The Diversity of Insects Visiting Flowers of Saw Palmetto (Arecaceae)

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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 phytophages, 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

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 (Arecales) 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...
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.

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
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
| 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)$^a$ | (Ball & Bousquet 2001) |
| | | *Galerita bicolor* (Drury) | | |
| | | *Lebia viridis* Say | Predator of beetle pupae (genus)$^a$ | (Ball & Bousquet 2001) |
| | **Scarabaeidae** | *Diplotaxis bidentata* LeConte | Phytophagous on roots (genus)$^a$ | (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)$^a$ | (Ritcher 1966) |
| | **Scirtidae** | *Cyphon* sp. A | | |
| | | *Cyphon* sp. B | | |
| | **Elateridae** | *Anchastus asper* LeConte | Decomposer & mycetophagous (family)$^+$ | (Lawrence 1991a) |
| | | *Neotrichophorus carolinensis* Schaeffer | | |
| | **Lycidae** | *Calochromus perfacetus* (Say) | Decomposer & mycetophagous (family)$^+$ | (Lawrence 1991a) |
| | | *Lycus lateralis* Melsheimer | 3 Decomposer & mycetophagous (family)$^+$ | (Lawrence 1991a) |
| | | *Plateros flavocutellatus* Blatchley | 2 Decomposer & mycetophagous (family)$^+$ | (Lawrence 1991a) |
| | **Lampyridae** | *Pyraconema angulata* (Say) | Decomposer & mycetophagous (family)$^+$ | (Lawrence 1991a) |
| | **Cantharidae** | *Chauliognathus marginatus* (Fabricius) | Predator of small insects (genus)$^a$ | (Blatchley 1910) |
| | | *Polemius laticornis* Say | | |
| | | *Tythonyx flavicollis* Blatchley | | |
| | **Dermestidae** | *Attagenus fasciatus* (Thunberg) | 1 Decomposer of dry organic matter | (Ali 1993) |
| | | *Cryptorhopalum focale* Beal | 5 Decomposer of dead insects (genus)$^a$ | (Kiselyova 2002) |
| | | *Cryptorhopalum ruficorne* LeConte | Predator of Lepidoptera eggs | (Mason and Ticehurst 1984) |

$^1$Additional floral hosts at the Archbold Biological Station.

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

| Order/Family | Species                                      | AFR | 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.                            |     |                                                |                                 |
|              | *Epurea luteola* (Erichson)                  |     |                                                |                                 |
|              | *Stelidota coenosa* Erichson                |     |                                                |                                 |
| Languriidae  | *Pharaxonotha floridana* (Casey)             |     |                                                |                                 |
|              | *Cycloneda sanguinea* (Linnaeus)             | 3   | Predator of Aphididae                         | (ABS)                           |
| Coryphidae   | *Orthoperus* sp.                             |     |                                                |                                 |
| Mordellidae  | *Mordella atrata* Ilseheimer                 | 19  | Decomposer of wood & mycetophagous (genus)*   | (Lawrence 1991b)               |
|              | *Mordella knalli* Ilieblad                   | 5   | Decomposer of wood & mycetophagous (genus)*   | (Lawrence 1991c)               |
|              | *Mordella marginata* Ilseheimer              | 4   | Decomposer of wood & mycetophagous (genus)*   | (Lawrence 1991c)               |
|              | *Mordellistena masoni* Ilieblad              |     |                                                |                                 |
| Tenebrionidae| *Epitragodes tomentosa* (LeConte)            |     |                                                |                                 |
|              | *Hymenuris* sp.                              |     |                                                |                                 |
| Oedemeridae  | *Oxycopis thoracica* (Fabricius)             | 1   |                                                |                                 |
| Meloidae     | *Pseudosentis longicornis* Horn              | 1   |                                                |                                 |
| Scaptiidae   | *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) |
|              | *Lycochoriolas 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 glebisitas* (Linnaeus)         |     | Phytophagous in seeds of *Arecaceae*          | (Kingsolver 2004)              |
| Curculionidae| *Notolomus basalis* LeConte                  | 2   | Phytophagous in buds of *Serenoa repens*     | (ABS)                           |

1Additional floral hosts at the Archbold Biological Station.
2Dietary role known for species in this family or subfamily, presumed for this species.
3Dietary role known for species in this genus, presumed for this species.

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TABLE 1. (CONTINUED) SERENO A REPENS FLOWER VISITORS AT THE ARCHBOLD BIOLOGICAL STATION.

| Order/Family | Species                                      | AFR | Role                                      | Source                                  |
|--------------|----------------------------------------------|-----|-------------------------------------------|-----------------------------------------|
| Nymphalidae  | *Vanessa virginiensis* (Drury)               | 2   | Phytophagous on Asteraceae                | (Heppner et al. 2003)                   |
|              | *Samia eclecsialis* (Guenée)                 |     | Phytophagous (genus)*                    | (Heppner et al. 2003)                   |
| Arctiidae    | *Dahana atripennis* Grote                    |     | Phytophagous on *Tillandsia*             | (Heppner et al. 2003)                   |
|              | *Uetheisella bella* Linnaeus                 | 1   | Phytophagous on seeds of *Crotalaria*     | (ABS)                                   |
| Noctuidae    | *Anica infecta* Ochsenheimer                 |     | Phytophagous on herbaceous plants        | (Heppner et al. 2003)                   |
|              | *Catocala consors* (Abbot & Smith)           |     | Phytophagous on *Carya*                  | (Heppner et al. 2003)                   |
|              | *Metallata absymens* (Walker)                |     | Phytophagous (genus)*                    | (Heppner et al. 2003)                   |
|              | *Mocis latipes* Guenee                       |     | Phytophagous on Gramineae                | (Heppner et al. 2003)                   |
|              | *Pseudaelcia uninucha* Haworth               |     | Phytophagous on herbaceous plants        | (Heppner et al. 2003)                   |
|              | *Spodoptera frugiperda* Smith                |     | Phytophagous on herbaceous plants        | (Heppner et al. 2003)                   |
|              | *Spodoptera ornithogalli* Guenee             | 3   | Phytophagous (genus)*                    | (Heppner et al. 2003)                   |
|              | *Spraguea onagrus* Guenee                    |     |                                            |                                         |
| Diptera      | *Bibionidae*                                 |     |                                            |                                         |
|              | *Dilophus orbatus* Say                       | 2   | Decomposer of plant matter               | (ABS)                                   |
|              | *Dilophus spinipes* Say                      |     |                                            |                                         |
|              | *Plecia nearctica* Hardy                     | 34  | Consumes aquatic microorganisms; adult hematophagous |                                         |
|              | *Culex sp.*                                 |     |                                            | (Wirth & Grogan 1988)                   |
| Culicidae    |                                             |     |                                            |                                         |
|              | *Allohelea johanniseni* (Wirth)              |     | Predator of small insects (genus)*       | (Genung 1959)                          |
| Ceratopogonidae | *Cninohelea bisaculata* Loew                |     |                                            |                                         |
| Tabanidae    | *Chlorotabanus crepuscularis* (Bequaert)     | 1   | Predator of aquatic invertebrates (genus)*; adult hematophagous | (Oldroyd 1964)                         |
|              | *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)*; adult hematophagous | (Genung 1959)                         |
|              | *Mydas clavatus* Drury                       |     | Predator of subterranean Coleoptera larvae (genus)*; adult hematophagous | (Genung 1959)                         |
|              | *Mydas maculiventris* Westwood              | 3   | Predator of subterranean Coleoptera larvae (genus)*; adult hematophagous | (Genung 1959)                         |
|              | *Phyllomydas parvulus* Westwood              | 1   |                                            |                                         |
| Stratiomyidae| *Hedriodiscus triquetra* (Say)               | 2   | Aquatic microorganisms (subfamily)+       | (Foote 1991a)                          |
|              | *Odontomyia sp.*                             |     |                                            |                                         |
|              | *Stratiomyus floridensis* Steyskal           |     |                                            |                                         |

1Additional 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.
### Table 1. (Continued) Serenoa repens flower visitors at the Archbold Biological Station.

| Order/Family | Species | AFR | Role | Source |
|--------------|---------|-----|------|--------|
| **Bombyliidae** | *Bombylia fraudulenta* Johnson | 4 | Predator of subterranean Hymenoptera larvae (genus)* | (Hull 1973) |
| | *Chrysanthrax cypris* (Meigen) | 16 | Predator of subterranean Hymenoptera larvae (genus)* | (Hull 1973) |
| | *Chrysanthrax dispers* (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. bigadatta* (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) | 3 | 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 | Decomposer of cactus | |
| | *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** | *Physoosepha sagittaria* (Say) | 18 | Predator of adult Apoidea | (Freeman 1966) |
| | *Physoosepha tibialis* (Say) | 2 | Predator of adult Apoidea (genus)* | (Freeman 1966) |
| | *Physosephon brachyrhynchus* (Macquart) | 13 | Predator of adult Apoidea (genus)* | (Freeman 1966) |
| | *Physosephon bulbrostris* (Loew) | 6 | Predator of adult Apoidea (genus)* | (Freeman 1966) |
| | *Physosephon floridanus* Camras | 1 | Predator of adult Apoidea (genus)* | (Freeman 1966) |
| | *Physosephon obscuripennis* (Williston) | 3 | Predator of adult Apoidea (genus)* | (Freeman 1966) |

1Additional 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.
### Table 1. (Continued) *Serenoa repens* flower visitors at the Archbold Biological Station.

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

1Additional 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.
TABLE 1. (CONTINUED) SERENOBA REPENS FLOWER VISITORS AT THE ARCHBOLD BIOLOGICAL STATION.

| Order/Family | Species | AFR | Role | Source |
|--------------|---------|-----|------|--------|
| Chloropidae  | Apallates dissidens (Tucker) | 12  | Decomposer of plant matter (genus)* | (Mulla 1962) |
|              | Hippelates plebius Loew     |     | Decomposer of plant matter (genus)* | (Mulla 1962) |
|              | Liohippelates pusio (Loew)  | 15  | Decomposer of plant matter          | (Mulla 1962) |
|              | Monochaetoscinella sp.      |     | Mycetophagous                        | (ABS)       |
|              | Ocella quadriovinata (Sabrosky) | |     |        |
| Tricimba sp. |                      |     |     |        |
| Muscidae     | Atherigona orientalis Schiner | 5   | Phytogamous & decomposer of plant matter | (Butcher 1954) |
|              | Coenosopsia prima Malloch   | 6   |     |        |
|              | Coenosia sp.                | 2   |     |        |
|              | 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 coeruleipicta (Macquart) | 4   | Decomposer of carrion                | (ABS)       |
| Sarcophagidae| Amobia floridensis (Townsend) | 7   | Predator of larval Hymenoptera      | (Krombein 1967) |
|              | Eusenotainia rufiventris (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) |

1Additional floral hosts at the Archbold Biological Station.
2Dietary role known for species in this genus, presumed for this species.
3Dietary role known for species in this family or subfamily, presumed for this species.
| Order/Family | Species | AFR | Role | Source |
|-------------|---------|-----|------|--------|
|             | *Ptilodesia* 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. |     |      |        |
|             | *Leucospis affinis* Say | 12  | Predator of larval Apoidea | (Krombein 1967) |
|             | *Leucospis birkmani* Brues |     |      |        |
|             | *Leucospis robertsoni* Crawford | 14  | Predator of larval Hymenoptera (genus)* | (Burks 1979) |
|             | *Leucospis slossonae* Weld | 23  | Predator of larval Apoidea | (Burks 1979) |
|             | *Goniozus nigrifemur* Ashmead |     |      |        |
|             | *Chrysis archboldi* Kimsey |     |      |        |
|             | *Chrysis inaequidens* Dahlbom | 1   | Predator of larval Vespidae | (Krombein 1967) |
|             | *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) |
|             | *Dasymutilla pyrrhus* (Fox) | 2   | Predator of larval Sphecidae | (ABSS) |
|             | *Pseudomethoca sanbornii* (Fox) |     |      |        |
|             | *Timulla ferrugata* (Fabricius) |     |      |        |
|             | *Campsomeris plumipes* (Drury) | 30  | Predator of larval Scarabaeidae | (Krombein 1979c) |
|             | *Brachymyrmex obscurior* Forel |     |      |        |
|             | *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 |     |      |        |
|             | *Camponotus nearcticus* Emery |     |      |        |

1Additional 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.
Table 1. (Continued) *Serenoa repens* flower visitors at the Archbold Biological Station.

| Order/Family | Species | AFR | 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) | | | (ABS) |
| Pseudomyrmex ejectus (F. Smith) | 6 | Predator of arthropods | (ABS) |
| Pseudomyrmex gracilis (Fabricius) | 5 | Predator of arthropods | (ABS) |
| Solenopsis invicta Buren | | | (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 fusci tus (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 slossonaec Fox | 18 | Predator of larval Lepidoptera (genus)* | (Krombein 1979b) |
| Zethus spinipes Say | 16 | Predator of larval Lepidoptera | (Krombein 1979b) |
| Pompilidae | | | |
| Ageniella obscura Banks | | | (Townes 1957) |
| Anoplius marginalis (Banks) | 1 | Predator of Lycosidae | (Evans 1951a) |
| Aporinellus fasciatus (Smith) | | | (Evans 1951b) |
| Ceropales elegans quaintanzei Viereck | | | (Townes 1957) |
| Episyron conterminus posterus (Fox) | 16 | Predator of Araneidae | (Evans 1950) |
| Pepsis saphirus Palisot | | | (Townes 1957) |
| Poecilopompilus interruptus (Say) | 4 | Predator of Araneidae | (Evans 1950) |

1Additional 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.
TABLE 1. (CONTINUED) SERENOAA REPENS FLOWER VISITORS AT THE ARCHBOLD BIOLOGICAL STATION.

| Order/Family | Species                                | AFR | Role                                | Source       |
|--------------|----------------------------------------|-----|-------------------------------------|--------------|
| Sphecidae    | Psorthaspis legata (Cresson)            | 2   | Predator of Ctenizidae              | (Krombein 1979d) |
|              | Sericopompilus apicalis (Say)           | 2   | Predator of Araneida                | (Evans 1950) |
|              | Tachypompilus ferrugineus (Say)         | 2   | Predator of Lycosida                | (Evans 1950) |
|              | Ammophila proceraphilsoni Dahlbom       | 7   | Predator of larval Lepidoptera      | (Krombein 1979a) |
|              | Ammophila urnaria Dahlbom               | 4   | Predator of larval Lepidoptera      | (Krombein 1979a) |
|              | Bembecinus floridanus Krombein          | 5   | Predator of Homoptera (genus)*      | (Krombein 1979a) |
|              & Willink                               |     |                                     |              |
|              | Bembix sayi Cresson                     | 8   | Predator of adult Diptera           | (Krombein 1979a) |
|              | Bicyrtes quadrifasciata (Say)           | 12  | Predator of Heteroptera             | (Krombein 1979a) |
|              | Cercheris blakei Cresson                | 24  | Predator of adult Coleoptera        | (Krombein 1979a) |
|              | Cercheris flavofasciata floridensis     | 5   | Predator of adult Coleoptera        | (Krombein 1979a) |
|              | Cercheris fumipennis Say                | 8   | Predator of adult Coleoptera        | (ABS)        |
|              | Cercheris 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) |
|              | Ecetemnius decimmaculatus tequesta Pate | 12  | Predator of adult Diptera (genus)*  | (Krombein 1979a) |
|              | Ecetemnius maculosus (Gmelin)           | 1   | Predator of adult Diptera (genus)*  | (Krombein 1979a) |
|              | Ecetemnius rufipes ase Pate              | 25  | Predator of adult Diptera           | (Krombein 1979a) |
|              | Isodontia auripes (Fernald)             | 4   | Predator of Orthoptera              | (Krombein 1979a) |
|              | 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 fulginosus muspa (Pate)           | 3   | Predator of Orthoptera (genus)*     | (Krombein 1979a) |
|              | Liris panamensis muesebecki (Krombein)  | 9   | Predator of Orthoptera (genus)*     | (Krombein 1979a) |
|              | Oxybelus decorosus (Mickel)             | 4   | Predator of adult Diptera (genus)*  | (Bohart & Menke 1976) |
|              | Oxybelus emarginatus Say                |     | Predator of adult Diptera           | (Krombein 1979a) |
|              | Oxybelus laetus fulvipes Robertson      | 12  | Predator of adult Apoidea           | (Krombein 1979a) |
|              | 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) |
|              | Sphecis speciosus (Drury)               |     | Predator of adult Cicadida          | (Krombein 1979a) |
|              | Sphecis ichneumoneus (Linnaeus)         | 6   | Predator of Orthoptera              | (Krombein 1979a) |

1Additional 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.
| Order/Family | Species | AFR | Role | Source |
|-------------|---------|-----|------|--------|
| Colletidae  | Sphex pensylvanicus Linnaeus | Predator of Orthoptera. | (Krombein 1979a) |
|            | Stictia carolina (Fabricius) | Predator of adult Diptera | (Krombein 1979a) |
|            | Stictiella serrata (Handlirsch) | Predator of adult Lepidoptera | (Krombein 1979a) |
|            | Tachytes grisselli Bohart (5) | Predator of Orthoptera (genus)* | (Krombein 1979a) |
|            | Tachytes guatemalensis Cameron | Predator of Orthoptera (genus)* | (Krombein 1979a) |
|            | Tachytes mergus Fox | Predator of Orthoptera | (ABS) |
|            | Tanyoprymnus monedulaeides (Packard) | Predator of Homoptera | (Krombein 1979a) |
|            | Trypargilum clavatum johannis (Richards) | Predator of Araneida | (Krombein 1967) (ABS) |
| Colletes   | Colletes banksi Swenk | Nectar & pollen | (ABS) |
|            | Colletes brimleyi Mitchell | Nectar & pollen | (ABS) |
|            | Colletes mandibularis Smith | Nectar & pollen | (ABS) |
|            | Colletes nudus Robertson | Nectar & pollen | (ABS) |
|            | Colletes sp. | Nectar & pollen | (ABS) |
| Hylaeus    | Hylaeus graenicheri Mitchell | Nectar & pollen | (ABS) |
| Halictidae | Agapostemon splendens (Lepeletier) | Nectar & pollen | (ABS) |
|            | Augoclorae pura Say | Nectar & pollen | (ABS) |
|            | Augochloropsis aurata (Smith) | Nectar & pollen | (ABS) |
|            | Augochloropsis metallica (Fabricius) | Nectar & pollen | (ABS) |
|            | Augochloropsis sumptiosa (Smith) | Nectar & pollen | (ABS) |
|            | Halictus poeyi Say | Nectar & pollen | (ABS) |
|            | Lasiglossum coreopsis (Robertson) | Nectar & pollen | (ABS) |
|            | Lasiglossum minutulius (Mitchell) | Nectar & pollen | (ABS) |
|            | Lasiglossum nymphafulis (Smith) | Nectar & pollen | (ABS) |
|            | Lasiglossum pectoralis (Smith) | Nectar & pollen | (ABS) |
|            | Lasiglossum plagioidens (Mitchell) | Nectar & pollen | (ABS) |
|            | Lasiglossum tegulare (Robertson) sp. group | Nectar & pollen | (ABS) |
| Megachilidae | Sphecodes heraclei Robertson | Predator of Apoidea (cleptoparasite) | (ABS) |
|            | Coelioxys sayi Robertson | Predator of Megachilidae (cleptoparasite) | (ABS) |
|            | Dianthidium floridense Schwarz | Nectar & pollen | (ABS) |
|            | Megachile pilocarvis Say | Nectar & pollen | (ABS) |
|            | Megachile xylocopoides Smith | Nectar & pollen | (ABS) |

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.
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 Braconid species 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 Neumatocera 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.

### TABLE 1

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

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.
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 cerambicid 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 *Paranictocerus 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 kept in check by saw palmetto flower-visiting predators, 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 fulgota*, 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.
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 (Lycaeidae).

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 Tiphiiidae, Scoliidae, Vespidae, Colletidae, Halictidae and Megachilidae. These males occasionally interrupt their rapid circuits to drink.
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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 Mutilidae, 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

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.
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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