

NEW RECORDS OF POLLINATORS AND OTHER INSECTS ASSOCIATED WITH ARIZONA MILKWEED, *ASCLEPIAS ANGUSTIFOLIA*, AT FOUR SITES IN SOUTHEASTERN ARIZONA

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Abstract—*Asclepias angustifolia* is a Mexican milkweed that barely enters the U.S.A. Its pollinators and other insect visitors have not been investigated. During 2018 and 2019, insect visitors were photographed at a native population and three gardens in and near the Huachuca Mountains, Southeastern Arizona. A total of 216 site visits produced at least 369 species of insects in seven orders. Images revealed 140 potential pollinators with a preponderance of Hymenoptera, Lepidoptera, and Diptera. Orders of insects are discussed, as are flowering phenology, potential pollinators in functional groups, introduced insects, and the value of *A. angustifolia* for monarch butterflies and other insects in pollinator gardens and in planting palettes created for restoration sites.

Keywords: Sky Island, Madrean Pine-Oak Woodland, monarch butterfly, Huachuca Mountains, gardening, restoration

INTRODUCTION

North American milkweeds (*Asclepias* spp.) provide nectar to an unusually large diversity of insects, making them important members of existing ecosystems and valuable additions to sites benefiting from a broad spectrum of pollinators (Ollerton et al. 2019, Tallamy 2007). For gardeners, their appealing forms and colours compliment plantings that mitigate habitat loss when converting backyard lawns or disused parcels to more natural, pesticide-free environments that provide food, shelter, and nesting sites for diverse pollinators during this era of widespread insect decline (Wagner 2020, Xerces Society 2020). Over the last three years, more than 64 million Americans purchased plants deemed beneficial to bees, butterflies, birds and other wildlife, and nearly 37 million Americans bought plants native to where they live (Ordóñez-Lancet 2020). Arizona milkweed, *Asclepias angustifolia*, appeals to gardeners, is comparatively easy to propagate and transplant, hosts numerous nectar feeders, and is a larval hostplant for the monarch (*Danaus plexippus*: Nymphalidae), a butterfly exhibiting precipitously declining North American populations and a candidate for protection under the Endangered Species Act. It has been recommended by the Natural Resources Conservation Service for Conservation Cover (bio-remediation and reclamation plantings) and Riparian Herbaceous Cover (Morris et al. 2015) and is one of the milkweeds planted at Arizona habitat restoration sites by Sky Island Alliance (Campbell 2015). Recent greenhouse studies demonstrated increased egg laying, and greater survival and fitness of larval and adult monarchs raised on *A. angustifolia* compared to those raised on pineleaf

milkweed, *A. linaria* Cavanillies, that produces higher concentrations of cardenolide toxins and greater amounts of defensive latex (Pegram & Melkonoff 2019). Planting milkweeds is becoming a widespread practice aimed at increasing north- or southbound cohorts of the monarch's complicated multi-generational migration; however, some authors (e.g., Inamine et al. 2016) argue that population declines of Eastern monarchs on the Mexican wintering grounds are not simply a function of milkweed availability, but are tied to threats faced by southbound monarchs, including habitat fragmentation and lack of nectar resources. Both may be addressed by altering roadside mowing regimes, planting hedgerows of late-flowering nectar plants, incorporating late-flowering nectar plants into large scale habitat restoration projects, and creating home, school and municipal gardens that offer fall nectar to monarchs and other insects. For these reasons, Arizona native plant nurseries are providing seeds or seedlings of *A. angustifolia* for pollinator gardens and habitat restoration sites (Appendix 1). Its previously recorded insects are few: tarantula wasps (Pompilidae: Pepsinae) (Nabhan & Borderlands Habitat Network 2018, p. 15), *Aphis nerii* (Aphididae), *Phymata* sp. (Reduviidae), *Ochrostomus uhleri* (Lygaeidae), *Batyle ignicollis* (Cerambycidae), *Apis mellifera* (Apidae), *Triscolia ardens* (Scoliidae), *Amblyscirtes elissa* (Hesperiidae), *Anartia fatima* (Nymphalidae: in Mexico), and several unidentified ants, flies, and butterflies (flickr 2020, iNaturalist 2020). Similar to many other North American milkweeds, it provides nectar and foliage resources for larvae and adults of an immense community of arthropods that not only serve as pollinators but provide myriad other benefits throughout the ecosystem (Rea 2011). Despite its many positive attributes, its increased availability, and growing presence in wildlife habitat gardens and restoration sites, little attention has been paid to the diverse suite of insects taking nectar from its flowers or feeding on its leaves and stems; and, as is true of the majority of *Asclepias* inhabiting the U.S., its pollinators

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have not been investigated (Borders & Lee-Mader 2014, M. Fishbein 2018 in litt., Ollerton et al. 2019).

Studies of *Asclepias* pollinators in North America have considered both widespread and abundant species; e.g., *A. tuberosa* L., *A. incarnata* L., *A. syriaca* L., and *A. verticillata* L. (e.g., Willson et al. 1979, Robertson 1891, Fishbein & Venable 1996, Ivey et al. 2003, Kephart & Theiss 2004, Baker & Potter 2018), and sparsely-distributed species; e.g., *A. meadii* Torr. ex A. Gray, *A. lanuginosa* Nutt., *A. solanoana* Woodson, and *A. hirtella* (Pennell) Woodson (Lynch 1977, Betz et al. 1994). Data have been collected from wild and cultivated populations; well-studied species (e.g., *A. syriaca*) revealed a pollinator spectrum of upwards of 150 insects (summarized by Ollerton et al. 2019), highlighting milkweeds' importance to insect fitness and diversity in healthy and compromised habitats. The primary pollinators of *Asclepias*, Hymenoptera (bees and wasps), Diptera (flies), and Lepidoptera (butterflies), form a diverse assemblage of seemingly generalist insects attracted by floral traits (morphological, chemical, and phenological) that may (or may not) direct feeding visits by certain insects (e.g., butterflies vs. large wasps). Certain insect visitors (e.g., bumble bees, *Bombus* spp.) may carry larger pollen loads or be more successful removing and reinserting pollinia (Fishbein and Venable 1996); over time, especially successful visits may shape floral traits, acting as a barrier to interspecies gene flow in sympatric milkweeds (Kephart & Theiss 2003). However, certain milkweeds, e.g., *A. incarnata* appear to be less reliant on specialization and are successfully pollinated by a broad diversity of insects (Ivey et al. 2003). For most North American *Asclepias*, these traits and the insects they attract remain unknown.

This study addressed the following questions:

1. What insects are nectarivorous, phytophagous, or predatory in a native population of *A. angustifolia* in Madrean Pine-Oak Woodland, and under cultivation in nearby gardens?
2. What is its pollinator spectrum in Madrean Pine-Oak Woodland and nearby gardens and how do they differ?
3. Would planting *A. angustifolia* in butterfly gardens and habitat restoration sites provide a food resource for a diversity of insects, augmenting the plant's other values?

MATERIALS AND METHODS

Study species

Asclepias angustifolia Schweigger (Arizona milkweed, [Spanish] *algodoncillo*, *talayote*) is a member of the clade Incarnatae, 10 species representing c. 8% of the c. 130 New World *Asclepias* (Fishbein in prep.). Widespread in the Sierra Madre highlands of Mexico, it ranges northward to three counties in south-eastern Arizona, where it has isolated populations in seven mountain ranges and is considered rare (SEINet 2018, Fishbein in prep., Woodson 1954). Occupying elevations of c. 1,066–2,133 m, it inhabits riparian areas in montane canyons, floodplain meadows, and wetland edges, growing as a low, bushy, perennial forb reaching c. 70 cm in height (Nabhan et al. 2015, SEINet

2018), but up to c. 120 cm in stream beds (pers. obs.). From April–October (rarely December in cultivation, pers. obs.), it bears terminal upright umbels of c. 15–18 small white to pinkish, actinomorphic, bisexual flowers 8–9 mm in diameter. The five tubular staminal hoods (hoods) comprising the corona are not elongate; their rounded apex extends a short distance above the flattened crown of the gynostegium. Horns emerging from the hoods are slender, incurved, meet over the gynostegium, and are as tall as the apices of the hoods. Plants are dense to open, with few to many stems and narrow, glabrous leaves. Drier sites produce smaller plants with fewer stems and c. 3–20 umbels; near streams or in irrigated gardens vigorous plants may have 200 or more umbels (pers. obs.). Unlike some congeners, it does not spread via underground rhizomes. Arizona populations are characterized by small numbers of scattered plants inhabiting moist canyon bottoms surrounded by Madrean Pine-Oak Woodland, a botanically rich, montane, plant association that is extensive in Mexico but limited in the U.S.A. to mountain ranges not far north of the Mexican border (Brown 1994).

Visitor observations

From 27 June–19 December 2018 (66 days), there were 83 site visits totalling 44.90 hrs, and from 25 April–19 October 2019 (109 days), there were 133 site visits totalling 98.87 hrs (Tab. I). Insects were photographed on flowers, leaves, and stems of *A. angustifolia*. Except for aphids (Aphididae), seed bug nymphs (Lygaeidae), and ants (Formicidae), insects were counted; a few very numerous species were estimated by multiples of 10 or 25. Mimetic crab spiders (Thomisidae) living in flower clusters captured butterflies, bees, and other pollinators; they were not enumerated. Insects that hovered over plants, touched them without feeding, or used them briefly as hunting perches were not considered, nor were insects that flew or jumped into plants after human disturbance. A few tiny insects (< 10) could not be identified to any taxon visually or with photos

TABLE I. Visits/site and hrs/site by year, total (Σ) visits/site, total hrs/site, total species/site, unique species/site, percentage of total hrs/site and percentage of total species/site. Garden Canyon, Fort Huachuca (GAR), Sullivan/Lee yard, Ramsey Canyon (RAM), Behrstock/LeMay yard, Ash Canyon (ASH), and Casa de San Pedro Bed & Breakfast (SAP).

Year	Totals	GAR	RAM	ASH	SAP
2018	Visits	7	11	61	4
	hrs	6.86	9.58	26.71	1.75
2019	Visits	18	21	79	15
	hrs	20.58	26.75	36.79	14.75
	Σ Visits	25	32	140	19
	Σ Hours	27.44	36.33	63.5	16.5
	Σ Species	130	149	212	90
	Σ Uniq	45	48	108	28
	% Σ Hours	19.08	24.26	44.16	11.47
	% Σ Species	35.23	40.38	57.45	24.39

and were not included in the species list. Some may have been successfully photographed on other occasions and including them would have resulted in duplication. Three additional insects (all bearing pollinia), photographed before or after the study, were included for completeness and appear with their names preceded by an asterisk and with a year in the date column (Tab. 2 at the end of the document). Five species (perhaps more) represent mixed assemblages of currently unidentifiable photos (i.e., *Lasioglossum* subgen. *Lasioglossum* sp. A, *Megachile* spp., cf. *Parancestrocerus* spp., cf. *Stenodynerus* spp., and *Gymnoclyte* sp. (spp?)). Most images were obtained with a Nikon D7000 digital camera, Nikon 200mm Micro-Nikkor lens, and Nikon SB-600 strobe; for several, a Sony DSC-HX400V Compact Camera was used. Digital files were adjusted with Adobe Photoshop Elements, Versions 12.0 and 18.0. Images were examined on a computer monitor for pollinia and associated structures (corpuscula, and translator arms). Once a species was known to carry pollinia, it was not necessarily re-photographed, yielding small sample sizes for many species. At the end of the study, all pollinator photos were re-validated, and the status of any visible pollinia was noted (Tab. 2). All pollinia in images appear to represent *A. angustifolia*. Sites were visited as often as practical and visit frequency increased during the second season. Visits ranged from 5–180 minutes, were non-random, and dictated by work schedule, weather events, and flowering phenology. Insect activity was minimal until plants were in full sun, generally 09:00–10:00 hrs. A second site visit usually began during late morning or early afternoon. A several hour visit with interruptions was counted as one visit. During 2019, three 10–15 min night-time visits failed to produce any additional species and are not included. Insects in photos were identified by the author and volunteers ranging from informed hobbyists to systematic entomologists, many of whom are associated with the BugGuide and iNaturalist online communities (BugGuide.Net 2020, iNaturalist.org 2020). A few insects were retained for confirmation or special projects (e.g., Behrstock et al. 2020) and sent to systematists. Because most species were only photographed, many were identified to the genus level and occasionally tribe, subfamily, or family. The taxonomic order of the species list largely adheres to the various sections in BugGuide.

Study area

The Huachuca Mountains, c. 61 km long and reaching a height of 2,885 m, are part of the Southern Basin and Range province of the south-western U.S.A. Surrounded by Chihuahuan or Sonoran Desert, they and other steep-sided mountains on both sides of the Mexican border are referred to as the Sky Island Region, and serve as biotic steppingstones connecting the Sierra Madre of Mexico and the Rocky Mountains of the U.S.A. and Canada (Warshall 1994). Their abruptly ascending flanks support a number of elevational life zones at the convergence of major floristic, biotic, and climatic provinces. In the Huachucas, one of the southern-most U.S. Sky Islands, these features account for a higher-than-expected plant diversity totalling c. 1,000 species (Bowers & McLaughlin 1996, Coblenz 2004). Additionally, the Madrean Pine-Oak Woodlands of the Sky Islands exhibit unusually rich invertebrate and vertebrate faunas and have

been named a global biodiversity hotspot (Van Devender et al. 2013).

The climate of the study sites is semi-arid with irregularly bi-modal peaks of rainfall. Annual precipitation (Sierra Vista, Arizona data and private weather stations) ranges from c. 330–762 mm and is greatest at higher elevations. Most precipitation occurs as monsoon rains from late June–September, followed in some years by winter rain and high elevation snow. Temperatures at the study sites range from c. -15.5°–37.8° C.

Southeastern Arizona is rich in cactus and other succulents, as well as numerous hummingbird-pollinated plants; their pollinator relationships have been documented extensively. The most pertinent study concerning the region's insect pollination systems was on the west side of the Huachucas, and examined pollinators and pollinator efficiency on butterfly milkweed, *A. tuberosa* (Fishbein & Venable 1996) (see below). Nearby, Bock et al. (2007) surveyed butterfly populations in three habitats subject to livestock grazing and exurban development (including effects of increased nectar availability). Studies on Fort Huachuca examined insects on an endangered fleabane (Asteraceae), and two of its more widespread congeners (Bailey & Kevan 2017), compared wet- and dry-year insect assemblages in xeric grasslands (Lance et al. 2017), and documented two nectar-feeding bats and associated insects and birds at two species of agaves (Asparagaceae) (Slauson 2000). The region's exceptional diversity of bees attracts biologists from around the world to the American Museum of Natural History's Southwest Research Station in the Chiricahua Mountains. Ascher and Pickering (2020) provide keys, illustrations, and plant associations for many of the Hymenoptera.

Study sites

Four sites were visited in Cochise Co., Arizona, the state's south-eastern-most county bordering the states of New Mexico to the east and Sonora, Mexico to the south. Three sites are in the south-east to central Huachuca Mountains, and one is c. 13 km eastward on the western floodplain of the San Pedro River, a north-flowing river whose headwaters are at the southern end of the Huachuca Mountains and nearby in northern Mexico. *Asclepias angustifolia* is native in Garden Canyon and introduced into wildlife habitat gardens at the other three sites. The gardens in Ash and Ramsey canyons approximated natural elevations *A. angustifolia* occupied nearby. The sites, from highest to lowest elevations, and their three letter abbreviations are:

City of Sierra Vista, U.S. Army Fort Huachuca, road through Garden Canyon: Plants were located along c. 1.93 km of roadside and streamside between 31.472405° and -110.354054°, elevation 1,640 m and 31.467407° and -110.355365°, elevation 1,684 m. Habitat is a riparian corridor through Madrean Pine-Oak Woodland in the central part of the Huachuca Mountains. Co-flowering plants included: *Cirsium ochrocentrum*, *Erigeron* spp., (Asteraceae), *Amorpha canescens*, *Melilotus albus* (Fabaceae), *Geranium caespitosum* (Geraniaceae), *Oenothera elata* (Onagraceae), *Erythranthe cardinalis* (Phrymaceae), *Penstemon barbatus* (Plantaginaceae), and *Aquilegia chrysantha* (Ranunculaceae).

A native population of c. 20 *A. angustifolia* growing along the roadside or at stream edge was examined. At least as many younger, or non-flowering plants were also present. The site was visited on 25 days for a total of 27.44 hrs (GAR).

Hereford, Ramsey Canyon, Sullivan/Lee residence: 31.449162° and -110.306567°, elevation 1,677 m. The habitat is a heavily planted residential butterfly/pollinator garden. Similar to GAR, it is an Arizona sycamore (*Platanus wrightii*)-lined montane riparian corridor surrounded by Madrean Pine-Oak Woodland. Co-flowering plants included: *Asclepias sullivantii* (Apocynaceae), *Achillea millefolium*, *Bidens* sp., *Helianthus maximiliani*, *Ratibida columnifera*, *Machaeranthera* sp. (Asteraceae), *Centranthus ruber*, *Lonicera sempervirens* (Caprifoliaceae), *Melilotus albus* (Fabaceae), *Monarda* sp., *Oreganum* spp., *Salvia greggii*, *S. leucantha*, *S. yangii* (Lamiaceae), *Alcea* sp. (Malvaceae), *Oenothera elata* (Onagraceae), and *Buddleja* spp. (Scrophulariaceae). There are c. 11 introduced *A. angustifolia*. The site was visited on 32 days for a total of 36.33 hrs (RAM).

Hereford, Thicket Place, lower Ash Canyon, Behrstock/LeMay residence: 31.380207° and -110.227962°, elevation 1,529 m. The habitat is a heavily planted rural residential wildlife habitat and native plant garden at the interface of Emory oak/blue oak woodland and velvet mesquite grassland (*Quercus emoryi* Torr./*Q. oblongifolia* Torr./*Prosopis velutina* Wooton). The southernmost of the four sites, it is c. 5.23 km north of the Mexican border. Co-flowering plants included: *Anisacanthus quadrifidus* (Acanthaceae), *Berlandiera lyrata*, *Cosmos* sp., *Gaillardia* sp. *Guardiola platyphylla*, (Asteraceae), *Lantana* sp. (Verbenaceae), *Monarda citriodora*, *Oreganum* sp., *Salvia farinacea*, *S. officinalis*, *S. greggii*, *Stachys coccinea*, *Vitex agnus-castus* (Lamiaceae), *Oenothera elata* (Onagraceae), *Phyla nodiflora*, and *Glandularia* spp. (Verbenaceae). There are 18–22 introduced *A. angustifolia*. The site, adjacent to the author's dwelling, was visited on 140 days for a total of 63.50 hrs (ASH).

Hereford, Casa de San Pedro Bed & Breakfast: 31.408918° and -110.106893°, elevation 1,278 m. Floodplain just west of the San Pedro River. The habitat is an irrigated wildlife garden surrounded by Mesquite Grassland in Upper Chihuahuan Desert. Co-flowering plants included: *Hesperaloe parviflora* (Asparagaceae), *Lantana* sp. (Verbenaceae), *Phlomis fruticosa*, *Salvia greggii*, *Vitex agnus-castus* (Lamiaceae), and *Gaura* sp. (Onagraceae). There are c. 12 introduced *A. angustifolia*. The site was visited on 19 days for a total of 16.50 hrs. (SAP).

RESULTS

Phenology

During weeks 1–2 of March, shoots emerged from the ground among the previous season's dead stems, occasionally from wind-dispersed seeds (ASH). Flower buds appeared during week 1 of April. Oviposition and eggs of monarchs were photographed 9 and 13 April 2019 (K. LeMay, ASH). Open flowers were first noted 17 April 2019 (K. LeMay, ASH), while flowers at higher elevations (GAR and RAM) were still in bud. By 14 May 2019, a few open flowers were

present at RAM. By 26 June, several plants at SAP and GAR had numerous follicles, some of which had ripened and released seeds; there was not a second blooming period. Plants at GAR flowered until c. 20 Aug 2019. On 23 September 2018, plants at ASH and RAM were largely bloomed out and many leaves had been eaten by Lepidoptera larvae (i.e., *Estigmene albida* and *Danaus gilippus*). However, four plants had clusters of flower buds and new stems appeared at the base of most plants (ASH). By 9 October, supplemental water (drip irrigation) encouraged flowers to appear at ASH and RAM. Despite several days of rain, high winds, and chilly weather, by 14 October, the largest irrigated plant at RAM again had 200 or more umbels and hosted c. 26 species of insects, including some not found earlier in the season. Flowers persisted until mid-November. By week 3 of December 2018, all that remained were brown stems. Although ASH produced the greatest diversity of insects, fruit set there is always low (c. 10 yrs. pers. obs.), and much higher at the other three sites.

Insects

Observations of flowers, leaves, and stems yielded seven orders of insects representing 89 families and 369 species (including at least five similar species clusters) identified to various taxonomic levels. All but six species were photographed. The orders (followed by percentage of the species total) were: Orthoptera (0.54%), Thysanoptera (0.27%), Hemiptera (10.03%), Coleoptera (15.18%), Hymenoptera (28.73%), Lepidoptera (19.51%), and Diptera (25.75%). Three hundred and forty-nine species (94.58%) associated with flowers (photos); two were collected from flowers but not photographed, and the remaining 18 (4.88%) were on leaves or stems. Pollinia and associated structures were present on 140 (37.94%) species, generally attached to the distalmost tarsomeres, although a fly (Tachinidae) and a wasp (Vespidae) had pollinia attached to the face or mouthparts. Identifications, the number of days a species was found at each and all sites, inclusive dates of observation, whether a species associated with flowers, presence or absence of pollinia, whether a species is deemed a potential pollinator, and general status of pollinia are listed (Tab. 2). Insects in certain families (Halictidae, Tachinidae), and genera (*Megachile*, *Parancestrocerus*, *Stenodynerus*), were especially difficult to identify from photos; the overall species total is conservative but serves to illustrate the range of diversity.

Two hundred and twenty-nine species (62.06%) were recorded only once as follows: GAR (45), RAM (48), ASH (108), and SAP (28). The most visited site (ASH), produced the majority of unique sightings; the fewest were at the least visited site (SAP) (Tab. 1). The number of species encountered at each site increased with sampling effort (Fig. 1); however, during 2018, the flowering period was up to three months longer at ASH and RAM where insects remained numerous. Insect activity was high throughout the summer, most so during the monsoon from mid-July to late August, when 20 to 30 species might be encountered during an hour-long site visit.

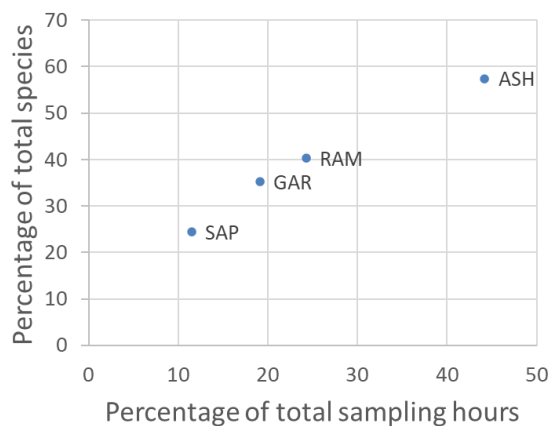


FIGURE I. Percentage of total sampling hours (x axis) vs percentage of total species (y axis)

DISCUSSION

Pollination

The highly specialized flowers of *Asclepias* are characterized by a column-like gynoeceum composed of fused pollen- and carpel-bearing structures, a short to tall whorl of cup-shaped, petal-like hoods containing rich nectar, and pollen grains aggregated into paired sacs (pollinia) that are joined by translator arms and a grooved corpusculum that attaches to an insect visitor. Unique to the family Apocynaceae, such specializations might suggest visitation by a guild of evolutionarily-dedicated insects; however, the pollinia of *Asclepias* are distributed by a characteristically diverse association of nectarivorous insects, primarily members of the order Hymenoptera, followed by Diptera and Lepidoptera (Willson et al. 1979, Robertson 1891, Wyatt & Broyles 1994, Fishbein & Venable 1996, Ivey et al. 2003, Ollerton et al. 2019, Fishbein in prep.). Willmer (2011, p. 434) summarized this lack of specialized visitation, stating "...it is an indisputable fact that any one plant may get flower visits from many different kinds of visitors, from different taxonomic groups, with visit patterns varying in space and time". Although visitors are diverse and may appear generalized, some *Asclepias* are visited preferentially (below), potentially resulting in increased follicle production and elaboration of preferred characteristics such as flower size, morphology, colour, scent, and the quantity and timing of nectar production. Evidence for highly specialized *Asclepias* pollination is scarce. Lynch (1977) recorded only three kinds of bees (including the introduced Western honey bee, *Apis mellifera*) pollinating *A. solanoana* Woodson, an exceptional level of reliance on a small cadre of insects for this northern California endemic that grows on toxic serpentine soils. More often, a broad spectrum of pollinators assesses floral traits spread across a landscape that may include sympatric milkweeds. Although insects are capable of cross-pollinating certain milkweeds, a combination of mechanical, behavioural, and physiological barriers precludes formation of viable hybrid follicles (Kephart 1981, Kephart & Theiss 2004).

An Indiana study of *A. syriaca*, *A. incarnata*, and *A. verticillata*, Kephart & Theiss (2004) revealed 177 insects carrying pollinia, 153 of them on *A. verticillata*. Large bees

and wasps (i.e., *Bombus*, *Apis*, *Xylocopa*, *Sphex*) were the most frequent pollinators; all were present on *A. verticillata*, whose flowers resemble *A. angustifolia*. Butterflies were important visitors, but only half as common on the smaller, pale flowers of *A. verticillata*. All three species showed some degree of specialization favouring long-tongued Hymenoptera and Lepidoptera. Owing to differences (e.g., search image, response to floral chemistry) pollinators discriminated between milkweeds, occurring in varying percentages and potentially influencing gene flow. Other factors affecting pre- and postzygotic isolation included position of pollinia on insects' legs, size of flowers, pollinia and pollen tube incompatibility, flowering phenology, distance and duration of flights between blossoms, and presence/absence of sympatric milkweeds. Hatfield & Kephart (2003) studied pollinators in sympatric Oregon populations of *A. fascicularis* and *A. speciosa*. Again, bees (*Apis*, *Bombus*, *Anthophora*), and wasps (Vespidae) were the dominant visitors. Reproductive isolation was maintained by the larger pollinia of *A. speciosa*, the smaller stigmatic chambers of *A. fascicularis*, and differences in flowering phenology; however, there is a tantalizingly-brief mention of insects (selectively?) not flying between the two milkweeds in mixed populations. On *A. verticillata* growing in Illinois, the majority of pollinators (80–93%) were Hymenoptera and Lepidoptera, including a significant contribution (2–9%) from introduced *Apis mellifera* and cabbage butterfly, *Pieris rapae* (Willson et al. 1979). Other prominent pollinators were wasps (Sphecidae, Vespidae, and Tiphiidae), and moths (Erebidae, Noctuidae). In south-eastern Arizona, long-tongued insects were prominent visitors at *A. tuberosa* (Fishbein & Venable 1996); certain taxa (e.g., *Apis*, *Bombus*, and medium Lepidoptera) were more important for removing and delivering pollinia. Although the success of these pollinators correlated positively with visit duration, the authors note sustained visits by other species (e.g., small Lepidoptera) may result in pollen being wasted in geitonogamous pollination.

The primary commonalities of *Asclepias* pollinators appear to be an attraction to an abundant nectar supply, the ability to fly, similar responses to floral colour and chemistry, daytime activity (most species), a flight season and distribution corresponding with that of the plant, and the size and strength to remove their leg and attached corpusculum, translator arms, and pollinia from a flower's anther wings. Failure to accomplish the latter may result in amputation or prevent escape from predators such as ambush bugs (Reduviidae), robber flies, or crab spiders, as may have been the fate of this bee fly (Fig. 2A). Addressing this topic, Robertson (1891) said of two milkweeds from the eastern U.S.A. "... it is obvious that the flower can hardly be considered as adapted to insects which often lose their lives this way" (p. 569). This statement may be appropriate for relatively unspecialized New-World *Asclepias*, but some South African milkweeds (e.g., *Pachycarpus* spp.) are highly specialized, employing dull-coloured flowers, concentrated nectar, and secondary compounds that repel other insects as they attract the few spider wasps (Pompilidae) that pollinate them, despite frequently being mutilated during the act of pollinia removal and insertion (Shuttleworth & Johnson 2006, 2011, Ollerton et al. 2019). Extremely similar, large

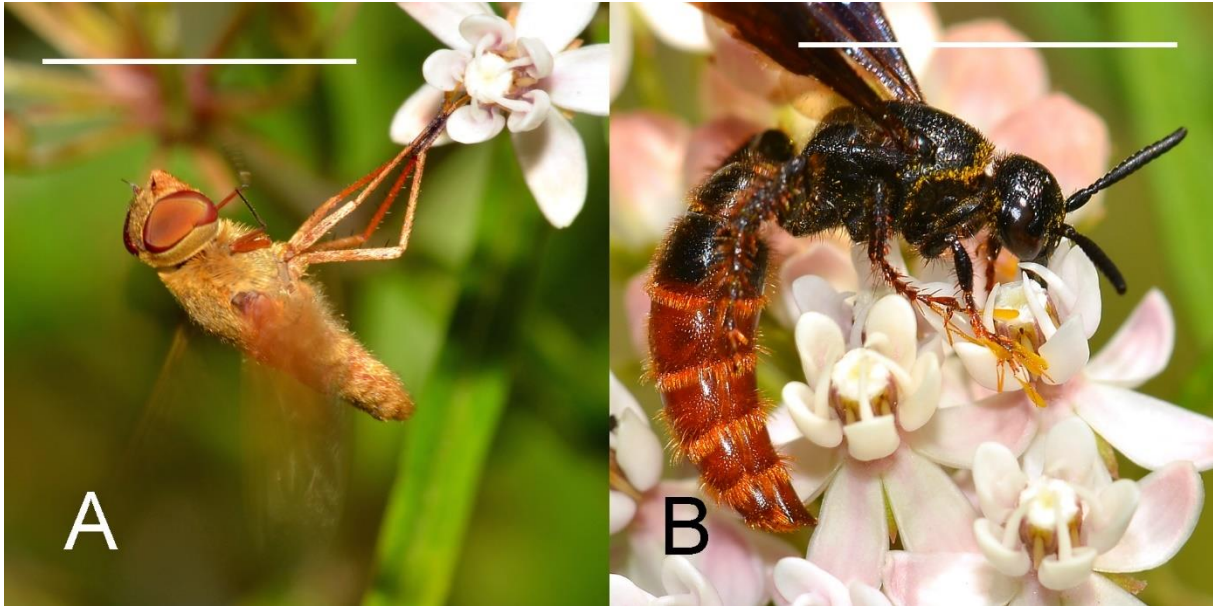


FIGURE 2. (A) Live *Chrysanthrax editulus* (Bombyliidae), trapped in flower, 5 June 2019 (SAP). (B) *Scolia dubia* (Scoliidae), with pollinia, 30 August 2018 (ASH). Scale bars = 10 mm.

spider wasps carry pollinia of *A. angustifolia*; as yet there is no evidence that they are anything more than members of the group of wasp pollinators (below). Although *Asclepias* may attract wasps with a floral scent that evolved in an African ancestor, perhaps it is more likely that a generalist African *Asclepias*, pollinated by a variety of insects, was better fit to colonize a New-World as-yet bereft of specialists. Were it the latter, the c. 10–15 million years the genus has been present in the New-World (Fishbein et al. 2011) have been insufficient for its descendants to evolve requirements for specialist pollinators, employing instead a wide variety of insects, including many Hymenoptera, attracted to abundant nectar. If coadaptation is considered specialization driven by both flower and pollinator (an unusual phenomenon in plant-pollinator interactions), it does not appear to have developed in the studied North American *Asclepias* and their pollinators. Indeed, nearly any sufficiently large insect, even a species considered dystopous, (destructive or at least not adapted for pollination), may transfer pollinia as it crawls among *Asclepias* flowers.

Pollination may be considered successful when an insect removes a pair of pollinia from the adjacent anther wings of one flower and inserts one or both pollinia into the stigmatic slit(s) of another flower (Betz et al. 1994). Evidence of success constitutes a corpusculum with one or both translator arms devoid of pollinia, suggesting the missing pollinium has been deposited in a recipient flower. Calculations of pollination efficiency based on such observations are obfuscated by unknowns, e.g., damage to, or loss of pollinia during feeding, grooming, or social interactions (Betz et al. 1994), but may be improved with observations of flowers.

Photography revealed a broad pollinator spectrum: 140 species bearing pollinia in five orders: Hemiptera (4 spp.), Coleoptera (7 spp.), Hymenoptera (68 spp.), Lepidoptera (41 spp.), and Diptera (20 spp.) (Tab. 2). Assessing the quality of pollination data for Apocynaceae, Ollerton et al. (2019)

scored an insect carrying pollinia as a code 2 observation (e.g., *Scolia dubia*, Fig. 2B). Thus, the present study recorded 140 code 2 observations, the majority of which were the expected orders: Hymenoptera, Lepidoptera, and Diptera. Pending escape, the entrapped bee fly (Fig. 2A) represents a potential code 1 observation. To differentiate very small insects unlikely to serve as pollinators, a subjective spectrum of likely, possible, and unlikely pollinators is suggested (Tab. 2). Of the total species, 240 (65%) are likely to be large and strong enough to affect pollination.

Lacking data on numbers of individuals and their contributions to successful pollination, it is useful to evoke the concept of functional groups of pollinators. Fenster et al. (2004) argue that animals sharing characteristics; i.e., similar morphology, behaviour, and responses to chemical stimuli, may guide natural selection by exerting comparable selective pressures on floral traits; thus, functional groups of pollinators are more likely to illuminate specialization than a list of species. For example, differing rates of visitation to sympatric *Asclepias* (e.g., more large butterflies than large bees) may reduce the likelihood of interspecific pollen transfer (Kephart & Theiss 2004), and visits by a pollinator with a greater rate of pollinia transfer (e.g., *Bombus*) may increase successful fertilization (Fishbein & Venable 1996). For this study, insects carrying pollinia were divided into 10 groups (with abbreviations for Fig. 3): Hemiptera (HEMI), Coleoptera (COLE), short-tongued bees (STB), large long-tongued bees (LLTB), small long-tongued bees (SLTB), wasps (WASP), small Lepidoptera (SLEPS), large Lepidoptera (LLEPS), bee flies (BOMBY) and large flies (LFLY). Hummingbirds (Aves: Trochilidae), are an important functional group, generally associated with colourful, tubular flowers. They were numerous and diverse at all four study sites where up to 15 species may occur, but were not observed at *A. angustifolia*, despite taking nectar at other plants a few centimetres away.

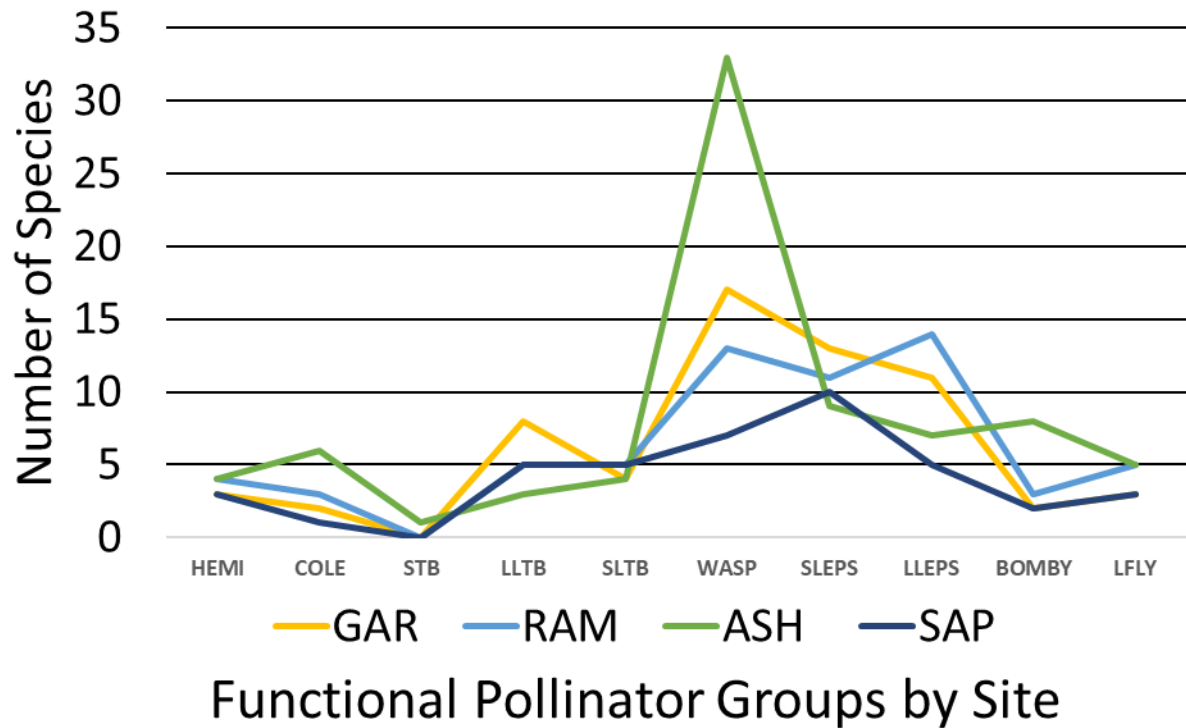


FIGURE 3. Numbers of pollinia-carrying insects (y axis) separated into functional groups of pollinators (x axis) and graphed by site.

The most numerous insects bearing pollinia were WASP, SLEPS, LLEPS, and LLTB. To help gauge their importance, images of potential pollinators were reviewed to assess the status of pollinia. Sample sizes for many species were small: once an insect was known to carry pollinia it was not always re-photographed, images did not often depict all six legs, residual corpuscula are not always visible, and distinguishing yellow translator arms from yellow leg spines was a confounding issue. Of the 140 potential pollinators, 132 had some complete pairs of pollinia: 65 Hymenoptera (15 LLTB, 7 SLTB, and 43 WASP), 41 Lepidoptera (22 LLEPS, 17 SLEPS, and two moths), 17 Diptera (8 BOMBY, 9 LFLY), 7 COLE, and 3 HEMI. Seventy species had one or more pairs with a missing pollinium: 38 Hymenoptera (11 LLTB, 1 SLTB, and 26 WASP), 24 Lepidoptera (15 LLEPS, 8 SLEPS, and a moth), 3 LFLY, 2 HEMI, and 2 COLE. Forty-two species had one or more translator arms wholly lacking pollinia: 22 Hymenoptera (7 LLTB and 15 WASP), 14 Lepidoptera (11 LLEPS and 3 SLEPS), 4 Diptera (2 BOMBY, 2 LFLY), and 2 COLE. All categories are dominated long-tongued insects: WASP, LLEPS, and LLTB, suggesting their particular importance as functional groups of pollinators. SLEPS, Diptera (BOMBY + LFLY), COLE and HEMI were less important functional groups. Nectaring HEMI and COLE may form a single functional group of morphologically-similar flower crawlers, but COLE (i.e., Cantharidae and Lycidae) are more likely to pollinate because of their greater numbers.

Site comparison and convenience sampling

Although located in a small area with relatively few plants, the 140 site visits (64.81%) outside the author's residence (ASH) produced 212 species, the highest site total, representing 57.45% of all species, as well as the greatest number (108) and percentage (47.16%) of unique species (Tab. 1). This intensity may be considered a form of "convenience sampling" (Szabo et al. 2012), wherein a greater number of visits at favoured locations or times (e.g. known productive sites or roadsides, during summer vacations or weekends) introduces temporal or spatial bias. Increased site visits from convenience sampling may produce a better picture of species richness by providing more opportunities to discover insects with unusual emergence patterns, vagrants from other regions or habitats, or species that may be expanding their ranges due to global warming (e.g., Behrstock et al. 2020). Conversely, there is no reason to expect equal sampling regimes will yield equal numbers or similar assemblages of pollinators. At their four *A. verticillata* study sites in Illinois, Willson et al. (1979) found notable disparities in seasonal distribution, rate of flower visitation, and occurrence of nectar thievery (presence vs. absence of pollinia), and statistically significant, between-site differences related to total species, native vs. introduced species, and frequency of major families. ASH produced the greatest numbers of COLE, WASP, and BOMBY, the totals being c. 50% greater than the next highest site (Fig. 3) and perhaps resulting from increased sampling intensity. The natural population of *A. angustifolia* (GAR) produced the greatest

number of LLTB and SLEPS and the second highest numbers of WASP and LLEP. The garden at RAM is located in a moist canyon bottom similar to GAR, but with a great diversity of introduced flowering plants. It produced the highest total of LLEPS, second highest totals of COLE and (along with SAP) LLTB. An irrigated garden surrounded by Mesquite Grassland, SAP, was the subject of somewhat more than 11% of total field hours. Species totals were similar to other sites for HEMI, STB, SLTB, and somewhat greater than ASH for LLTB and SLEPS. Again, the smaller number of species may reflect sampling intensity.

Insect orders encountered

Orthoptera: Grasshoppers and katydids

Spur-throat grasshopper nymphs (*Melanoplus* spp.: Acrididae) and a katydid *Scudderia* cf. *mexicana* (Tettigoniidae) were encountered in small numbers c. six times. Most roosted on stems, but the two katydids and c. two early instar *Melanoplus* fed on flowers, facilitated perhaps by the very low level of toxic cardenolides in *A. angustifolia* (Agrawal et al 2009).

Thysanoptera: Thrips

Thrips, likely in the family Phlaeothripidae, were encountered three times (GAR, RAM, ASH). Beating flower clusters to dislodge smaller cryptic insects would likely have generated additional records.

Hemiptera: True bugs

Fourteen families of Hemiptera representing c. 37 species (including two kinds of unidentified nymphs) were recorded. Numerically and visually prominent, were the seed bugs (Lygaeidae). Several genera (milkweed bugs), are usually adorned in bold red or orange and black aposematic (warning) patterns advertising chemical defences provided by toxic cardenolides ingested from their host plants—with which they may have coevolved (Agrawal 2017). Lygaeid nymphs were often present by the hundreds, their feeding activities damaging pods and seeds and compromising a plant's reproductive potential. Adults, often present by the dozens (Fig. 4A), frequently took nectar at flowers. Three species carried pollinia and two more were likely pollinators. Adults of *Lygaeus kalmii* and *O. fasciatus* sometimes bore pollinia. Found on 85 and 86 site visits respectively, they are potentially important and are known pollinators of *Asclepias* (Ollerton et al. 2019). Occasionally, *Melacoryphus lateralis* was numerous, at times bearing pollinia. Nymphs of *L. kalmii*, *O. fasciatus*, and oleander aphids (aka milkweed aphids), *Aphis nerii*, were often present by the hundreds, sucking fluid from the milkweed's phloem. This clustering aphid specializes on Apocynaceae; its yellow coloration is considered aposematic (Agrawal 2017). Other Hemiptera present in small numbers were predators (Geocoridae, Nabidae, Reduviidae); fed on nectar and plant tissues (Cicadellidae, Alydidae, Largidae, Coreidae, Rhopalidae, Thyreocoridae); or both (Berytidae, Miridae, Pentatomidae).

Coleoptera: Beetles

There are limited records of beetle pollination (cantharophily) in North American *Asclepias*, beginning with the work of Robertson (1887a), and summarized recently by Ollerton et al. (2019). Of the 29 native U.S. *Asclepias* they list (approximately 40% of the U.S. species), pollinating beetles were recorded on only nine. Several were identified simply as Coleoptera. Of the remainder, five families were represented: Soldier beetles (Cantharidae), scarab beetles (Scarabaeidae), fireflies (Lampyridae) weevils (Curculionidae), and longhorn beetles (Cerambycidae), each with one to four identified species and a few more categorised to family or genus. Additionally, Quinn (2015) provides identified photos of two scarab beetles and two soldier beetles from the U.S. transporting pollinia. Given the paucity of records, the intensity of the literature search (including unpublished records), and the immense diversity of Coleoptera inhabiting North America (various websites suggest 25,000-30,000 species), beetles appear to be minor pollinators of U.S. *Asclepias*; nonetheless, discoveries await to be made.

Fifteen families representing 56 species were encountered; some were leaf or stem feeders not associating with flowers, or too small to remove pollinia from flowers (e.g., various Chrysomelidae and Melyridae). Representatives of three families transported pollinia. In Southeastern Arizona, soldier beetles (Cantharidae) (Fig. 4B) and net-winged beetles (Lycidae), are diverse families whose members may be present by the hundreds, nearly obscuring the flowers upon which they cluster during feeding or mating aggregations. Both families are known pollinators of many plants. They are protected chemically with noxious tastes and odours and exhibit characteristic aposematic colours and patterns shared in both Batesian and Müllerian mimicry complexes within their own families, and occasionally other families or orders (e.g., lycid-mimicking moths) (Eisner 2008, Linsley et al. 1961). Four of the seven *Chauliognathus* soldier beetles and two of the six *Lycus* net-winged beetles carried pollinia. During 2018, *Lycus loripes* was especially abundant, blanketing some milkweeds (RAM especially) where many individuals carried one or several pair of pollinia, suggesting it and other members of the Lycidae are potentially important pollinators (Fig. 4C). With additional observations of less-numerous species, most or all members of both families may eventually be observed with pollinia. Three species of scarab beetles were noted, all strong insects whose slow, lumbering movements suggest they might be effective in gathering and transporting pollinia. Of those, the Western rose chafer, *Macrodactylus uniformis* (Melolonthinae), was noted carrying pollinia (SAP). Three longhorn beetles (Cerambycidae), were photographed. *Rhopalophora meeske* is aposematically coloured in orange and black. Two milkweed beetles, *Tetraopes discoideus* (widespread) and *T. linsleyi* (once, ASH) were encountered. Like the milkweed bugs mentioned previously, the c. 27 *Tetraopes* belong to the guild of milkweed-feeding insects. By way of convergent evolution, they have evolved the characteristics of the guild: aposematic coloration, a feeding behaviour for avoiding the milkweed's sticky latex, and the molecular changes necessary to ingest leaves containing toxic cardenolides (Agrawal 2017).



FIGURE 4. Insects on *Asclepias angustifolia*. (A) Large milkweed bugs, *Oncopeltus fasciatus* (Lygaeidae), 27 September 2019 (RAM). (B) Soldier beetle, *Chauliognathus lecontei* (Cantharidae), 18 August 2019 (ASH). (C) Portion of an aggregation of net-winged beetles, *Lycus loripes* (Lycidae), 4 July 2018 (RAM). (D) *Rhynchophion flammipennis* (Ichneumonidae), a tarantula wasp mimic, 25 August 2019 (ASH). (E) *Lasioglossum* subgenus *Lasioglossum* (Halictidae), 21 October 2018 (RAM). (F) Checkered white, *Pontia protodice* (Pieridae), with pollinia, 6 June 2019 (GAR). (G) larva of a milkweed specialist moth *Euchaetes antica* (Erebidae), 18 August 2018 (ASH). (H) A wasp-like bee fly, *Poecilanthrax ingens* (Bombyliidae), 26 August 2019 (RAM). (I) A large wasp mimicking fly, *Mydas arizonensis* (Mydidae), 19 August 2019 (ASH). Scale bars = 10 mm.

Hymenoptera: Ants, bees and wasps

The order Hymenoptera represents the largest percentage of insect species pollinating milkweeds (Ollerton et al. 2019). Ants frequently take nectar at milkweed flowers; additionally, they may be predators, scavengers, herbivores, or tend colonies of aphids (Rea 2011), rarely serving as pollinators (Ollerton et al. 2019). None of the five species encountered bore pollinia. Twenty families of bees and wasps representing c. 100 species were photographed: parasitic wasps (seven families), bees (five families) and aculeate wasps (eight families). Species of all sizes form an assemblage of Müllerian

mimics, whose aposematic colouration, and patterns alert predators to their common defence mechanism. Some serve as models for harmless Batesian mimics, including flies, beetles, moths, and harmless hymenopterans; e.g., the large, docile ichneumonid wasp *Rhynchophion flammipennis* (Fig. 4D) is a convincing mimic of a number of tarantula wasps (Pompilidae) that deliver a vicious sting. Many species, especially tiny parasitic wasps and the smallest bees, are incapable of achieving pollination in milkweeds. Among the remainder, 68 (64.15% of the Hymenoptera) carried pollinia attached to the distal tarsal segments (often on leg hairs), the tarsal claws, and arolium (the fleshy pad between the claws).

One species, *Stenodynerus ochrogonius* (Eumeninae) had an unbroken pair of pollinia attached to its palps. Well-represented families included Halictidae (15+ spp.), Megachilidae (8+ spp.), Crabronidae (14 spp.), Scoliididae (10 spp.), and Vespidae (17+ spp.). Of the latter, 10 genera of Eumeninae (potter wasps), including several rare or infrequently collected Mexican border species, was noteworthy (M. Buck 2019, in litt.). Frequently the most abundant insects, present by the dozens or hundreds, belonged to the genus *Lasioglossum* (Halictidae) (Fig. 4E), many of which are extremely similar, generally not identifiable in the field or from photos, and usually too small to pollinate *Asclepias*. Table 1 lists seven identified only to subgenus; twice as many may have been present. Allowing for the quantity of unidentified species, the overall number of bees encountered, at least 13–17 species, was similar between sites.

The introduced Western honey bee, *Apis mellifera*, is a dominant pollinator of many *Asclepias*, e.g., *A. fascicularis*, *A. speciosa*, *tuberosa*, *syriaca*, and *A. verticillata*, and its importance of as a pollinator milkweeds is significant (Robertson 1887a, Willson et al. 1979, Fishbein & Venable 1996, Ollerton & Liede 1997, Hatfield & Kephart 2003, Kephart & Theiss 2003). Entrapment in the anther wings of *Asclepias* flowers is often documented (e.g., Robertson 1887a, 1891, G. Thomas 2020, in litt.); Frost (1965) noted struggling bees generally escaped from flowers, occasionally by sacrificing leg segments, and Willson et al. (1979) note overburdened *Apis* may remove accumulated pollinia. In this study, where both wild nests and domesticated hives are present, honey bees, including several distinctive black morph individuals, were observed on *A. angustifolia* during 34 site visits. Nearly every bee carried pollinia on its tarsomeres, tarsal claws, or (infrequently) tibiae. Some individuals were burdened with 25 or more pairs of pollinia or corpuscula with empty translator arms, underscoring their importance as pollinators of the small-flowered *A. angustifolia*.

Insects removing larger numbers of pollinia are also more likely to insert more pollinia per flower visited (Ivey et al. 2003). Here, larger bees (e.g., *Aphis*, *Anthophora*, *Melissodes*, *Tachusa*, *Megachile*) and wasps (e.g., *Prionyx*, *Isodontia*, *Colpa*, *Delis*, *Myzinium*, *Polistes*, and *Scolia*) carried the largest loads of pollinia. Individuals were frequently noted to feed on the same plant for long periods (c. 15–30 + min.), which may account for lost pollinia sitting atop flowers. Taken to an extreme, long feeding visits may increase the likelihood of self-pollination (i.e., autogamy or geitonogamy). Quellar (1985) demonstrated that after 150 sec. away from the flower, most pollinia of *A. exultata* L. dried and their translator arms rotated, facilitating insertion into a receptive flower, a hazard during a 15–30-minute visit to a single plant. Low likelihood of self-fertilization due to mechanical or ethological barriers may be overridden in part by extreme duration of visits; however, genetic self-incompatibility (itself variable between species and populations) may preclude success from most self-fertilizations (Lipow et al. 1999) and may help explain the low fruit set at ASH. Fishbein & Venable (1996) noted larger bees (*Bombus*) were most effective transferring pollinia of *A. tuberosa*. Noteworthy in the present study was the near absence of the locally common Sonoran bumble bee, *B. sonorus* and complete lack of carpenter bees,

Xylocopa. Both genera were important pollinators, more speciose, and more plentiful in other studies (e.g. Lynch 1977, Ivey et al. 2003, Kephart & Theiss 2004, Fishbein & Venable 1996, Baker & Potter 2018). On 13 July 2019 (SAP), c. 10 *B. sonorus* nectared on low red and yellow *Lantana* sp., and c. 20 more nectared on a tall *Vitex agnus-castus*, all ignoring adjacent plantings of *A. angustifolia*. During 143.77 field hrs, *B. sonorus* was observed on *A. angustifolia* only once at ASH and twice at SAP, and *Xylocopa*, represented by at least two local species, was never recorded. Unlike Arizona's c. seven high-elevation bumble bees, *B. sonorus* is most numerous on the lower elevation Chihuahuan and Sonoran Desert and grassland surrounding the Sky Island ranges (Schmidt and Jacobson 2005). The few occurrences of *Bombus* on *A. angustifolia* were at the lowest study sites (ASH and SAP). Higher, in GAR, *Bombus* and swallowtail butterflies foraged on the larger, yellow or orange flowers of *A. tuberosa*, ignoring nearby *A. angustifolia*. During this study, *Bombus* and *Xylocopa* preferentially visited other plants including *A. tuberosa* (Apocynaceae) (see Fishbein & Venable 1996); introduced *Cosmos* spp.; native *Circium* spp.; *Helianthus petiolaris*; *H. annuus*; introduced *H. maximiliani*; *Plectocephalus rothrockii*; and introduced *Tithonia* spp. (Asteraceae); *Eysenhardtia orthocarpa*; *Senna lindheimeriana*; and introduced *Melilotus alba* (Fabaceae); native and introduced *Salvia* spp.; native and introduced *Monarda* spp.; and introduced *Origanum* (Lamiaceae); and a horticultural *Leucophyllum* sp. (Scrophulariaceae). Owing perhaps to the chemical composition of its nectar or scent, Hymenoptera present only a few meters away by the tens or hundreds ignored or infrequently visited *A. angustifolia*, feeding preferentially at other flowers. These included various bees, e.g., cuckoo bees (Halictidae spp.), *Melissodes*, *Centris*, *Anthophora*, and *Xylocopa*. Some bees (*Osmia*: Megachilidae, *Pseudopanurgus* and *Perdita*: Andrenidae) were present in the study area, but never encountered. Also absent or nearly so were some wasps (Tiphidae and Campsomerinae).

Lepidoptera: Butterflies and moths

Ollerton & Liede (1997) provide an extensive literature survey of pollinators of Asclepiadaceae, noting butterfly pollination among members of the tribe Asclepiadeae (including *Asclepias*) is almost exclusively a New-World phenomenon. As New-World *Asclepias* diversified, providing abundant nectar in a variety of habitats, butterflies would certainly have been attracted to them, becoming members of their diverse assemblage of pollinators.

Sixty butterflies and 12 moths were encountered (Tab. 2), occasionally in impressive numbers: during two hours on 6 June 2019, 16 species, most bearing pollinia, were noted on three adjacent plants (GAR), including this Checkered white, *Pontia protodice* (Fig. 4F). The diversity of butterflies was nearly equal at higher GAR and RAM (34 vs. 33 spp.), and lower SAP and ASH (25 vs. 24 spp.) sites. Of the 60 butterflies, 39 (65.00%), as well as two diurnal moths carried pollinia, nearly all attached to the distal-most tarsal segments, rarely on the tibia, a tibial spur, or a tarsal claw, and never on the face or mouthparts. Larger species especially (e.g., *Thorybes pylades*, *Cogia hippalus*, *Euptoieta claudia*, *Vanessa cardui*, *Vanessa virginiensis*, *Junonia evarete nigrosuffusa*,

Chlosyne lacinia, *Pontia protodice*), often bore corpuscula or empty translator arms, suggesting successful pollination. These observations mirror those of Müller (1883, p. 400 with illustration), who found 22 pollinia of tropical milkweed, *A. curassavica* L. on a single leg of a butterfly (possibly a *Vanessa*), 14 of which had apparently been broken during pollen transfer. Not only large species carried pollinia. As pollinators of milkweeds, Robertson (1887b, p. 224) stated “Small butterflies are worse than useless. They remain long on the umbels, sucking, but resting their feet superficially on the flowers, and seldom effecting pollination”. In this study, a number of our smallest butterflies transported pollinia, among them: *Copaeodes aurantiaca*, four species of *Amblyscirtes*, *Piruna aea*, and *Leptotes marina*. Not all butterflies at the study sites were attracted to *A. angustifolia*; avoiders included *Erynnis funeralis*, *E. tristis* (Hesperiidae), *Agraulis vanillae*, *Limenitis arthemis* (Nymphalidae), and *Papilio multicaudata* (Papilionidae). *Phoebis sennae* (Pieridae), was often present by the dozens; only one was recorded on *A. angustifolia*.

The diversity of butterflies was greater than that found by Fishbein & Venable (1996) at their *A. tuberosa* study area at Canelo Hills, Santa Cruz Co., Arizona, where they recorded 40 kinds of butterflies among 80 insect species encountered. Eighteen butterflies (45%) carried pollinia. Canelo Hills, on the west side of the Huachuca Mountains, is c. 24 km west of this study area and somewhat lower than the three Huachuca sites. Differences in species numbers and composition at Canelo may reflect the narrower window of data collection (June–July), slightly lower elevation, more open habitat, the larger orange or yellow flowers and floral other traits of *A. tuberosa*, and, importantly, a protocol that emphasised observing focal plants during fixed observation periods. Although species numbers of brush-footed butterflies (Nymphalidae) and whites/yellows (Pieridae) were virtually identical in both studies, the greater elevational gradient sampled in and near the Huachuca Mountains and longer field seasons yielded a higher total of skippers (Hesperiidae) (22 vs. 7) and metalmarks (Riodinidae) (4 vs. 0). However, the smaller white flowers of *A. angustifolia* attracted a lower diversity of swallowtails (Papilionidae) (1 vs. 4). Similarly, in Indiana, the larger and more colourful flowers of *A. syriaca* and *A. incarnata* attracted more *Battus philenor* (Papilionidae) than the smaller white flowers of *A. verticillata* (Kephart & Theiss 2004).

Arizona’s importance to breeding, migrating, and overwintering monarchs and the paths different populations take while moving to and from overwintering sites in Mexico or California are only now being elucidated (Morris et al. 2015, Billings 2019). During tagging studies and extensive field searches (Billings 2019), south-eastern Arizona’s migrating monarchs concentrated (and bred) in upper elevation grasslands, floodplain habitats, and riparian corridors adjacent to the Santa Cruz and San Pedro rivers. These sites provide a rich supply of nectar (including *A. tuberosa*), as well as horsetail milkweed, *A. subverticillata* (Gray), utilized for oviposition. Occasional monarchs visit canyons with Madrean Pine-Oak Woodland. These few observations suggest *A. angustifolia* is likely of limited use to migrants and breeders; however, rearing data (Pegram & Melkonoff 2019) suggest it would be of value to monarchs

and other specialist foliivores (e.g., *Euchaetes* spp., Fig. 4G) in gardens or revegetation projects in lower or more open habitats.

Diptera: Flies

“The Diptera are the second most important order among flower-visiting (anthophilous) and flower-pollinating insects worldwide” (Larson et al. 2001, p. 439). In the U.S., a six-milkweed compilation by Fishbein & Venable (1996) ranked Diptera the second most important order of pollinators for the white, small-flowered whorled milkweed, *A. verticillata* L., whose flowers are similar to those of *A. angustifolia*. Twenty-two families of flies were documented; many were nectarivores too small to serve as pollinators of *Asclepias*. Most flies were present in small numbers but a freeloader fly (Milichiidae) was briefly numerous at ASH, where c. 600 flies/plant were visually estimated. There was no evidence suggesting specialized fly pollination (myophily), but the foraging breadth of the region’s flies is not well documented. Many flower flies (Syrphidae), and bee flies (Bombyliidae), are hover feeders and ineffective pollinators. Ollerton et al. (2019) found few records of either pollinating North American milkweeds, and they pertained to genera other than *Asclepias*. The fauna of south-eastern Arizona includes many Bombyliidae and Syrphidae that alight on or walk on flowers and may serve as pollinators (pers. obs.). Bombyliidae, Syrphidae, and parasitic Tachinidae were well represented (30, 9, and c. 24 spp. respectively). One tachinid fly (*Cylindromyia* sp.) bore a pair of pollinia attached to its face. Although important pollinators of plants with loose pollen, these few observations yielded no Syrphidae transporting pollinia, compared to (conservatively) seven Tachinidae, and 10 Bombyliidae. The Bombyliidae included six or seven *Exoprosopa* (one is undescribed, A. Calderwood 2019, in litt.); five carried pollinia. This genus of large, common, well-marked but often confusingly similar pollinators, has yet to be clarified, and remains a stumbling block for field entomologists in the American Southwest. Four other genera of Bombyliidae carried pollinia including two wasp-like *Poecilanthrax* (Fig. 4H). Other pollinating flies were *Esenbeckia delta* (Tabanidae), a common blow fly *Lucilia* sp. (Calliphoridae), and *Mydas arizonensis* (Mydidae) a large wasp-mimic that is perhaps best included in the pollinator group with wasps (Fig. 4I). The overall percentage of Diptera, 95 of 369 total species (25.75%), was quite different than that found by Fishbein & Venable (1996), who encountered 6 dipterans among 80 insects (7.50%) on *A. tuberosa* during a study that focused on certain plants.

Introduced insects

At least six insects native to the Old-World were encountered, two carried pollinia and the syrphid is a potential pollinator. Oleander aphid, *Aphis nerii* (Aphididae) was numerous and found at all sites; Western honey bee, *Apis mellifera* (Apidae) was encountered at all sites (only once at GAR); cabbage white, *Pieris rapae* (Pieridae) occurred in small numbers at all sites except ASH (but was seen there several days during May 2020); despite being locally numerous, the Yellow fever mosquito, *Aedes aegypti* (Culicidae), whose males are known to feed on nectar, was seen just once at ASH; thick-legged hoverfly, *Syrretta pipiens* (Syrphidae), a potential

pollinator, was present five days at ASH, likely represented by only one or two individuals; and Bermudagrass stem maggot, *Atherigona reversura* (Muscidae) was seen in small numbers at ASH during three site visits. The scentless plant bug *Liorhyssus hyalinus* (Rhopalidae), noted at all sites except GAR, is found throughout much of the world and may be introduced in North America.

Value for restoration sites and planting palettes

Restoration ecologists apply scientific principles to restore ecosystems damaged by destructive forces such as fire, flooding, construction, and invasive flora (including agriculture), all serious issues in the American Southwest. Selecting suitable plants to augment or replace compromised vegetation relies on the availability of native species adapted to the area's ecological milieu. Success and financial investment are maximized when the suite of seeds or seedlings is fine-tuned to damaged areas. Based on many factors; e.g., access, fire risk, precipitation, labour force, elevation, and soil type, plant combinations (planting palettes) may be developed, ideally at the site level, with an eye toward current and future climatic conditions. Success depends not simply on increasing floral diversity, but understanding requirements of pollinators; e.g., flower morphology preferences, understory structure, and even weekly floral colour availability. For example, in much the same way gardeners provide nectar and larval host plants for butterflies, Tooker et al. (2006) suggest the structure and diversity of fly assemblages may be controlled by manipulating combinations of their preferred host plants. More recently, effects of global warming on the physiology of plants and their pollinators have been investigated (e.g., blooming phenology, nectar and pollen production, flight period, life span, etc.); these data are integral to developing successful planting palettes resilient to changing climate (Scaven & Rafferty 2013, Campbell 2020). For Arizona restoration sites (and gardens), *A. angustifolia* exhibits key characteristics favoured by Tallamy (2007): an attractive, hardy native adapted to the region's climate, utilization by a variety of nectar feeders, and foliage eaten by Lepidoptera and other insects that provide food for birds and other predators. In the Huachuca Mountains, it is but one of c. 1,000 species of plants, many of which provide resources for pollinators. Characteristics that tip the scales in its favour include a protracted blooming period (potentially five–six months), its ability to be propagated in large numbers, tolerance of low winter temperatures, survival (with supplemental water at certain elevations) throughout an elevational range of over 1,000 m, and a supply of abundant nectar attractive to an unusually diverse assemblage of insects, thus providing a host of benefits throughout the community. As such, it should be considered a valuable addition to pollinator gardens and habitat restoration sites, especially in riparian corridors, or where breeding or migrating monarch butterflies may be present.

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APPENDICES

Additional supporting information may be found in the online version of this article:

APPENDIX I. Arizona nurseries that supply *Asclepias angustifolia*.

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TABLE 2. Insect visitors to *Asclepias angustifolia* at four sites in SE Arizona. Orders and families, identification, number of days encountered at each study site, inclusive dates encountered during 2018 and 2019 (month/day), presence on flowers or not (F or -), presence of pollinia/ associated structures or not (+ or -), spectrum of visitors that are likely (X), possible (?), or unlikely (-) to affect pollination, and status of pollinia on known pollinators: unbroken pair(s) (U), one pollinium remaining (I), corpusculum and empty translator arms (E). Insects preceded by an asterisk (three species) were encountered before or after the study and a year is given in the date column.

Order/Family	Identification	GAR	RAM	ASH	SAP	Σ Visits	Dates	F	P	S	Poll. Status
Orthoptera											
Acrididae	<i>Melanoplus</i> spp. (nymphs)		2	I	I	4	6/16-8/15	F	-	X	-
Tettigoniidae	<i>Scudderia</i> cf. <i>mexicana</i> (Saussure, 1861)	I	I			2	5/29-9/3	F	-	X	-
Thysanoptera											
cf. Phlaeothripidae	species A	I	I	I		3	5/16-7/10	F	-	-	-
Hemiptera											
Cicadellidae	<i>Graphocephala aurora</i> (Baker, 1898)		I			1	7/18	-	-	-	-
Miridae	<i>Lygus lineolaris</i> (Palisot de Beauvois, 1818)		I	I	I	3	5/30-6/21	F	-	-	-
	<i>Lopidea</i> sp. A			I		1	5/28	F	-	-	-
	<i>Lopidea</i> sp. B			I	I	2	6/5-9/16	F	-	-	-
	cf. <i>Pseudopsallus</i> sp.				I	1	6/24	F	-	-	-
Nabidae	<i>Nabis</i> sp.		I			1	7/1	F	-	X	-
Reduviidae	<i>Zelus renardii</i> Kolenati, 1856	9	6		I	16	6/6-8/12	F	-	X	-
	<i>Phymata fasciata</i> (Gray, 1832)			II		11	9/10-9/29	F	-	X	-
	<i>Phymata rossi</i> Evans, 1931	5				5	6/8-7/21	F	-	X	-
Berytidae	<i>Jalysus</i> cf. <i>wickhami</i> Van Duzee, 1906				I	1	7/19	F	-	-	-
Geocoridae	<i>Geocoris</i> cf. <i>omani</i> Barber, 1935				I	1	6/5-	F	-	-	-
	<i>Geocoris</i> sp.		I	I		2	6/17-7/1	F	-	-	-
Lygaeidae	<i>Lygaeus kalmii</i> Stål, 1874	3	16	61	5	85	4/24- 10/14	F	+	X	U
	<i>Melacoryphus circumlitus</i> (Stål, 1862)			3		3	7/21-8/28	F	-	X	-
	<i>Melacoryphus lateralis</i> Dallas, 1852	3	II	29	4	47	6/11- 10/24	F	+	X	I
	<i>Ochrostomus uhleri</i> (Stål, 1874)	6	5	8	3	22	7/4-8/28	F	-	X	-
	<i>Oncopeltus fasciatus</i> (Dallas, 1852)	9	18	54	5	86	5/31- 10/19	F	+	X	U, I
	<i>Nysius</i> sp.		3	2	I	6	7/23-8/12	F	-	X	-
	Orsillinae		3			3	7/9-8/18	F	-	-	-
Alydidae	<i>Darmistus</i> sp.	2		2		4	5/4-7/25	F	-	X	-
Coreidae	<i>Catorhintha guttula</i> (Fabricius, 1794)	3		I		4	7/15-7/25	F	-	X	-
	<i>Catorhintha</i> sp.	I	2			3	7/10-8/12	F	-	X	-
Rhopalidae	<i>Arhyssus</i> cf. <i>lateralis</i> (Say, 1825)	I	I	3		5	6/5-8/29	F	-	-	-
	<i>Liorhyssus hyalinus</i> (Fabricius, 1794)		I	2	2	5	6/12-8/18	F	-	-	-
	<i>Harmostes</i> sp.	I	2			3	5/18-9/3	F	-	?	-
Pentatomidae	<i>Tylospilus acutissimus</i> (Stål, 1870)		I			1	10/21	F	-	X	-

Tab. 2 continued

Order/Family	Identification	GAR	RAM	ASH	SAP	Σ Visits	Dates	F	P	S	Poll. Status
	<i>Lineostethus tenebricornis</i> (Ruckes, 1957)		I			1	8/20	-	-	X	-
	<i>Cosmopepla decorata</i> (Hahn, 1834)		I			1	10/14	F	-	?	-
	<i>Euschistus bififormis</i> Stål, 1862		5	I		6	7/9-10/21	F	+	X	U?
	<i>Thyanta custator</i> (Fabricius, 1803)			2		2	8/9-8/17	F	-	X	-
Thyreocoridae	species		I			1	7/24	F	-	-	-
	<i>Galgupha?</i> sp.			I		1	8/7	F	-	-	-
Largidae	<i>Largus cf. sculptilis</i> Bliven, 1959	I				1	7/10	-	-		-
	<i>Stenomacra marginella</i> (Herrich-Schaeffer, 1850)	I	I			2	5/9-8/12	-	-	X	-
	nymphs sp. A	2				2	6/6-6/15	F	-	X	-
	nymph sp. B			I		1	9/6	F	-	X	-
Aphididae	<i>Aphis nerii</i> Boyer de Fonscolombe, 1841	7	12	54	4	77	6/27- 12/19	-	-	-	-
Coleoptera											
Carabidae	<i>Lebia viridis</i> Say, 1823	I	3	2	I	7	6/8-9/22	F	-	-	-
Mordellidae	<i>Mordella</i> sp.			2		2	8/22-9/9	F	-	-	-
Tenebrionidae	<i>Lobometopon</i> sp.		2	I		3	8/15-8/20	F	-	X	-
Cleridae	<i>Enoclerus laetus</i> (Klug, 1842)			I		1	9/15	F	-	X	-
	<i>Trichodes peninsularis</i> <i>horni</i> Wolcott and Chapin, 1918			3		3	8/20-9/3	F	-	X	-
Melyridae	<i>Collops</i> nr. <i>grandis</i> Champion, 1914	I				1	7/13	F	-	X	-
	<i>Collops</i> cf. <i>granellus</i> Fall, 1912			I		1	5/31	F	-	X	-
	<i>Attalus</i> sp.			2		2	5/24-6/12	F	-	-	-
	Malachiini sp.			3		3	5/24-9/16	F	-	-	-
	Listrini			10		10	7/31-9/29	F	-	-	-
Coccinellidae	<i>Scymnus</i> sp. A		I			1	9/18	F	-	-	-
	<i>Scymnus</i> sp. B large	I				1	7/7	F	-	-	-
	<i>Scymnus</i> sp. (spp.?) C	I		5		6	5/18-7/9	F	-	-	-
	<i>Coleomegilla maculata</i> De Geer, 1775				4	4	5/14-6/24	F	-	-	-
	<i>Cycloneda sanguinea</i> (Linnaeus, 1763)	2	I	I	3	7	5/29-9/12	-	-	-	-
	<i>Hippodamia convergens</i> Guérin-Méneville, 1842		I			1	10/14	F	-	-	-
Cerambycidae	<i>Rhopalophora meeskei</i> Casey, 1891		I			1	8/17	F	-	X	-
	<i>Tetraopes linsleyi</i> Chemsak, 1963			I		1	7/27	F	-	-	-
	<i>Tetraopes discoideus</i> LeConte, 1858	2	7		3	12	6/21-9/27	F	-	-	-
Chrysomelidae	<i>Zabrotes chavesi</i> Kingsolver, 1980			I		1	6/12	F	-	-	-
	<i>Mimosestes amicus</i> (Horn, 1873)			I		1	7/13	F	-	-	-

Tab. 2 continued

Order/Family	Identification	GAR	RAM	ASH	SAP	Σ Visits	Dates	F	P	S	Poll. Status
	<i>Sennius</i> sp.	1				1	6/28	F	-	-	-
	Bruchinae sp.			I		1	9/13	-	-	-	-
	<i>Lema trabeata</i> Lacordaire, 1845	2				2	5/9-6/1	F	-	-	-
	<i>Oulema</i> subgen.	1				1	6/26	F	-	?	-
	<i>Hapsidolemoides</i> cf. <i>arizonae</i> (Schaeffer, 1919)										
	<i>Agroiconota bivittata</i> (Say, 1827)			I		1	7/23	-	-	-	-
	<i>Odontota arizonica</i> (Uhmann, 1938)	3	I			4	6/28-8/3	F	-	-	-
	<i>Disonycha alternata</i> (Illiger, 1807)				I	1	6/24	-	-	-	-
	<i>Disonycha</i> cf. <i>glabrata</i> Fabricius, 1781		I	3		4	7/5-9/9	F	-	-	-
	<i>Colaspis nigrocyanea</i> Crotch, 1873			6	2	8	8/4-8/30	-	-	-	-
	<i>Lexiphanes</i> sp.			I		1	8/23	F	-	-	-
Brentidae	Apioninae nr. <i>Coelocephalapion?</i>	1		I		2	6/28-7/18	F	-	-	-
Curculionidae	<i>Sitona californicus</i> Mannerheim, 1843			I		1	5/24	F	-	-	-
	<i>Onychobaris</i> sp.		I			1	8/26	F	-	-	-
	<i>Geraeus picumnus</i> (Herbst, 1797)	2	3	2		7	7/1-8/18	F	-	-	-
	<i>Acanthoscelidius</i> sp.	1				1	7/13	F	-	-	-
	<i>Anthonomus</i> sp.	1				1	6/28	F	-	-	-
Buprestidae	<i>Acmaeodera cazieri</i> Knull, 1960.	2				2	6/30-7/10	F	-	?	-
	<i>A. solitaria</i> Kerremans, 1897		I	I		2	8/25-8/26	F	-	?	-
Cantharidae	<i>Chauliognathus lecontei</i> Champion, 1914			4		4	8/18-9/20	F	+	X	U
	<i>C. lewisi</i> Crotch, 1874			5		5	8/27-9/10	F	+	X	U
	<i>C. limbicollis</i> LeConte, 1858		I			1	9/18	F	-	X	-
	<i>C. misellus</i> Horn, 1885		2	2		4	9/18-10/14	F	-	X	-
	<i>C. omissus</i> Fall, 1930		I	3		4	8/30-10/14	F	-	X	-
	<i>C. opacus</i> LeConte, 1866		I	4		5	8/28-9/27	F	+	X	U
	<i>C. profundus</i> LeConte, 1858			3		3	9/12-9/23	F	+	X	U
Lycidae	<i>Lycus arizonensis</i> Green, 1949	1	I	2		4	7/4-7/15	F	-	X	-
	<i>L. fernandezi</i> Dugés, 1878			4		4	7/11-7/27	F	+	X	U, I, E
	<i>L. loripes</i> Chevrolat, 1835	3	5	17		25	6/25-7/27	F	+	X	U, I, E
	<i>L. rubescens</i> (Schaeffer, 1908)	1				1	7/5	F	-	X	-
	<i>L. sanguineus</i> Gorham, 1884			3		3	5/4-5/13	F	-	X	-
	<i>L. simulans</i> Schaeffer, 1911			I		1	7/15	F	?	X	-

Tab. 2 continued

Order/Family	Identification	GAR	RAM	ASH	SAP	Σ Visits	Dates	F	P	S	Poll. Status
Dermestidae	<i>Cryptorhopalum</i> sp.			4		4	7/22-8/25	F	-	-	-
Scarabaeidae	<i>Euphoria</i> sp.	1				1	8/5	F	?	X	-
	<i>Macrodactylus uniformis</i> Horn, 1876	1	6		2	9	7/18-8/29	F	+	X	U
	<i>Strigoderma pimalis</i> Casey, 1884	4				4	7/15-8/5	F	?	X	-
Hymenoptera											
Chalcididae	<i>Conura</i> sp.		I			1	10/21	F	-	-	-
Eulophidae	species	1				1	6/26	F	-	-	-
Eurytomidae	Eurytominae or Rileyinae			3		3	5/24-6/5	F	-	-	-
Perilampidae	<i>Perilampus</i> sp.			3		3	5/23-7/23	F	-	-	-
Pteromalidae	species			1		1	7/23	-	-	-	-
Braconidae	Agathidinae		I	9	I	11	7/1-10/19	F	-	?	-
	Braconinae			7		7	7/2-9/18	F	-	X	-
	Cardiochilinae			1		1	8/22	F	-	X	-
	Microgastrinae sp. A			1		1	9/10	F	-	?	-
	Microgastrinae sp. B (spp?)			2		2	5/27-6/12	F	-	-	-
	Microgastrinae sp. C				I	1	6/8	F	-	?	-
Ichneumonidae	species A			1		1	5/23	F	-	-	-
	Metopiinae <i>Metopius?</i> sp.			1		1	8/23	F	+	X	U
	<i>Rhynchophion flammipennis</i> (Ashmead, 1894)			4		4	8/22-8/25	F	+	X	U, I
	<i>Rhynchophion</i> or <i>Thyreodon?</i>	2		2		4	8/5-8/30	F	+	X	U
Andrenidae	<i>Andrena</i> sp.		I			1	7/24	F	+	X	U, I
Apidae	<i>Anthophora urbana</i> Cresson, 1878	6	2		I	9	6/1-7/15	F	+	X	U, I, E
	<i>Apis mellifera</i> Linnaeus, 1758	1	6	19	9	35	5/5-10/19	F	+	X	U, I, E
	<i>Bombus sonorus</i> Say, 1837			1	3	4	8/9-8/23	F	+	X	U, I, E
	* <i>Centris caesalpiniae</i> Cockerell, 1897				I	1	28.06.2020	F	+	X	U
	<i>Ericrocis pintada</i> Snelling & Zavortink, 1984			1		1	7/9	F	+	X	U
	<i>Melissodes</i> Subgen. <i>Melissodes</i>	3	I		I	5	7/5-8/12	F	+	X	U, I, E
	Eucerini sp. (spp?)				3	3	6/5-8/17	F	+	X	U
	<i>Ceratina</i> subgen. <i>Zadontomerus</i>	2				2	7/15-7/21	F	-	-	-
Colletidae	<i>Hylaeus</i> sp.			I	2	3	5/24-6/18	F	-	-	-
	* <i>Ptiloglossa</i> sp.			I		1	7/25/2015	F	+	X	U, I, E
Halictidae	<i>Augochloropsis metallica</i> (Fabricius, 1793)				I	1	6/8	F	+	X	U, I
	<i>Agapostemon</i> sp.				I	1	7/1	F	+	X	U
	<i>Augochlorella neglectula</i> (Cockerell, 1897)	1				1	7/5	F	-	X	-
	<i>Augochlorini</i> sp.			I		1	10/14	F	-	X	-

Tab. 2 continued

Order/Family	Identification	GAR	RAM	ASHI	SAP	Σ Visits	Dates	F	P	S	Poll. Status
	<i>Halictus (Seladonia)</i> <i>tripartitus</i> Cockerell, 1895		I	I2	5	18	5/14-8/30	F	+	?	U
	<i>Lasioglossum</i> Subgen. <i>Dialictus</i> <i>L.</i> <i>clematisellum</i> (Cockerell, 1904)			2	3	5	5/27- 7/15	F	-	-	-
	<i>Lasioglossum</i> Subgen. <i>Dialictus</i> spp.	15	16	33	14	78	5/5-10/14	F	+	-	U
	<i>L.</i> Subgen. <i>Evylaeus</i> sensu lato				1	1	6/5	F	-	-	-
	<i>L.</i> Subgen. <i>Lasioglossum</i> sp. A	2	8	5	2	17	5/24- 10/21	F	+	-	U
	<i>L.</i> Subgen. <i>Lasioglossum</i> sp. B	4				4	6/26-7/15	F	+	X	U
	<i>L.</i> Subgen. <i>Lasioglossum</i> sp. C		I			1	10/21	F	-	X	-
	<i>L.</i> Subgen. <i>Hemihalictus</i>		I			1	6/28	F	-	-	-
	<i>Sphecodes</i> sp. A		2			2	7/4-8/26	F	+	?	U
	<i>Sphecodes</i> sp. B	I		I	3	5	5/31-6/18	F	-	?	-
	<i>Nomia</i> sp.	I	6	I		8	7/21-9/18	F	+	X	U, I
Megachilidae	<i>Lithurgopsis apicalis</i> (Cresson, 1875)	5				5	6/1-6/26	F	+	X	U
	<i>Anthidiellum notatum</i> <i>gilense</i> (Cockerell, 1897)	3	I			4	7/13-7/25	F	+	X	I, E
	<i>Dianthidium arizonicum</i> Rohwer, 1916	I				1	7/15	F	+	X	U
	<i>Trachusa manni</i> Crawford, 1917	I	I			2	7/29-8/26	F	+	X	U, I
	<i>Megachile</i> Subgenus <i>Megachile lippiae</i> Cockerell, 1900	I				1	6/28	F	+	X	U, I
	<i>M.</i> Subgen. <i>Litomegachile</i> sp.	2		5		7	6/26-7/18	F	+	X	U, I, E
	<i>M. sidalceae</i> Cockerell, 1897				3	3	7/1-7/19	F	+	X	U, I
	<i>Megachile</i> spp.	2	I	3	4	10	5/29-8/9	F	+	X	U, E
Crabronidae	<i>Bembix</i> sp.				2	2	7/19-8/9	F	-	X	-
	<i>Steniolia</i> sp.	I				1	6/6	F	+	X	U, I, E
	<i>Crabro</i> sp.				I	1	7/19	F	-	X	-
	<i>Ectemnius centralis</i> (Cameron, 1891)				I	1	6/12	F	-	X	-
	<i>E. sonorensis</i> (Cameron, 1891)	9	2			11	5/29-8/26	F	+	X	U, E
	<i>Ectemnius</i> sp.	I				1	7/13	F	-	X	-
	<i>Tachysphex</i> sp.				4	4	6/5-8/17	F	+	X	U
	<i>Tachytes werner</i> Bohart, 1994 (and other spp?)			29		29	7/3-9/12	F	+	X	U, I, E
	<i>T. pepticus</i> (Say, 1837)			6		6	8/17-8/24	F	+	X	U, I
	<i>T. amazonus</i> Smith, 1856			I		1	8/17	F	+	X	E
	<i>Spilomena</i> sp.		I			1	10/21	F	-	-	-
	<i>Cerceris insolita</i> Cresson, 1865				2	2	7/19-8/9	F	+	X	U, I, E
	<i>Cerceris</i> sp.			I		1	7/31	F	+	X	U, E

Tab. 2 continued

Order/Family	Identification	GAR	RAM	ASH	SAP	Σ Visits	Dates	F	P	S	Poll. Status
	<i>Philanthus gibbosus</i> (Fabricius, 1775)			2	2	4	6/8-8/22	F	+	X	U
Sphécididae	<i>Podalonia</i> sp.	4	5			9	5/30-8/29	F	+	X	U, I
	<i>Ammophila</i> (spp.?)	6	3	5		14	6/1-11/19	F	+	X	U, I
	<i>Prionyx parkeri</i> Bohart & Menke, 1963 (and other spp.?)	12	5	23		40	5/29-9/23	F	+	X	U, I
	<i>Isodontia philadelphica</i> (Lepelletier de Saint Fargeau, 1845)			4		4	9/13-9/23	F	+	X	U, E
	<i>Sphex ichneumoneus</i> (Linnaeus, 1758)	2	1	6		9	6/26-9/18	F	+	X	U
Bethylidae	species A	1		3		4	5/24-6/28	F	-	-	-
Formicidae	<i>Dorymyrmex</i> sp.		6			6	7/1-10/19	F	-	?	-
	<i>Forelius</i> sp.			20	1	21	5/11-9/22	F	-	-	-
	<i>Formica</i> sp.			4		4	5/24- 10/10	F	-	?	-
	<i>Crematogaster</i> sp.		2			2	8/12-9/3	F	-	-	-
	<i>Monomorium</i> sp.			4		4	5/24-8/30	F	-	-	-
Pompilidae	<i>Pepsis</i> cf. <i>pallidolimbata</i> Lucas, 1894			4		4	7/21-9/16	F	+	X	U
	Pepsinae			1		1	7/2	F	-	X	-
	<i>Aporus luxus</i> (Banks, 1914)			1		1	9/23	F	+	X	U
	<i>Aporinellus</i> sp.	1				1	6/6	F	-	X	-
Scoliidae	<i>Colpa octomaculata</i> (Say, 1823)			1		1	7/9	F	+	X	U
	<i>Dielis pilipes</i> (Saussure, 1858)				2	2	6/5-6/8	F	+	X	U, I
	<i>D. tolteca</i> (Saussure, 1857)	2				2	7/5-7/15	F	-	X	-
	<i>Pygodasis ephippium</i> (Say, 1837)			3		3	8/8-9/15	F	+	X	U, I
	<i>Xanthocampsomeris</i> <i>completa</i> (Rohwer, 1927)	1	1	3		5	7/4-7/15	F	+	X	U, I, E
	<i>X. limosa</i> (Burmeister, 1853)		2			2	8/26- 10/14	F	+	X	U
	<i>Scolia dubia</i> Say, 1837			6		6	8/28-9/14	F	+	X	U, I
	<i>S. mexicana</i> (Saussure, 1858)			3		3	8/30-9/18	F	+	X	U, I
	<i>S. nobilitata</i> (Fabricius, 1805)			8		8	7/13-9/13	F	+	X	U, I
	<i>Triscolia ardens</i> (Smith, 1855)			1	1	2	7/1-7/20	F	+	X	U, E
Thynnidae	<i>Myzinum maculatum</i> (Fabricius, 1793)		1	11		12	8/20-9/14	F	+	X	U, I, E
Tiphiidae	<i>Epomidiopteron julii</i> Romand, 1836	2	4			6	7/15-8/29	F	+	X	I
	<i>Neotiphia novomexicana</i> Allen, 1935 (and other spp.?)			9	2	11	6/8-9/23	F	+	X	U, I
Vespidae	<i>Eumenes americanus</i> Saussure, 1852	2		3		5	7/15-7/25	F	+	X	U
	<i>E. crucifera</i> Provancher, 1888	1				1	7/15	F	+	X	U, I

Tab. 2 continued

Order/Family	Identification	GAR	RAM	ASH	SAP	Σ Visits	Dates	F	P	S	Poll. Status
	<i>Euodynerus annulatus</i> (Say, 1824)			10	2	12	6/12-8/9	F	+	X	U
	<i>E. guerrero</i> (Saussure, 1857)	4				4	7/15-7/25	F	+	X	U, I
	<i>Hypalastoroides slevini</i> (Bohart, 1948)			2		2	8/28-8/30	F	+	X	U, I, E
	<i>Leptochilus</i> sp.				1	1	7/1	F	-	X	-
	<i>Monobia arizonensis</i> (Bequaert, 1940)	1				1	7/5	F	-	X	-
	<i>Pachodynerus</i> cf. <i>nasidens</i> (Latreille, 1812)			1		1	7/18	F	+	X	U
	<i>Parancistrocerus bicornis cushmani</i> (Bohart, 1949)			1		1	8/22	F	+	X	U, I, E
	cf. <i>Parancistrocerus</i> spp.	2		3		5	7/10-7/19	F	+	X	U
	<i>Parazumia tolteca</i> (de Saussure, 1875)	4	I			5	7/5-8/26	F	+	X	U
	<i>Smeringodynerus morelios</i> (Saussure, 1857)	1	I			2	7/15-8/26	F	+	X	U, I, E
	<i>Stenodynerus ochrogonius</i> Bohart, 1944			2		2	7/11-7/13	F	+	X	U, I, E
	cf. <i>Stenodynerus</i> spp.	8	I	3	I	13	7/3-8/5	F	-	X	-
	<i>Polistes comanchus navajoe</i> Cresson, 1868	1	5	1		7	6/29-8/29	F	+	X	U, I
	<i>P. dorsalis</i> (Fabricius, 1775)			18		18	7/1-10/7	F	+	X	U, I, E
	<i>P. cf. major</i> Palisot de Beauvois, 1818	2	4	1		7	6/26-10/21	F	+	X	U, I
Lepidoptera											
Scythrididae	species			5		5	5/25-9/10	F	-	-	-
Geometridae	<i>Eupithecia</i> nr. <i>miserulata</i> Grote, 1863 (larvae)				3	3	6/18-6/24	F	-	-	-
Erebidae	<i>Estigmene albida</i> (Stretch, 1873) (larvae)		I	7		8	8/19-9/21	-	-	-	-
	<i>Euchaetes antica</i> (Walker, 1856) (larvae)			12	3	15	8/9-9/29	-	-	-	-
	<i>Pygostenucha terminalis</i> (Walker, 1854) (larvae)		I			1	8/21	-	-	-	-
	<i>Ctenucha venosa</i> Walker, 1854			4		4	9/13-9/23	F	+	X	U
Noctuidae	<i>Striacosta albicosta</i> Smith, 1888		I			1	8/24	F	-	X	-
Hesperiidae	<i>Cecropterus casica</i> (Herrich-Schäffer, 1869)	3	I	I		5	6/15-7/29	F	+	X	U, I, E
	<i>Cecropterus drusius</i> (W.H. Edwards, [1884])	1	I			2	7/25-8/6	F	+	X	U
	<i>Cecropterus pylades</i> (Scudder, 1870)	13	6	4		23	5/29-8/26	F	+	X	U, I
	<i>Cecropterus dorantes</i> (Stoll, 1790)		3			3	8/15-10/21	F	+	X	U
	<i>Telegonus cellus</i> (Boisduval & LeConte, [1837])		I			1	8/17	F	+	X	U
	<i>Codattractus arizonensis</i> (Skinner, 1905)		I			1	9/3	F	-	X	-
	<i>Cogia caicus</i> (Herrich-Schäffer, 1869)		I			1	8/15	F	+	X	U

Tab. 2 continued

Order/Family	Identification	GAR	RAM	ASH	SAP	Σ Visits	Dates	F	P	S	Poll. Status
	<i>C. hippalus</i> (W.H. Edwards, 1882)		2	3		5	7/11-8/29	F	+	X	U, I, E
	<i>Copaodes aurantiaca</i> (Hewitson, 1868)	14	1	10	6	31	5/29-- 8/28	F	+	X	U, I
	<i>Amblyscirtes aenus</i> W.H. Edwards, 1878	13	12	1		26	6/26-8/26	F	+	X	U, E
	<i>A. cassus</i> W.H. Edwards, 1883	11	1			12	6/6-8/12	F	+	X	I
	<i>A. elissa</i> Godman, 1900			3	2	5	7/1-8/9	F	-	X	-
	<i>A. exotera</i> (Herrich-Schäffer, 1869)	5				5	7/10-7/29	F	+	X	U, I?
	<i>A. nysa</i> W.H. Edwards, 1877				1	1	7/19	F	+	X	U
	<i>Lerodea eufala</i> (Edwards, 1869)			4		4	6/21-8/17	F	+	X	U
	<i>Atalopedes campestris</i> Boisduval, 1852				1	1	7/5	F	+	X	U
	<i>Atrytonopsis deva</i> (W. H. Edwards, 1877)	1				1	6/6-6/15	F	+	X	U
	<i>A. python</i> (W.H. Edwards, 1882)	1	1			2	6/4-6/8	F	+	X	U, I, E
	<i>Hylephila phyleus</i> (Drury, 1773)			4		4	7/1-7/19	F	+	X	U
	<i>Polites carus</i> (W. H. Edwards, 1883)				1	1	7/19	F	+	X	U, I
	<i>Piruna aea</i> (Dyar, 1912)		1			1	8/20	F	+	X	U
	<i>Apyrrothrix araxes</i> (Hewitson, 1867)		6			6	8/20-9/3	F	+	X	U, I, E
	<i>Pholisora catullus</i> (Fabricius, 1793)	1			3	4	6/30-7/19	F	+	X	I
	<i>Staphylus ceos</i> (W.H. Edwards, 1882)	2	4	4	1	11	6/11-8/20	F	+	X	U, I?
	<i>Burnsius cf. albescens</i> (Plötz, 1884)		2	1		3	5/4-10/14	F	+	X	U
Lycaenidae	<i>Brephidium exile</i> (Boisduval, 1852)		1		1	2	6/5-10/21	F	-	X	-
	<i>Celastrina echo</i> (W. H. Edwards, 1864)	1	1			2	6/15- 10/14	F	+	X	U, I, E
	<i>Hemiargus ceraunus</i> (Fabricius, 1793)		2	4	2	8	7/1-10/14	F	-	X	-
	<i>Leptotes marina</i> (Reakirt, 1868)	12	5	12	7	36	5/14-9/12	F	+	X	U
	<i>Plebejus (Icaricia) lupini</i> (Boisduval, 1869)	1				1	6/6	F	-	X	-
	<i>Callophrys gryneus siva</i> (W. H. Edwards, 1874)	6	1			7	5/29-7/10	F	+	X	U, I
	<i>Ministrymon leda</i> (W. H. Edwards, 1882)			1	1	2	6/12-6/21	F	-	X	-
	<i>Strymon melinus</i> Hübner, 1818	5	1	6	1	13	5/30-9/20	F	+	X	U, I
Nymphalidae	<i>Danaus gilippus</i> (Cramer, 1776) (adult)		1	8	4	13	6/5-10/7	F	+	X	U, I
	<i>D. gilippus</i> (Cramer, 1776) (larvae)			20	3	23	7/13- 10/14	-	-	-	-
	<i>D. plexippus</i> (Linnaeus, 1758) (adult)		2	2		4	4/9-8/29	F	?	X	-

Tab. 2 continued

Order/Family	Identification	GAR	RAM	ASH	SAP	Σ Visits	Dates	F	P	S	Poll. Status
	<i>D. plexippus</i> (Linnaeus, 1758) (larvae)	1	2	2	I	6	5/8-10/18	-	-	-	-
	<i>Euptoieta claudia</i> (Cramer, 1776)	2	I	I		4	6/6-8/17	F	+	X	U, E
	<i>Libytheana carinenta</i> (Cramer, 1777)			2		2	8/26-9/9	F	?	X	-
	<i>Vanessa cardui</i> (Linnaeus, 1758)		2		I	3	7/13-9/3	F	+	X	U, I, E
	<i>V. virginiensis</i> (Drury, 1773)	6	2		I		6/6-8/29	F	+	X	U, I, E
	<i>Junonia coenia</i> Hübner, 1822	2				2	6/6-6/26	F	+	X	U, I, E
	<i>J. evarete nigrosuffusa</i> W. Barnes & McDunnough, 1916	6				6	6/1-6/28	F	+	X	U, I, E
	<i>Anthanassa texana</i> (W.H. Edwards, 1863)	3	I	I		5	6/6-6/26	F	+	X	U, I
	<i>Chlosyne lacinia</i> (Geyer, 1837)	4				4	6/6-7/29	F	+	X	U, I, E
	<i>Dymasia dymas</i> (W. H. Edwards, 1877)			2		2	6/5-8/30	F	-	X	-
	<i>Phyciodes mylitta</i> (W.H. Edwards, 1861)	4	I			5	6/15-10/14	F	-	X	-
	<i>Phyciodes tharos</i> (Drury, 1773)	1				1	7/25	F	-	X	-
Papilionidae	<i>Battus philenor</i> (Linnaeus, 1771)			5	2	7	6/17-9/13	F	?	X	-
Pieridae	<i>Colias eurytheme</i> Boisduval, 1852	1				1	7/29	F	-	X	-
	<i>Eurema mexicana</i> (Boisduval, 1836)	2				2	6/1-6/15	F	?	X	-
	<i>Nathalis iole</i> (Boisduval, 1836)	1				1	6/6	F	-	X	-
	<i>Phoebis sennae</i> (Linnaeus, 1758)			2		2	8/3-8/5	F	+	X	U, I, E?
	<i>Pyrisitia proterpia</i> (Fabricius, 1775)			2		2	8/20-8/23	F	?	X	-
	<i>Zerene cesonia</i> (Stoll, 1790)	4				4	6/6-6/28	F	-	X	-
	<i>Pieris rapae</i> (Linnaeus, 1758)	4	I		I	6	6/8-7/24	F	+	X	U, I
	<i>Pontia protodice</i> (Boisduval & Leconte, 1830)	2			I	3	6/6-7/21	F	+	X	U, I, E
Riodinidae	<i>Calephelis nemesis</i> (W.H. Edwards, 1871)				I	1	6/12	F	-	X	-
	<i>C. arizonensis</i> (McAlpine, 1971)	3	4	I	I	9	6/19-8/23	F	-	X	-
	<i>Emesis ares</i> (W.H. Edwards, 1882)	1	4			5	7/21-8/29	F	?	X	-
	<i>E. zela</i> Butler, 1870	4	10			4	6/30-8/29	F	+	X	U, I
	<i>Plesioarida palmerii</i> (Edwards, 1870)				I	1	8/17	F	-	X	-
Sesiidae	<i>Carmenta auritincta</i> (Engelhardt, 1925)			2		2	8/3-8/23	F	-	X	-
	* <i>Carmenta engelhardti</i> Duckworth & Eichlin, 1973			I		1	7/23/2017	F	+	X	U

Tab. 2 continued

Order/Family	Identification	GAR	RAM	ASH	SAP	Σ Visits	Dates	F	P	S	Poll. Status
Thyrididae	<i>Dysodia granulata</i> (Neumoegen, 1883)			I		1	9/14	F	-	X	-
Helioidinidae	<i>Lithariapteryx</i> cf. <i>abroniacella</i> Chambers, 1876	I				1	7/21	F	-	-	-
Zygaenidae	<i>Harrisina metallica</i> (Stretch, 1885)	I		I		2	7/15-8/16	F	+	X	U?
	<i>Pyromorpha dyari</i> (Jordan, 1913)	I				1	7/5	F	-	-	-
Diptera											
Sciaridae	species			2		2	5/18-8/23	F	-	-	-
Culicidae	<i>Aedes aegypti</i> (Linnaeus in Hasselquist, 1762)			I		1	8/24	F	-	-	-
	<i>Toxorhynchites rutilus</i> (Coquillett, 1896)		I	I		2	9/18-9/23	F	-	X	-
Tabanidae	<i>Esenbeckia delta</i> (Hine, 1920)		2			2	8/26-8/29	F	+	X	E
Bombyliidae	cf. <i>Neacreotrichus</i> sp. A		I			1	7/1	F	-	-	-
	cf. <i>Neacreotrichus</i> sp. B		I			1	9/12	F	-	-	-
	<i>Poecilognathus</i> sp. A			3		3	8/20-9/12	F	-	X	-
	<i>Poecilognathus</i> sp. B			2		2	8/22-8/23	F	-	X	-
	<i>Geron</i> sp. (or spp?)	I	5	4	2	12	6/5-8/20	F	-	-	-
	<i>Toxophora virgata</i> Osten Saken, 1877			I		1	7/27	F	-	X	-
	<i>Anastoechus</i> sp.			I		1	10/19	F	-	-	-
	<i>Sparnopolius</i> sp.			I		1	9/9	F	-	-	-
	<i>Amphicosmus arizonicus</i> Hall, 1975			I		1	9/16	F	-	-	-
	<i>Aphoebantus</i> sp.			I		1	8/20	F	-	-	-
	<i>Exoprosopa</i> sp.			I		1	7/31	F	-	X	-
	<i>E. argentifasciata</i> Macquart, 1846			2		2	8/16-9/9	F	+	X	U
	<i>E. near bifurca</i> Loew, 1869?			3		3	8/20-8/30	F	+	X	U
	<i>E. fumosa</i> Cresson, 1919		2			2	8/20-8/26	F	+	X	E
	<i>E. cf. pueblensis</i> Jaenicke, 1867			I		1	8/16	F	+	X	U
	<i>E. fasciata</i> -group nr. <i>brevirostris</i> ?			I		1	7/2	F	+	X	U
	<i>E. undescribed</i> (<i>fide</i> A. Calderwood)		I			1	8/20	F	-	X	-
	<i>Chrysanthrax cypris</i> (Meigen, 1820)			10		10	8/19-9/18	F	-	X	-
	<i>C. edititius</i> (Say, 1829)			6		6	5/23-8/28	F	+	X	U
	<i>C. undescribed</i> ? (<i>fide</i> J. Kits)			3		3	8/20-8/28	F	-	X	-
	<i>Hemipenthes celeris</i> (Wiedemann, 1828)	I	I	16		18	7/13-9/25	F	+	X	U
	<i>H. cf. jaenickeana</i> (Osten Sacken, 1886)	I				1	6/15	F	-	X	-
	<i>H. cf. scylla</i> (Osten Sacken, 1887)		I			1	8/15	F	-	X	-
	<i>Lepidanthrax</i> sp.		I	I		2	5/24-8/26	F	-	-	-

Tab. 2 continued

Order/Family	Identification	GAR	RAM	ASH	SAP	Σ Visits	Dates	F	P	S	Poll. Status
	<i>Paravilla cf. consul</i> (Osten Sacken, 1886)			I		1	8/23	F	-	X	-
	<i>Poecilanthrax effrenus</i> (Coquillett, 1887)			I	I	2	7/1-7/5	F	+	X	U
	<i>P. ingens</i> Johnson & Johnson, 1957		2			2	8/26-8/29	F	+	X	E
	<i>Villa</i> sp. A		I	I		2	8/3-8/26	F	-	X	-
	<i>Villa</i> sp. B (or spp?)	2		2	I	5	5/14-7/7	F	+	X	U
	<i>Villa?</i>	I				1	6/15	F	-	X	-
Mydidae	<i>Mydas arizonensis</i> Wilcox, Papavero & Pimentel, 1989			12		12	8/16-9/12	F	+	X	U, E
Empididae	Empidinae sp. A			2		2	7/31-8/3	F	-	-	-
	Empidinae sp. B		2			2	8/9-8/12	F	-	-	-
Nemestrinidae	species		I			1	8/18	F	-	X	-
Syrphidae	<i>Helophilus latifrons</i> Loew, 1863		I			1	7/24	F	-	X	-
	<i>Syritta pipiens</i> (Linnaeus, 1758)			5		5	5/23-6/5	F	-	X	-
	<i>Ferdinandea croesus</i> (Osten Sacken, 1877)		I			1	7/18	F	-	X	-
	<i>Copestylum opinator</i> (Williston, 1891)		2			2	10/14-11/17	F	-	X	-
	<i>Paragus haemorrhous</i> Meigen, 1822	I				1	6/15	F	-	-	-
	<i>Allograpta obliqua</i> (Say, 1823)			I		1	8/5	-	-	-	-
	<i>Eupeodes volucris</i> Osten Sacken, 1877			I		1	7/31	F	-	?	-
	Subgenus <i>Metasyrphus</i> (<i>Eupeodes americanus/pomus</i> group)		I			1	6/19	F	-	X	-
	<i>Syrphus opinator</i> Osten Sacken, 1877		I			1	10/14	F	-	X	-
Muscidae	<i>Musca</i> sp.				2	2	6/8-6/18	F	-	-	-
	<i>Atherigona reversura</i> Villaneuve, 1936			3		3	6/12-9/13	F	-	-	-
	Muscidae sp. A			2		2	7/2-7/21	F	-	-	-
	Muscidae sp. B			I		1	5/24	F	-	-	-
	Muscidae sp. C			I		1	5/16	F	-	-	-
Calliphoridae	Chrysomyinae			I		1	8/17	F	-	X	-
	<i>Lucilia</i> sp.		4	11	I	16	5/5-10/14	F	+	X	U
Sarcophagidae	Sarcophaginae			3		3	5/22-5/28	F	-	?	-
Tachinidae	Dexiini sp. (spp?)			13		13	5/18-9/14	F	+	X	U
	Dexiini sp.			3		3	5/23-5/28	F	-	X	-
	<i>Billaea?</i> sp.			I		1	7/15	F	+	X	U
	<i>Euchaetogyne roederi</i> Williston, 1893	I				1	7/21	F	+	X	U, I
	<i>Microchaetina</i> sp.		I			1	10/14	F	-	X	-
	<i>Mochlosoma?</i> sp.				I	1	9/8	F	+	X	U, I
	<i>Ptilodexia</i> spp.		4	I		5	5/27-9/18	F	+	X	U
	Voriini possibly <i>Chaetoplagia</i> sp.			I		1	8/24	F	-	?	-

Tab. 2 continued

Order/Family	Identification	GAR	RAM	ASH	SAP	Σ Visits	Dates	F	P	S	Poll. Status
	Exoristinae cf. Blondeliini			I		1	5/22	F	-	?	-
	<i>Chetogena</i> subgen. <i>Stomatomyia</i>			I		1	5/28	F	-	?	-
	Exoristini poss. <i>Chetogena</i>			I		1	5/27	F	-	?	-
	Goniini		I			1	7/4	F	-	X	-
	Exoristinae				I	1	5/18	F	-	X	-
	cf. Exoristinae			I		1	6/12	F	-	?	-
	<i>Cylindromyia</i> sp.	2	3		2	7	5/29-7/14	F	+	X	U
	<i>Gymnoclytia</i> sp. (spp.?)		4	5		9	7/2-10/14	F	-	-	-
	<i>Gymnoclytia</i> cf. <i>unicolor</i>			I		1	8/4	F	-	-	-
	<i>Phasia</i> sp.	1	1	3	5	10	5/24-6/21	F	-	-	-
	Leskiini		I	3		4	7/4-7/15	F	-	?	-
	<i>Vanderwulpia sequens</i> Townsend, 1892			2	I	3	5/27-7/25	F	-	X	-
	<i>Siphona</i> sp.		2			2	6/19-7/1	F	-	-	-
	<i>Archytas analis</i> complex		I			1	10/14	F	?	X	-
	<i>Archytas</i> sp.			I		1	9/13	F	-	X	-
	<i>Peleteria</i> (some are subgenus <i>Sphyrmyia</i>)	5	4			9	5/29- 10/21	F	+	X	U, I
Ephydriidae	sp. A			I		1	5/24	F	-	-	-
	sp. B	I				1	6/28	F	-	-	-
Conopidae	<i>Physoconops townsendi</i> Camras, 1955		I			1	8/20	F	-	x	-
	<i>Zodion</i> sp. A	I	2	4	I	8	5/30-9/18	F	-	-	-
	<i>Zodion</i> sp. B			I		1	6/12	F	-	-	-
	<i>Stylogaster beresfordi</i> Burt, Skevington & Rocha, 2014	I		I		2	8/4-8/5	F	-	-	-
Sciomyzidae	Tetanocerini			I		1	5/24	F	-	-	-
Richardiidae	<i>Sepsisoma</i> sp.			2		2	7/19-7/23	F	-	-	-
Tephritidae	<i>Euaresta bellula</i> Snow, 1894			I		1	9/18	F	-	-	-
	<i>Neaspilota aenigma</i> Freidberg and Mathis, 1986			I		1	9/18	F	-	-	-
Ulidiidae	Ulidiinae			I		1	7/19	-	-	-	-
Agromyzidae	Agromyzinae		3	2		5	5/18- 10/21	F	-	-	-
Chloropidae	Oscinellinae	I		2		3	7/16-9/10	F	-	-	-
Milichiidae	sp. A	2	3	9		14	7/2-10/21	F	-	-	-
	Milichiinae		I			1	8/26	F	-	-	-
Sepsidae	<i>Sepsis</i> sp.			17		17	5/5-8/23	F	-	-	-