predators of arthropods make up the largest group of species supported by saw palmetto flowers, 158 out of 228 species (69.2%) with known diets. This group includes almost all Hymenoptera other than bees. Five species of cleptoparasitic bees are included as functional predators, bringing the number of predatory Hymenoptera up to 96 species. Other predators include almost half the Diptera, 53 out of 117 species, 8 out of 52 Coleoptera, and 1 species of Neuroptera. With the exception of a few Coleoptera and the single species of Neuroptera, no adult predatory species consume their prey, although adults of many species hunt prey.

There are 44 species visiting saw palmetto flowers that are predators of adults or larvae of other flower visitors (Table 1). We do not include predators such as crab spiders (Thomisidae) or robber flies (Asilidae) that use the inflorescence as a hunting site but do not themselves subsist on nectar or pollen. Some predatory saw palmetto flower visitors, such as conopid flies or sphecids of the genera *Ectemnius*, *Oxybelus* and *Philanthus* attack adult bees or flies. Others such as some bombyliid flies, leucospid and mutillid wasps, and parasitic bees prey on larvae of flower-visiting bees and wasps.

Flower-visiting predatory insects may be useful to individual saw palmetto plants as pollinators, but they may not provide significant additional services as predators of phytophagous species that attack saw palmetto. It is possible that the few phytophagous species known to attack this plant are kept in check by saw palmetto flower-visiting predators, but there is little evidence of this. The only indication of such a relationship is provided by the saw palmetto flower-visiting carabid beetle *Calleida fulgida*, which, like the related species *C. viridipennis* (Say) eats larvae of the palmetto-eating chrysomelid beetle *Hemisphaerota cyanea* (Say) (Eisner 2003). Saw palmetto may attract its own protective predatory insects in more direct ways: we have observed ants visiting droplets apparently produced by extrafloral nectaries on the rachis of flower spikes, and on apparent surface exudations of young fruits.

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In the ecological web of which saw palmetto is a part, predatory saw palmetto flower visitors might have a significant cumulative role in the control of phytophagous insects on other plant species. At least 68 saw palmetto flower visitors attack phytophagous insects, especially caterpillars or root-eating scarabs (Table 1).

Phytophagous Species. Phytophagous insects visiting saw palmetto flowers comprise two groups: insects whose larvae feed on pollen, and those whose larvae feed on tissues of living plants.

Species whose larvae feed on pollen or nectar and pollen include 24 species of bees and one fly. The five species of cleptoparasitic bees are not included here, as they are functional predators, even though their larvae obtain their nourishment almost entirely from pollen and nectar. None of the pollen-gathering species were observed to be "pollen robbers" on saw palmetto; that is, species that collect pollen without approaching the stigma in a way that might transfer pollen.

A narrower definition of "phytophagous" would limit the term to species that feed on tissues of living plants. At the ABS 23 such species have been observed on saw palmetto flowers (Table 1). Most of these are Lepidoptera (17 species), joined by 3 Coleoptera and 3 Diptera. The small number of strictly phytophagous species is notable, considering that over 1,100 species of Lepidoptera are known from the ABS (Minno 1992), the great majority of which are phytophagous species whose elongate mouthparts suggest an adult diet of nectar. It is probable that some nocturnal Lepidoptera that visit saw palmetto have escaped observation at the ABS.

Decomposers. Decomposers visiting saw palmetto flowers include 44 species, 19.3% of the 228 species with known trophic roles. These decomposers are mostly Coleoptera and Diptera, orders with large numbers of decomposers at the ABS. Table 1 suggests that the Diptera (other than Bibionidae) tend to feed on rapidly-decaying material that can be raked in with the mouth-hooks found in larval Brachycera, while larval Coleoptera, Lepidoptera and Diptera Nematocera are associated with more resistant materials, such as wood and leaves, that are gnawed with mandibles. About half these decomposers are Diptera, 21 species scattered among 10 families. Decomposer Lepidoptera, primarily represented at the ABS by Tineoidea and Noctuidae, have not been found on saw palmetto flowers, with the exception of *Calycopis cecrops* (Lycaenidae).

Saw Palmetto Flower Visitors as Potential Pollinators of Other Plants

Most insect species found on saw palmetto flowers have been found at the ABS on at least one other floral host. At least some of these insects must act as pollinators on these additional hosts, although no attempt was made to document this. From the perspective of pollination ecology, there are many three-way relationships between saw palmetto, its flower visitors, and alternate floral hosts of these insects. The total number of documented insect-flower-visitor relationships at the ABS that include saw palmetto is 2029 (Table 1, summarized in Fig. 3). This number is obtained by combining the number of alternate hosts for every saw palmetto flower-visiting species in Table 1.

There is no evidence that saw palmetto and other plants compete for pollinators, although such competition is possible. It would be necessary to show that certain plants are pollinator-limited, and that this limitation appears in association with the blooming of supposedly competing plants, and disappears if these plants are removed. No such experiment has been done with saw palmetto and the alternate hosts of its flower visitors. One might hypothesize that the abundance and extensive range of saw palmetto might have caused competitive displacement of the blooming period of some other species, but there is no evidence of this. Intuitively, such displacement seems unlikely because the timing of the most intense flowering by saw palmetto can be irregular due to the effect of sporadic fires that can increase and accelerate flowering in saw palmetto (Hilmon 1969; Abrahamson 1999). In a review of competition among plants for pollinators, Kodric-Brown & Brown (1979) concluded that competition for pollinators probably has a relatively weak effect on the adaptive evolution of sympatric, distantly-related plants. Intense competition, they argue, is more probable between animals dependent on floral resources. Floral diversity is more plausibly interpreted as promoting floral constancy among pollinators than as competitive displacement (Kodric-Brown & Brown 1979).

Additional Relationships Between Insects and Saw Palmetto Inflorescences

Not all insects associated with saw palmetto flowers are exclusively attracted by floral resources. As mentioned above, Conopidae and members of some genera of Sphecidae not only consume saw palmetto nectar, but also hunt other visitors as prey or hosts. Some additional predators found on saw palmetto inflorescences have not been observed consuming nectar or pollen. These include species of Asilidae, Anthocoridae, Reduviidae, Phymatidae, Eucharitidae and Thomisidae.

At the ABS many insects appear to search for mates around blooming saw palmettos. Especially conspicuous are male Hymenoptera patrolling a series of inflorescences for females, including species of Tiphiidae, Scoliidae, Vespidae, Colletidae, Halictidae and Megachilidae. These males occasionally interrupt their rapid circuits to drink

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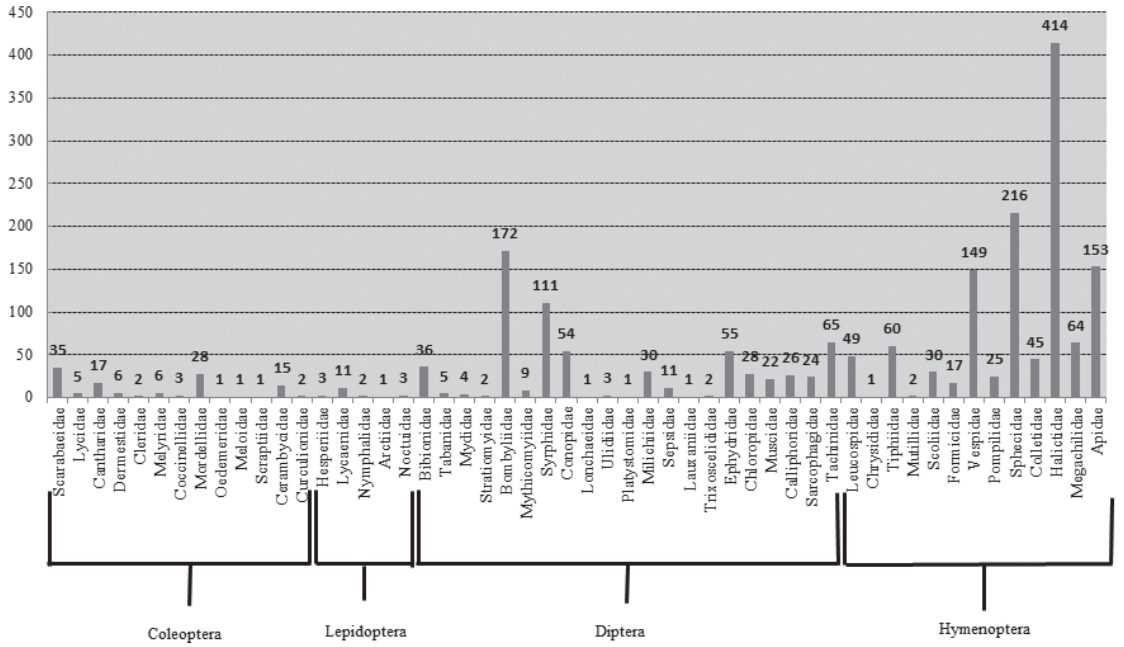


Figure 3. Numbers of additional floral relationships of species visiting flowers of *S. repens* at the Archbold Biological Station, arranged by insect order and family.

nectar. Such males are often observed to patrol a series of inflorescences, and their occasional flower visits may promote cross pollination. A few beetles in the families Lycidae, Cantharidae and Oedemeridae appear to aggregate for mating on saw palmetto inflorescences. Copulating Bibionidae, especially *Plecia nearctica*, aggregate as they feed on saw palmetto flowers, but copulation is initiated elsewhere in aerial swarms, often observed in early morning at the ABS.

Some insects, especially ants, are attracted to extrafloral nectaries on immature inflorescences of SP.

A common local treehopper (Membracidae), *Idioderma virescens* Van Duzee, is a specialized sap-sucker whose nymphs feed exclusively on the rachis of palm inflorescences, especially those of saw palmetto (Kopp & Tsai 1983). At the ABS the honeydew of this membracid forms accretions with black fungus below the inflorescence. This honeydew/fungus combination is consumed by a wide variety of insects, including species of Mutillidae, Pompilidae, Bethylidae, Eucharitidae, Ichneumonidae, Braconidae, and Milichiidae, many of which have not been observed visiting saw palmetto flowers.

Finally, some insects feed on the saw palmetto inflorescence itself at the ABS. These include sap-sucking Coreidae: *Acanthocephala confraterna* (Uhler); Largidae: *Largus davisi* Barber; Miridae: *Dagbertus fasciatus* (Reuter); caterpillars of Arctiidae: *Seirarctia echo* (J.E. Smith); and caterpillars of Noctuidae: *Litoprosopus futilis* (Grote and Robinson). Unopened flower buds are consumed by larvae of Curculionidae: *Notolomus basalis*, and by an unidentified Cecidomyiidae. Both the latter species appear to be prey of parasitoid wasps.

Discussion

The multiplicity of species of flower visitors associated with saw palmetto, and their general lack of specificity is typical of large pollination networks, according to a review by Oleson & Jordano (2002). We had expected however, to find at least a few saw palmetto visitors that were specialized to efficiently exploit this abundant, widespread, seasonally-focused resource. We encountered, however, no species that are found commonly and exclusively on saw palmetto flowers. While there are many species that were found only on saw palmetto flowers (Table 1), none of these were common on this host, and there is no reason to believe that they are dependent on saw palmetto. There are several species of oligolectic bees at the ABS (Deyrup et al. 2002), but saw palmetto does not have a specialized bee. We also suspected that there might be an oligolectic assemblage specific to the Arecaceae (*Serenoa*, 2 species of *Sabal*) at the ABS, but there is no indication of such a group of species. Another expectation was that the species that feed on saw palmetto pollen would be more specialized (have fewer alternate ABS

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hosts) than species that feed exclusively on nectar, but the opposite is true. In the flies and bees there are 52 known species of pollen-consumers. The average number of alternate hosts for these species is 18.1. The remaining species, presumed to be nectar feeders only, average 4.1 alternate hosts per species. A possible explanation is that there is an observer bias in favor of pollen feeders. Insects that collect both nectar and pollen tend to spend more time on flowers and are more likely to be observed on a range of their hosts. Female bees, in particular, show conspicuous persistence on flowers, as they must gather relatively large amounts of pollen and nectar for their offspring.

The flowers of *Serenoa repens* are an enormous resource available to hundreds of species of local flower-visiting insects, thereby supporting local taxonomic diversity. While there is no evidence of a specialized insect fauna associated with saw palmetto flowers, some species might be seasonally dependent on this host especially in habitat types that lack other large floral resources in spring. This study adds to the known ecological value of saw palmetto, summarized by Takahashi et al. (2011), and reinforces the conservation importance of this familiar plant.

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